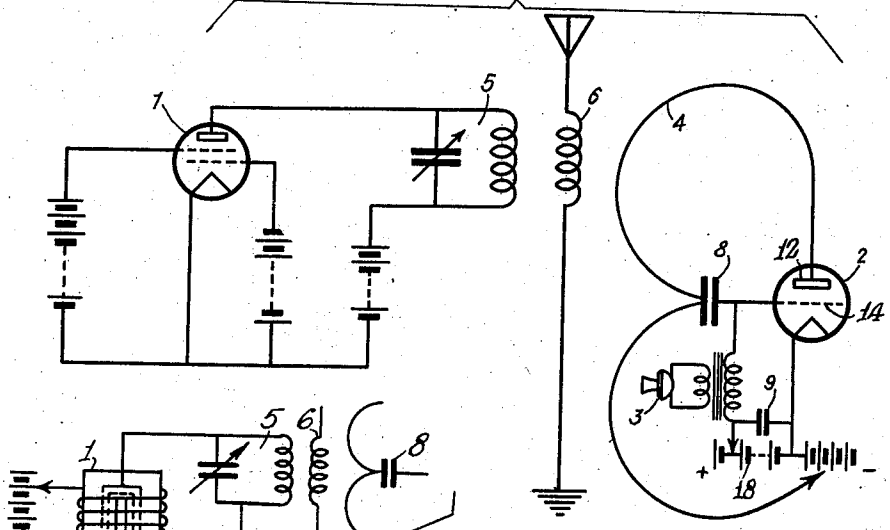
June 28, 1938. A. A. LINSELL 2,121,877

ULTRAHIGH FREQUENCY ELECTRON DISCHARGE MODULATOR

Filed Dec. 9, 1935

Fig. 1.



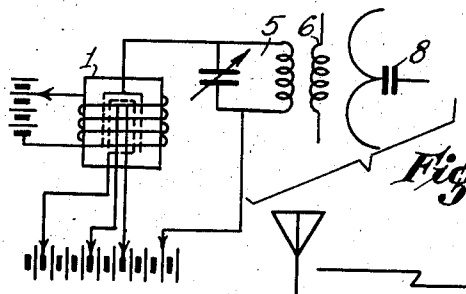


Fig. 1a.

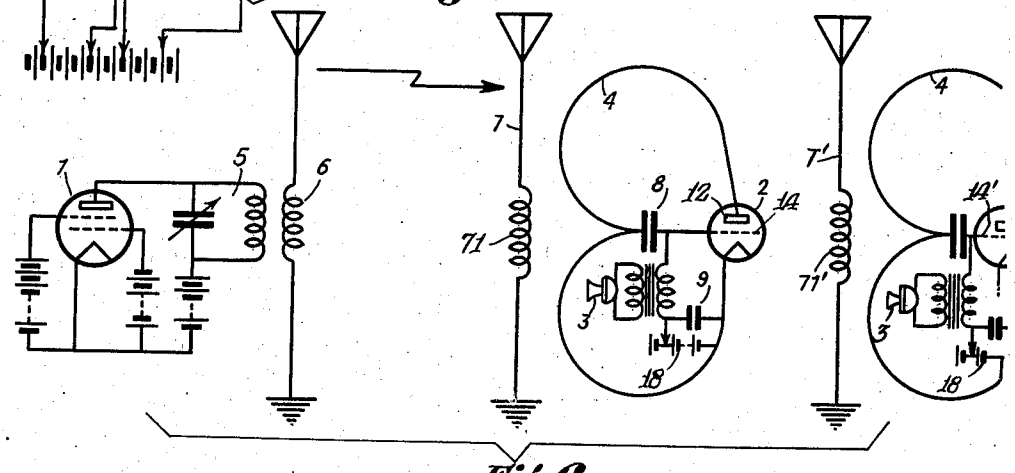
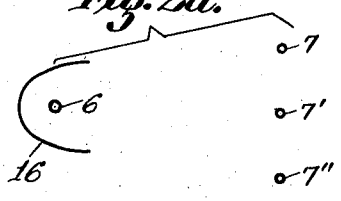


Fig. 2.

Fig. 2a.



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ULTRAHIGH FREQUENCY ELECTRON DISCHARGE MODULATOR

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5 Claims. (Cl. 250—6)

This invention relates to modulator arrangements for use at very high frequencies.

In order that the invention may be the better understood there will be first described certain phenomena which are believed to take place in a thermionic tube operated under suitable conditions. It is believed that these phenomena underlie the present invention and provide an explanation of the results thereof. It is, however, to be understood that the utility and advantages of the present invention are not dependent upon the sufficiency and accuracy or otherwise of the theoretical explanation now to be advanced.

