

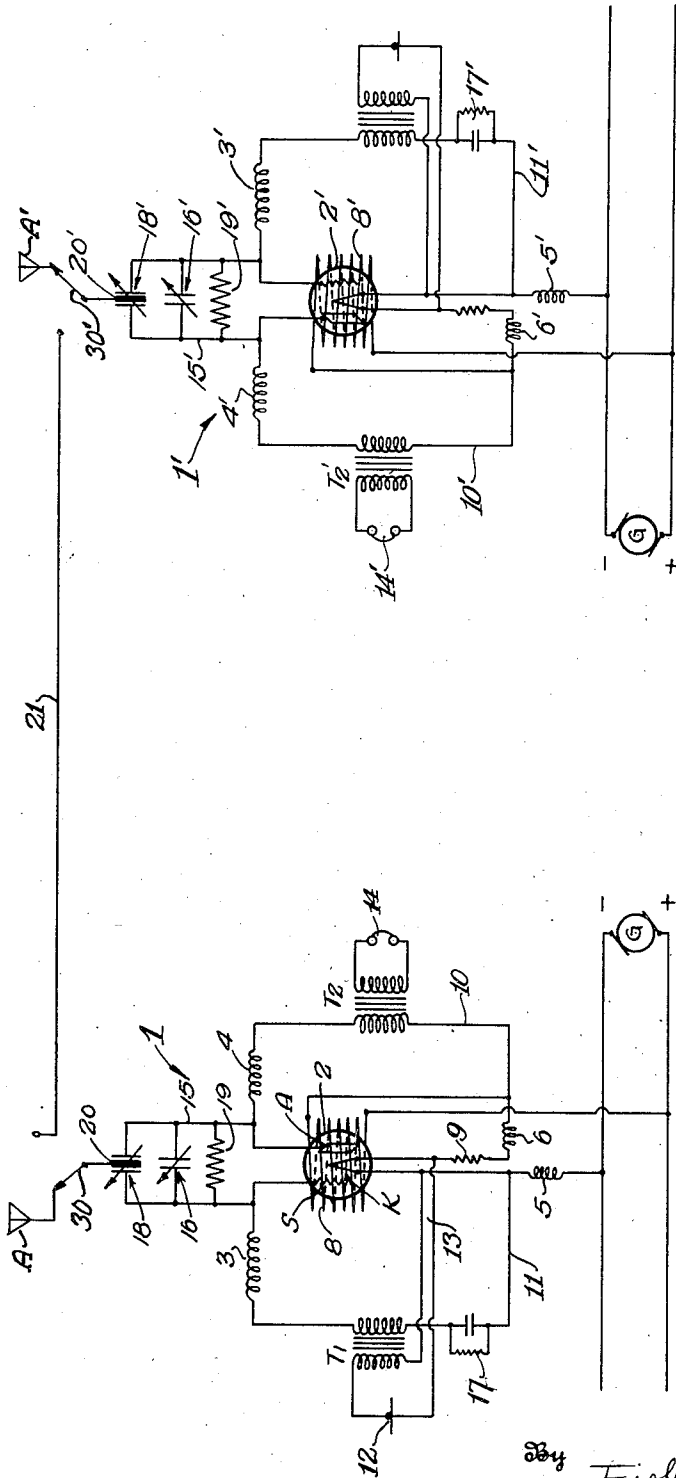
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RADIOCOMMUNICATION

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RADIOCOMMUNICATION

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This invention relates to apparatus for the generation of sustained oscillations of extremely high frequencies, corresponding to periodicities of the order of thirty to one hundred thousand kilocycles or more; and to the utilization of such apparatus for purposes of "short wave" communication by radio or over electrical conductors.

5 An object of the invention is to provide a tuned thermionic oscillation generator operable at the frequencies specified, characterized in that the periodicity of oscillation may be predetermined and controlled in substantial independence of the electrical circuits requisite for energization of the thermionic element, or for the radiation of the generated high frequency energy.

