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ULTRAHIGH FREQUENCY GENERATOR

Original Filed Oct. 3, 1935

FIG. 1

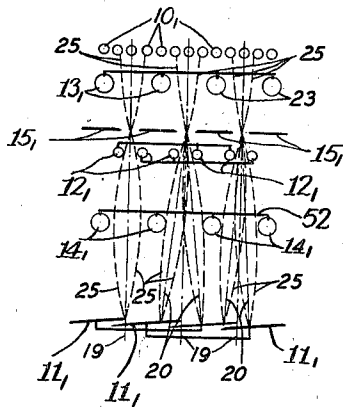


FIG. 2

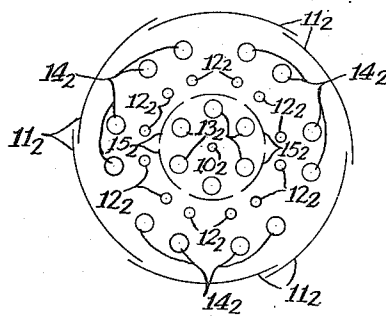
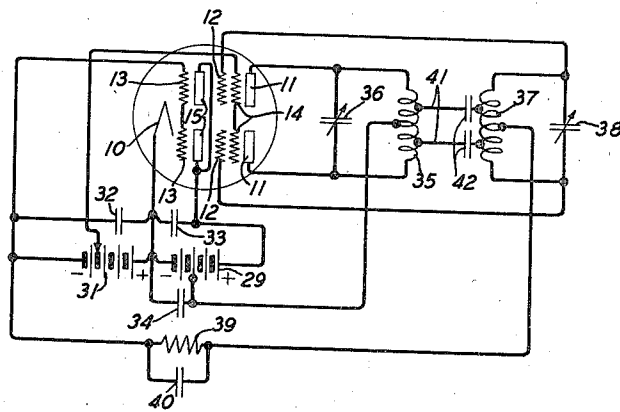


FIG. 3



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ULTRAHIGH FREQUENCY GENERATOR

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43,298. Divided and this application May 13,
1936, Serial No. 79,485

4 Claims. (Cl. 250—36)

This invention relates to electron discharge devices and more particularly to such devices capable of generating and amplifying ultra-high frequency impulses. This application is a division of application Serial No. 43,298, filed October 3, 1935.

As is known in the art, in electron discharge devices including at least a cathode, an anode and a control electrode or grid, the electrons emanating from the cathode are subjected to the potential on the control electrode or grid in their passage to the anode. In the present devices the electrons are under the influence of the grid potentials throughout a relatively large distance in the path the electrons traverse in passing to the anode. At ultra-high frequencies, the time required for the electrons to traverse the distance in which they are acted upon by the grid potentials may become too great a part of the cycle at which it is desired to operate the device. To overcome this, it has been proposed to make the electrode spacings extremely small. However, the attainment of such small spacings involves mechanical and electrical difficulties and, furthermore, may necessitate the use of relatively small electrodes so that the power output obtainable from devices so constructed is relatively small.

In electron discharge devices of conventional construction, at ultra-high frequencies the rapidly reversing grid potentials cause a large proportion of the electrons emanating from the cathode to execute a to-and-fro or oscillating motion between the grid and the cathode, which motion results in a power loss. Also, as a result of this motion, the passage of some of the electrons from the grid to the anode is not initiated until late in the cycle so that these electrons extract energy from the grid circuit which is not compensated for by movement of the electrons away from the grid and to the anode. The resulting loss of energy, which is commonly known as the active grid loss, becomes of appreciable magnitude at ultra-high frequencies.

One object of this invention is to efficiently generate impulses of ultra-high frequencies.

Another object of this invention is to reduce the active grid losses in electron discharge devices whereby the efficiency of such devices, particularly at ultra-high frequencies, is increased.

A further object of this invention is to enable the use of relatively wide electrode spacings and relatively large electrodes in electron discharge devices adapted for the generation of ultra-high frequency impulses.

In one illustrative embodiment of this inven-

tion, an electron discharge device comprises an incandescent cathode, a plurality of anodes having juxtaposed end portions, and a plurality of control electrode elements disposed between the cathode and the anodes and adapted to influence electron beams from the cathode so that each of the beams impinges alternately upon two of the anodes, to constitute the device a repeater device of the electron beam type.

At ultra-high frequencies, a time delay may occur between the potential changes on the control electrode elements and the corresponding deflections of the electron beams at their points of incidence upon the anodes. In accordance with a feature of this invention the deleterious effects of such time delay are prevented by a shifting in phase of the variable potentials appearing upon the control electrode elements and upon the anodes. For example, either the input or output circuit of the device may be detuned slightly to provide the proper phase shift. If the device is utilized as an oscillation generator, the input and output circuits may be connected by a transmission line or other delay circuit to provide the proper phase shift in the potentials upon the control electrode elements and the anodes.