Consider the case of a thermionic tube having a line filament, a cylindrical grid concentrically surrounding said filament and a cylindrical anode concentrically surrounding said grid and suppose the grid to be maintained at a positive voltage with respect to the filament and the anode at a slightly negative voltage with respect thereto, for example—2 volts. Electrons leaving the filament of this tube and moving towards the grid may over-shoot the grid before they are slowed down and reversed in direction and may again overshoot the grid in the other direction, and in this manner may oscillate backwards and forwards past the grid a number of times before they are finally caught thereon. To put the matter in another way, the electrons may oscillate backwards and forwards between the neighborhood of the filament and the neighborhood of the anode and experiments indicate that such oscillation has a natural time period which depends substantially solely upon the tube dimensions and upon the voltage applied to the grid. This type of oscillator is now well known as the Barkhausen-Kurz or Gill-Morell type. Now, if there be applied between the filament and the anode an alternating electro-motive force of small amplitude and of periodicity corresponding to the periodicity at which the electrons oscillate in the previously described action, the said oscillations will (for those electrons for which the phase of the applied electro-motive force is correct) become larger and larger in amplitude until some of the electrons reach the anode.

The above phenomena will be found described in detail in the specification of British Pat. #404,708, accepted Jan. 22, 1934, which specification describes an invention according to which detection is obtained by applying the wave to be detected between the anode and cathode of a thermionic tube and applying to the grid of said tube a critically selected positive potential of such magnitude that a correspondence exists between the periodicity of the energy to be detected and the natural periodicity of the electron oscillation about said grid.

In one circuit arrangement described in the specification of said British Pat. #404,708, the anode of a tube is connected through an aperiodic loop in series with a large blocking condenser to the grid which is in turn connected through a large blocking condenser to the cathode. Positive potential is applied to the grid relative to the cathode and a source of ultrashort wave energy is loosely coupled to the aperiodic loop, an indicating galvanometer being connected between the cathode and the side of the first mentioned blocking condenser remote from the grid. With this arrangement, the anode current (as measured by the galvanometer) varies substantially with variation of grid voltage the characteristic curve connecting these variables being a sharply peaked curve—like that of a tuned circuit—thus indicating that the periodicity of electron oscillation about the grid varies with applied grid potential.

The present invention utilizes the same general principles as were utilized in the invention contained in the British Pat. #404,708 and consists in employing what may be termed an "electron oscillator" to effect modulation. In carrying out this invention, modulating potentials are applied to vary the periodicity of the electron oscillation and the resultant varying frequency output is utilized to effect an ultrahigh frequency oscillator to cause modulation.

The invention is illustrated in the accompanying diagrammatic drawing, wherein Figs. 1, 1*a*, 2*a* and 2 illustrate diagrammatically two modifications of my invention, each of which include electron type oscillators and means for modulating the very high frequencies produced in a novel manner.

Referring to Figs. 1 and 1*a*, which show one way of carrying out this invention, an ultrahigh frequency oscillator 1 consisting, for example, of a magnetron tube oscillator as shown in Fig. 1*a* or as shown in Fig. 1, of a dynatron tube oscillator, has a frequency determining tuned circuit 5 the inductance of which is coupled to an inductance 6 in an aerial or other utilization circuit. Also coupled either to the inductance 6 in the aerial circuit or to the inductance in the tuned circuit 5 or to both, is an aperiodic loop 4, which is connected in series with a large blocking condenser 8 between the anode 12 and grid 14 of a tube 2 arranged in accordance with the principles above

outlined to produce electron oscillation about the grid 14. The grid of this tube is positively biased relative to the cathode by means of a suitable source of potential 18 connected in the cathode grid circuit, there being in series with this source, the secondary of a transformer to whose primary modulating potentials are applied, e. g. from a microphone 3 so that the total potential on the grid will vary with the modulating potentials. The fixed grid biasing source is shunted by a suitable blocking condenser 9 and a negative point on this source relative to the point at which the cathode is connected, is connected to the plate 12 which is connected to the grid through the blocking condenser 8. It will be seen accordingly that the natural periodicity of the electron oscillation about the grid of the modulator tube 2 will vary with the applied modulating potentials and by reason of the coupling of the aperiodic loop 4 there will be a consequent reaction upon the oscillatory circuit of the electron or other ultrahigh frequency oscillator 1 with consequent modulation of the energy radiated.

The invention may also be used in conjunction with the invention contained in the specification of Br. Pat. #413,646, accepted July 17, 1934, or in the specification accompanying my copending U. S. appln. Ser. No. 15,384, filed April 9, 1935, patented December 7, 1937, No. 2,101,440. In other words, in the former case the output from the ultrahigh frequency oscillator 1 providing the carrier energy which is to be modulated may be fed to a radiator and the output from what may be termed the "modulator oscillator" 2 may be fed to an auxiliary conductor associated with said radiator modulation resulting in the final outgoing radiation by reason of the relationship between the radiator and auxiliary conductor or reflector and in accordance with the principles set forth in the specification of said British Pat. #413,646.