10 A further object of the invention is to provide a tuned ultra-high frequency generator, employing standard parts, the operation of which may, from time to time, be duplicated, either with the same apparatus, or with similar apparatus constructed in accordance with manufacturing tolerances common to the type of equipment employed.

15 Another object of the invention is to provide a system of short wave communication between two or more stations, each radiating continuously at a common extremely high carrier frequency, the several stations being so arranged that two-way intercommunication may be carried on continuously between stations at the common carrier frequency and at energy levels exceeding those heretofore obtainable at the wave lengths in question.

20 Although various systems are known for the generation of electrical oscillations within the short wave range contemplated by this invention, all such proposals are variously objectionable, (1) as failing to sustain oscillations at appreciable power outputs for wave lengths down to a fraction of a meter, (2) as being generally seriously limited as to the available power output, (3) as being unstable and unreliable in operation, (4) as providing oscillatory energy the frequency of which, particularly the upper limiting frequency, is largely determined by the constants of the electrical apparatus employed, such as the thermionic device and the requisite associated circuit elements, and therefore as not depending for operation upon criteria by which the periodicity may be predetermined, controlled and duplicated in substantial independence of unavoidable variations in such constants, and (5) as not being adapted to tuning whereby the periodicity may be arbitrarily adjusted at will throughout a range in frequency.

In contrast to these defects the present invention provides an oscillation generator which inherently provides a relatively large available power output adjustable at will both in amplitude and in frequency. By associating wave radiating, signal modulating and detecting means with a plurality of oscillation generators, in accordance with the present invention, remotely located for purposes of communication, and by causing the several resulting stations to generate high frequency oscillations and so react upon each other as to remain in exact syntony, a system of standing waves in space may be established between stations, which is a measure of the potential or stored-up high frequency energy of the several stations, available at each station for purposes of signal transmission and reception.

5 As a result of these standing waves each station reacts upon every other station, and the high frequency energy generated at a given station may thus be made available at all other stations for amplifying the signal. Apparently at any given station of a system in accordance with the present invention, the amplitude of the carrier frequency generated thereat is enhanced to the extent of the aggregate amplitudes of the several carrier waves emanating from the other stations which are picked up by the local antenna. Accordingly, modulation of this resultant amplitude in transmitting produces a greater modulated carrier wave signal output than would be obtained in the absence of these received energies. Likewise in receiving, the amplitude of carrier oscillation is similarly enhanced, and the detected wave correspondingly amplified.

10 The manner in which the present invention achieves the novel results above pointed out is best explained by reference to the single figure of the drawing wherein there is shown diagrammatically a pair of high frequency units in accordance with the present invention, each unit embodying an oscillation generator together with the requisite signal transmitting, receiving and modulating apparatus for effecting two-way intercommunication between units.

15 Referring to station 1 shown at the left in the figure, the circuit employs a vacuum tube 2 having an anode A, a filament or cathode K and a control grid S. Tube 2 is energized from a direct current source G, the negative terminal of which is connected through a high frequency blocking impedance 5 to one side of the cathode K. The positive terminal of source 7 is connected through a magnetron coil 8 surrounding tube 2, to the other side of the cathode through blocking im-

pedance 6 and resistance 9; and also over conductor 10 to the anode A. The potential drop across resistance 9 applies the necessary positive operating potential to the anode A of the tube.

5 The grid S is connected over conductor 11 to the negative side of the cathode. A signal modulating device 12, such as a microphone transmitter, energized over conductors 13 by the potential drop across the cathode K, is coupled through transformer T₁ to the grid conductor, for purposes of modulating the high frequency carrier in accordance with signaling currents. Similarly a receiving element 14, such as a pair of headphones, is coupled to the anode conductor 10 through transformer T₂ for indicating the rectified component of the modulated carrier wave, detection of which is effected through the action of the grid leak 17 included in the grid conductor 11.