It will be apparent that in devices constructed in accordance with this invention the electrons flowing to the anodes are subjected to the influence of the control electrode throughout but a small portion of the path they traverse in passing to the anodes. The small change of direction of motion of the electrons produced in the vicinity of the control electrodes is multiplied because of the movement of the beams, analogously to the principle of levers, so that a large displacement of the electron beams occurs at their points of incidence upon the anodes. Hence, the electrodes may be relatively widely spaced and the difficulties attendant upon the extremely small electrode spacings used heretofore in ultra-high frequency devices are obviated.

The invention and the several features thereof will be understood more clearly and fully from the following detailed description with reference to the accompanying drawing in which:

Fig. 1 is a diagrammatic view showing the form and arrangement of the electrodes in an electron discharge device illustrative of one embodiment of this invention;

Fig. 2 is a diagrammatic view illustrating another embodiment of this invention wherein the electrodes are arranged coaxially; and

Fig. 3 illustrates a typical oscillator circuit including an electron discharge device constructed

in accordance with this invention and including also a time delay element for providing a phase shift between the potentials upon the control electrode elements and the anodes.

5 In Figs. 1 and 2, the elements corresponding to the elements in Fig. 3 are given the same numerical designations as in said Fig. 3 although distinguished from each other by use of distinctive subscripts.

10 Referring now to Fig. 3 of the drawing, the electron discharge device shown therein comprises, generally, a cathode 10, a plurality of anodes 11, and a control electrode 12 disposed between the cathode and the anodes. Disposed
15 between the cathode 10 and the control electrode 12 is a focussing electrode 13. Another focussing electrode 14 is positioned between the control electrode 12 and the anodes 11. An auxiliary or accelerating electrode 15 is arranged between the
20 focussing electrode 13 and the control electrode 12.

As shown in Fig. 1, illustrating one of two specific tubes that are adapted to be used with the Fig. 3 circuit, the other of which is illustrated
25 by Fig. 2, the cathode, here identified by 10₁, to distinguish from the cathode of Fig. 2, may comprise a plurality of filaments connected in series or in parallel, and arranged in a plane. The anodes 11₁ may be constituted by an in-
30 definite number of flat plates as disclosed disposed at a very small angle to the cathode plane, with adjacent end portions overlapping. Their interconnections to cause them to effectively constitute two anodes will be explained later. The
35 control electrode 12₁ may include a plurality of pairs of linear metallic wires or rods connected as shown so as to comprise two groups and positioned parallel to the cathode plane and on
40 opposite sides of normals 19 extending from the cathode plane to the overlapping end portions of the anode plates.

If the anodes 11₁ of Fig. 1 are operated at a positive potential, electrons will flow from the cathode 10₁ to the anodes 11₁ in substantially
45 linear paths and some of the electrons will pass between the wires or rods of the control electrode and be subject to potentials upon the control electrode. Thus, if the potentials upon the wires or rods are varied, the electron beams passing
50 therebetween will be deflected in accordance with such potential variations and may be caused to impinge alternately upon two of the anode plates as indicated by the broken lines 20.

The accelerating electrode 15 may be composed of a plurality of flat plates as disclosed
55 disposed parallel to the cathode plane and spaced to form openings or slits in alignment with the normals 19. Alternatively, the accelerating electrode 15₁ may be a single flat plate having suitable
60 openings or slits therein. Preferably the electrode 15₁ is operated at a greater positive potential, relative to the cathode 10₁, than the potential on the anodes 11₁ so that the electrons are subjected to a retarding force between
65 the control electrodes 12₁ and the anodes 11₁ and, therefore, will have a relatively low velocity when reaching the anodes, whereby a high operating efficiency is obtained.

The electrode 13₁ may include a plurality of
70 pairs of metallic rods or wires electrically connected together as shown and positioned parallel to the cathode plane and on opposite sides of the normals 19. The rods or wires may be operated at either a positive or negative potential,
75 the potential preferably being such that the

electron beams are focussed upon the openings or slits in the accelerating electrode 15₁.

The electrode 14₁ similarly may be composed of a plurality of pairs of metallic rods or wires electrically connected together as shown and ar-
5 ranged parallel to the cathode plane and on opposite sides of the normals 19. Preferably the electrode 14₁ is operated at a negative potential of such magnitude that the electron beams are focussed upon the overlapping end portions of
10 the anode plates.

As indicated by the dotted lines 25 in Fig. 1, electrons emanating from the cathode 10₁, under the influence of the positive potentials upon the anode plates and the plates of the accelerating
15 electrode 15₁ travel toward the accelerating electrode 15₁. The electrons are subjected to the field of the elements of the electrode 13₁ and are focussed thereby upon the openings or slits of the accelerating electrode and, because of their high
20 velocities, pass through the openings or slits and between the elements of the control electrode 12₁. If said elements of the control electrode 12₁ are at the same potential, the electrons
25 tend to spread uniformly after passing the control electrode. This tendency to spread is counteracted by the field of the elements of the electrode 14₁ and the electrons are concentrated to form
30 beams each focussed upon the overlapping end portions of the anode plates. If an alternating potential is applied between the elements of the control electrode 12₁ each of the electron beams
35 will be deflected in accordance with the potential variations and impinge alternately upon two of the anode plates, as indicated by the dotted lines 20, the plates being so connected that the electrons
40 flowing thereto from the several beams are in phase. For example, if a device includes four anode plates, as shown in Fig. 1, alternate plates may be electrically connected together as shown.