Where the invention is used in conjunction with the invention contained in the specification accompanying my above mentioned patent, the output from the ultrahigh frequency oscillator may be fed to a radio beam generating arrangement 6 and 16 as shown in Figures 2 and 2*a* and a plurality of reflectors or conductors 7, 7', and 7'' which may be graded in effectiveness, are positioned in the path of said beam so as to alter the convergence or divergence of the said beam in accordance with the principles set forth in the copending specification in question, the outputs from a plurality of "modulator oscillators" comprising elements 2, 3, 4, 8, 9, etc., as herein described being coupled to the reflectors or conductors 7, 7', and 7''. In the installation of this nature illustrated in Figs. 2 and 2*a*, the ultrahigh frequency oscillator 1 is coupled at 5, 6 to a radiator as described in the embodiment of Fig. 1, the radiator with the beam reflector 16 forming part of an installation for radiating an ultrashort wave beam. In the path of this beam is interposed a plurality of conductors or reflectors, there being two such conductors 7, 7' shown in Fig. 2 and three such conductors 7, 7', and 7'' shown in Fig. 2*a*. Conductors 7, 7', etc., are connected as shown with interposed inductances 71, 71', etc., respectively, there being coupled to each of said inductances an aperiodic loop 4 of a "modulator oscillator" 2 as hereinbefore described and illustrated. The oscillators 2 are modulated by potentials from source 3.

In the claims which follow, the expression "electron oscillator" is employed to mean oscillators (of which the Barkhausen-Kurz and Gill-Morell and the magnetron types are examples) wherein the oscillations generated are due to electron oscillations, as distinct from what may be termed "feed back oscillators" wherein the oscillations are due to energy feed back from an output circuit to an input circuit. The energy feed back type of oscillator, of course, depends for its action upon controlling potentials fed to a controlling electrode, usually a grid. An electron oscillator, however, does not depend for its action upon this but, as stated, directly upon oscillations of electrons.

What is claimed is:

1. In combination a very high frequency oscillator, a radiator coupled thereto, and modulating means therefor, a conductor in the path of radiation from said radiator, said modulating means comprising an electron oscillator having an output circuit, means for applying modulating potentials to vary the periodicity of said electron oscillator, and means for coupling the output circuit of said electron oscillator to said conductor in the path of radiation from the radiator coupled with the very high frequency oscillator whereby modulation of the final outgoing radiation from the combination of radiator and reflector is obtained.

2. In combination, an ultrahigh frequency oscillator, a beam radiator coupled to said oscillator, a conductive member in the path of radiation of said beam radiator and modulating means comprising an electron oscillator including a tube having its electrodes coupled in high frequency oscillatory circuits including an output circuit, means for coupling said output circuit to said conductive member in the path of said beam from said beam radiator and means for modulating the potential on an electrode in said electron oscillator to thereby modulate the periodicity of oscillation thereof and the radiation from said beam radiator.

3. In a signalling system, a high frequency radiator and means for energizing the same by high frequency oscillations, a conductive member in the path of radiation of said radiator, an electron discharge device having an anode, a control electrode and a cathode, alternating current circuits inter-coupling said anode, said control electrode and said cathode, means for applying a positive potential to the control electrode of said tube and a negative potential to the anode of said tube whereby electrons oscillate between the anode and cathode of said tube and in said circuits, a coupling between said circuits and conductive member, and means for modulating the potential on the control electrode of said device in accordance with signals.

4. In a signalling system, a beam radiator and means for setting up high frequency oscillations therein, a plurality of conducting members in the path of radiation from said beam radiator and a controlled oscillator coupled to each conducting member, each controlled oscillator comprising an electron discharge device having an anode, a cathode, and a control electrode, means for applying positive potential to said control electrodes with respect to said cathodes, and a potential of lesser value to said anodes with respect to said cathodes whereby the electrons emitted by said cathode oscillate between said anodes and cathodes, and means for applying modulating potentials to said control electrodes.

5. In a signalling system, an ultrahigh fre-

quency radiator, an ultrahigh frequency oscillator coupled to said radiator to produce radiation of ultrahigh frequency energy therefrom and means for modulating said ultrahigh frequency oscillations comprising an electron discharge device having an anode, a cathode and a control grid, a loop circuit including a blocking condenser in series between said anode and control grid, a second loop circuit including said blocking condenser in series between said control grid and cathode, means for applying a positive potential to said control electrode and a lesser potential to said anode, means for applying modulating potentials between said control grid and said cathode, and a coupling between one of said loop circuits and said radiator.

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