20 High frequency blocking impedances 3 and 4 are included in the grid conductor 11 and the anode conductor 10, respectively, for restricting the high frequency oscillatory currents within their proper paths as will now be explained.

25 The portion of the system responsible for the periodicity of the generated high frequency oscillations comprises, reduced to its essentials, circuit 15 consisting of the effective capacity C₁ of the extremely small variable condensers 16 and 18 connected in parallel by short leads directly between grid S and anode A of tube 2, together with the connecting leads and the resultant capacity C₂ of the interelectrode capacities of the tube which are effective between grid and anode electrodes. The periodicity *f* of this circuit is determined by its effective series capacity C and inductance L, substantially in accordance with the formula:

$$40 \quad (1) \quad f = \frac{1}{2\pi\sqrt{LC}}$$

The inductance L is that of the closed loop 15, which is of extremely small physical dimensions. The capacity C which is the effective capacity of condensers C₁ and C₂ in series is given by the formula:

$$45 \quad (2) \quad C = \frac{C_1 C_2}{C_1 + C_2}$$

50 It is apparent from Formula (2) that the effective capacity C can never exceed the grid-to-anode capacity C₂, no matter how large the tuning condenser C₁ may be made. It is likewise apparent from Formula (2) that if the variable condenser C₂ is made small in comparison with the grid-to-anode capacity C₂, say of the order of one-tenth C₁ or less, then the effective capacity C will become substantially equal to C₁.

55 The significance of this is that if the magnitude of condenser C₁ is made comparable to or smaller than that of C₂, the former will have a controlling influence on the periodicity of oscillation in loop 15. By making C₁ variable as shown in the drawing, the periodicity of oscillation may be adjusted throughout a relatively wide continuous frequency range of the order of 100,000 kilocycles. As a result of frequency adjustment thus provided, tubes of standard construction, the electrical constants of which vary from tube to tube in accordance with the usual manufacturing tolerances, may be utilized in the circuit without necessitating a departure from the frequency at which it is desired to operate.

60 The extremely short wave lengths to which the circuit of the present invention may be adjusted, result from the facts that the inductance

L is inherently extremely small, whereas the effective capacity C, is, for reasons stated, reduced below that of the tube interelectrode capacities. The circuit of the present invention has in fact been utilized for the production of sustained oscillations corresponding to wave lengths down to a small fraction of a meter.

65 It is well known that a necessary condition generally for the maintenance of sustained oscillations in a vacuum tube circuit, is that the oscillatory circuit must be so coupled to the tube that oscillations in the circuit will cause the grid and anode of the tube to assume opposite instantaneous polarities with respect to the filament or cathode. With the circuit of the present invention wherein the oscillatory circuit 15 is coupled to the tube through the grid-anode impedance, it will be seen that this condition is necessarily satisfied provided at the frequency of oscillation the effective impedance between 20 grid and cathode, is of the same character, i. e. has the same reactance sign, as the effective impedance between cathode and anode. If the one impedance is capacitive the other must likewise be capacitive.

25 A second condition requisite to the maintenance of sustained oscillations is that tube 2, arranged in circuit as shown, must be capable of providing an impedance as measured between the grid and anode electrodes which contains a negative resistance component at least as great as the effective energy absorbing resistance of the oscillatory circuit. If this condition is satisfied, the oscillations will increase in amplitude until the negative resistance between grid and anode electrodes of the tube becomes equal in magnitude to the energy absorbing resistance of the oscillatory circuit. This variation in negative resistance component of the tube with amplitude in oscillation occurs by reason of the curvature in the grid voltage-plate current characteristic of the tube, i. e. its mutual conductance, whereby the system automatically adjusts itself to stability of oscillation both in amplitude and in frequency.