As shown in Fig. 2, the invention may be embodied also in electron discharge devices having coaxially arranged electrodes. In this figure elements corresponding to the elements shown in
45 Fig. 1 are similarly designated except as using a different subscript. In this embodiment, the cathode 10₂ may be a single linear filament or a plurality of filaments arranged in a cylindrical boundary, and the focussing electrode 13₂
50 may comprise a plurality of metallic linear wires or rods which are equally spaced, parallel to each other and to the cathode 10₂, and are arranged in a cylindrical boundary about and coaxial with the cathode. The accelerating electrode 15₂ may
55 include a plurality of arcuate plates arranged in a cylindrical boundary coaxial with the cathode 10₂. The elements of the control electrode 12₂, which may be wires or rods disposed parallel to each other and to the cathode 10₂, are disposed
60 in a cylindrical boundary coaxial with the cathode 10₂, these elements being electrically connected together by means not shown similarly as in Fig. 1. Likewise, the elements of the focussing electrode 14₂ may be linear wires or rods
65 disposed parallel to each other and to the cathode 10₂ and arranged in a cylindrical boundary coaxial with the cathode 10₂. The anodes 11₂ may be arcuate plates having overlapping end portions and forming a substantially cylindrical enclosure coaxial with the cathode 10₂, alternate
70 plates being electrically connected together similarly as in Fig. 1 by means not shown. The several electrodes, it will be apparent, are arranged to provide unimpeded radial paths for electrons to the overlapping edges of the anodes.

The paths traversed by electrons in the device shown in Fig. 2 will be clear, it is believed, from the detailed description hereinabove with reference to Fig. 1.

5 In the typical oscillator circuit illustrated in Fig. 3, the anodes 11 are connected to opposite ends of an inductance 35 which is shunted by a suitable variable condenser 36 to constitute the whole a tuned circuit. Similarly, corresponding
10 elements of the control electrode 12 are connected to opposite ends of an inductance 37, which is in parallel with a variable condenser 38. The midpoint of the inductance 37 is connected to the negative terminal of the source 31 through a resistance 39 shunted by a condenser 40.

At ultra-high frequencies, because of the electron transit times, a time delay may occur between the potential changes on the elements of the control electrode 12 and the corresponding
20 deflections of the electron beams at their points of focus upon the anodes 11. This time delay may be counteracted by slightly detuning either the control electrode or anode circuit by varying the condenser 38 or 36, respectively. The re-
25 site shifting in the phase of the alternating potentials upon the control electrode 12 and anodes 11 to counteract the time delay may be obtained also by coupling the inductances 35 and 37 by a suitable time delay circuit such as a short trans-
30 mission line 41, suitable stopping condensers 42 being connected in series with the line 41.

Although specific embodiments of this invention have been shown and described it will be understood, of course, that various modifications
35 may be made therein without departing from the scope and spirit of this invention as defined in the appended claims.

What is claimed is:

1. A wave generator comprising an electron discharge repeater device having input and output
40 electrodes, and a feed-back means coupling said output electrodes with said input electrodes, said means comprising, with the inherent impedances of said device, frequency determining means
45 whereby the frequency is so high that the electron transit time is finite and a material part

of the generated wave cycle and comprising also a transmission line for shifting the phase of the fed-back wave at the input electrodes to any desired degree dependent on the efficient operation
5 of the circuit as a whole without substantial effect on the characteristic generator frequency.

2. The generator specified in claim 1 in which said electron discharge repeater device is of the electron beam type.

3. A wave generator comprising in combination, an electron discharge device comprising a cathode, a pair of anodes, means including a control electrode for deflecting an electron beam alternately to said anodes, a circuit connecting
10 said anodes and said cathode, another circuit connecting said cathode and said control electrodes, and means comprising a transmission line coupling said circuits and adapted to determine the generated wave frequency, said frequency
15 being so high that the electron transit time is finite and a material part of the wave cycle, said transmission line being adapted for shifting the phase of the potentials appearing on said anodes relative to the potentials appearing on said control
20 electrode to an extent sufficient to compensate for the dephasing effect resulting from the finite electron transit time without substantial effect on the characteristic generator frequency.

4. A wave generator comprising in combination, an electron discharge device comprising a
30 cathode, a pair of anodes, means including a control electrode for deflecting an electron beam alternately to said anodes, a tuned circuit connecting said cathode and said anodes, a tuned circuit connecting said cathode and said control
35 electrode, each of said tuned circuits being tuned to the characteristic generator frequency, said frequency being so high that the electron transit time is finite and a material part of the generator wave cycle, and a transmission line coupling said
40 tuned circuits for shifting the phase of the potentials on said anodes relative to the potentials on said control electrode to an extent sufficient to compensate for the dephasing effect resulting from the finite electron transit time.

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