45 It has been observed that inclusion of resistance 19 in the circuit renders the generation of oscillations extremely stable in both amplitude and frequency. This suggests the possibility that at the extremely high frequencies in question resistance 19 may partake of the nature of a crystallographic control. Although it is impossible to settle this point definitely in the absence of suitable measuring apparatus operable at the frequencies in question, some support for this view results from the high value of resistance 19 employed. It is well known in this connection that extremely high resistance units evidence peculiarities of operation not noticeable in resistance elements of low magnitude.

60 In order to supplement the oscillatory action due to the direct impedance coupling provided by the grid-to-anode capacity between loop 15 and vacuum tube 2, a magnetron coil 8 may be included in the anode circuit as shown in the drawing.

65 A convenient method for withdrawing oscillatory energy from or impressing oscillatory energy upon loop 15 is provided by the triplate condenser 18, of extremely small capacity, comparable to that of condenser 16. The external plates of condenser 18 are connected directly to the grid and anode respectively of tube 2. The intermediate plate 20 of condenser 18 may be connected by operation of a switch 30 to a con- 75

ductor 21 which extends to the corresponding switch 30' for connecting conductor 21 to plate 20' of the analogous system 1' at the right of the figure for purposes of intercommunication.

Or plate 20 may be extended directly to an antenna by alternative operation of switch S, in which event system 1' would be connected by means of switch S with a similar antenna A'. The external plates of condenser 18 are relatively adjustable for the purpose of adjusting the constants of the oscillatory circuit.

The intermediate plate 20 of condenser 18 serves the purpose of impressing upon the conductor 21, or an antenna, a desired fraction of the total available output energy of loop 15.

With the foregoing analysis in mind, operation of the system to transmit and receive signals may be briefly explained. Modulating frequencies originating in device 12 are impressed upon the grid electrode S through transformer T₁, causing thereby the amplitude of high frequency oscillations existing in loop 15 to vary in accordance with the modulating frequencies. The resulting modulated carrier wave is propagated to system 1' where it is impressed through condenser 18' upon circuit 15' in which oscillations are continuously generated and sustained by tube 2' at the carrier frequency. Due to the presence of the grid leak 17', there results a demodulation of the resulting frequencies impressed upon tube 2', as a consequence of which the signaling frequency flows in the anode conductor 19' and is thereby impressed through transformer T₂, upon the headphones 14'.

Referring to the drawing, an analysis of the circuit will show that the high frequency energy generated at station 1' in circuit 15', is propagated to and impressed directly upon the analogous circuit 15 at station 1, likewise generating high frequency oscillations. In the same way high frequency energy generated in circuit 15 is propagated to and impressed upon circuit 15'. In this way the thermionic oscillation generators at stations 1 and 1' react upon one another through the intervening wave propagating media. Due to the non-linear operating characteristics inherent in the thermionic elements 2 and 2', the oscillation generators will, in a manner known, fall into step at a common carrier frequency provided they are adjusted to oscillate sufficiently close to the common frequency independently of one another.

It appears probable that the resistances 19 and 19' assist in this "falling into step", since it has been observed that their presence facilitates tuning remote stations to the common carrier frequency and in the maintenance of sustained oscillations at that frequency.

Due to the fact that each station generates and radiates, in the manner explained, at a common carrier frequency, a system of standing waves in space will necessarily be produced between stations, resulting from the superposition of waves oppositely propagated at a constant velocity. The high frequency energy available at each station for purposes of signal propagation is thus enhanced to the extent of that received thereat from each of the remotely located stations.

The multiple amplification thus imparted to the received signal by operation in accordance with the principles of the invention as outlined is of extreme importance in the field of short wave communication, due (1) to the limited power output which short wave oscillators generally are

capable of providing, and (2) to the fact that no means are at present known capable of providing straight amplification at the frequencies or wavelengths under consideration.

I claim as my invention:

1. An oscillation generator comprising a condenser connected between grid and anode electrodes of a thermionic tube forming thereby in conjunction with the inherent inter-electrode tube capacities, an oscillatory circuit the natural periodicity of which is regulated by said condenser, and means connecting said anode and grid to the cathode of said tube for producing sustained oscillations in said circuit, said anode connection including a magnetron coil.

2. A short wave combined radio transmitter and receiver comprising a triplate condenser, the several plates of which are relatively adjustable for varying the capacities therebetween, conductors extending from the external plates of said condenser to the grid and anode electrodes respectively, of a thermionic tube forming thereby in conjunction with the inherent inter-electrode tube capacities, an oscillatory circuit the periodicity of which is regulated by said condenser, connections from grid and anode respectively, to the cathode of said tube for causing sustained oscillations in said circuit of the periodicity thereof, signal transmitting and receiving means interposed in said connections respectively, and wave radiating means connected to the intermediate plate in said condenser.

3. A short wave radio transmitter and receiver comprising a condenser connected between grid and anode electrodes of a thermionic tube forming thereby in conjunction with the inherent interelectrode tube capacities, an oscillatory circuit the periodicity of which is regulated by said condenser, means connecting said grid and anode to the cathode of said tube for producing sustained oscillations in said circuit, said anode connection including a magnetron coil signal transmitting and receiving means interposed in said connections respectively, and wave radiating means coupled to said oscillatory circuit.

4. A short wave radio transmitter and receiver comprising, a triplate condenser, the several plates of which are relatively adjustable for varying the capacities therebetween, means connecting the external plates of said condenser respectively to the grid and anode electrodes respectively, of a thermionic tube, a second variable condenser connected between said grid and anode electrodes, said condensers and connections, together with the inherent interelectrode tube capacities forming an oscillatory circuit the periodicity of which is regulated by said condensers, connections from said grid and anode respectively, to the cathode of said tube adapted to cause sustained oscillations in said circuit, signal transmitting and receiving means interposed in said connections respectively, and wave radiating means connected to the intermediate plate of said triplate condenser.

5. Short wave generating and signalling apparatus comprising, a thermionic tube having an anode, a cathode and a grid, a connection between anode and grid, adjustable capacity serially interposed in said connection forming together with the interelectrode capacities of said tube an oscillatory circuit the periodicity of which is regulated by said adjustable capacity, connections from said anode and grid respectively to said cathode, choke coils interposed in said connections adjacent said anode and grid, signal

modulating and grid biasing means interposed in said grid connection, signal indicating means interposed in said anode connection, and wave radiating means capacitively coupled to said adjustable capacity.

- 5 6. Short wave generating and signalling apparatus comprising, a thermionic tube having an anode, a cathode and a grid, a connection between anode and grid, capacity, including a tri-plate condenser having its external plates connected to said anode and grid, serially interposed in said connection forming together with the interelectrode capacities of said tube an oscillatory circuit, wave radiating means connected to the intermediate plate of said tri-plate condenser, connections from said anode and grid respectively, to said cathode, choke coils interposed in said connections adjacent said anode and grid, signal modulating and grid biasing means interposed in said grid connection, and signal indicating means interposed in said anode connection.

7. Short wave generating and signalling apparatus comprising, a thermionic tube having an anode, a cathode and a grid, a tri-plate condenser having its external plates connected to

said anode and grid respectively, and its intermediate plate connected to wave radiating means, a resistance in shunt to said tri-plate condenser between said anode and grid, connections from said anode and grid respectively to said cathode, choke coils interposed in said connections adjacent said anode and grid, signal modulating and grid biasing means interposed in said grid connection, and signal indicating means interposed in said anode connection.

8. Short wave generating and signalling apparatus comprising, a thermionic tube having an anode, a cathode and a grid, a tri-plate condenser having its external plates connected to said anode and grid respectively, and its intermediate plate connected to wave radiating means, a second condenser in parallel with resistance connected between said anode and grid, connections from said grid and anode respectively to said cathode, choke coils interposed in said connections adjacent the anode and grid respectively, signal modulating and grid biasing means interposed in said grid connection, and signal indicating means interposed in said anode connection.

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