Jan. 1, 1935. C. W. HANSELL 1,985,924

TRANSMITTER

Filed Jan. 31, 1930 2 Sheets-Sheet 1

Fig. 1

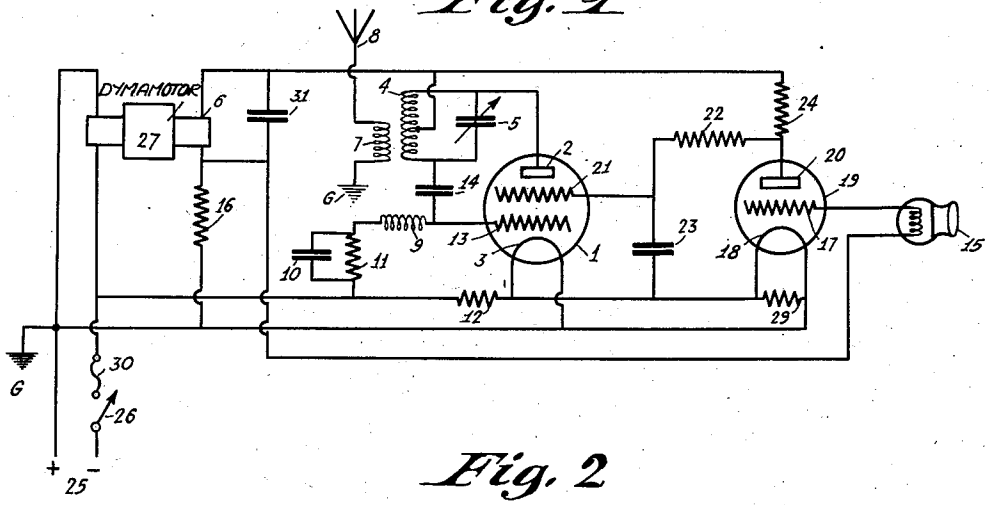
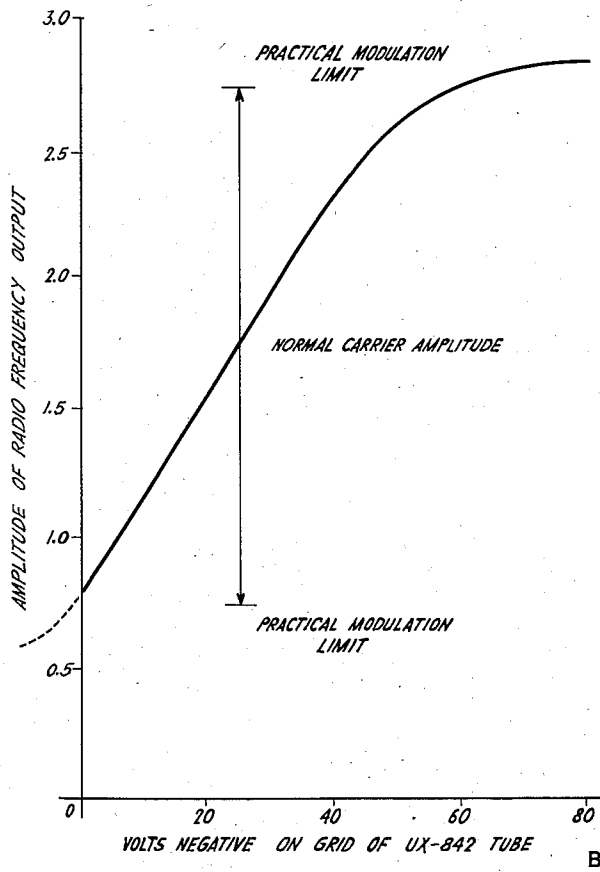


Fig. 2



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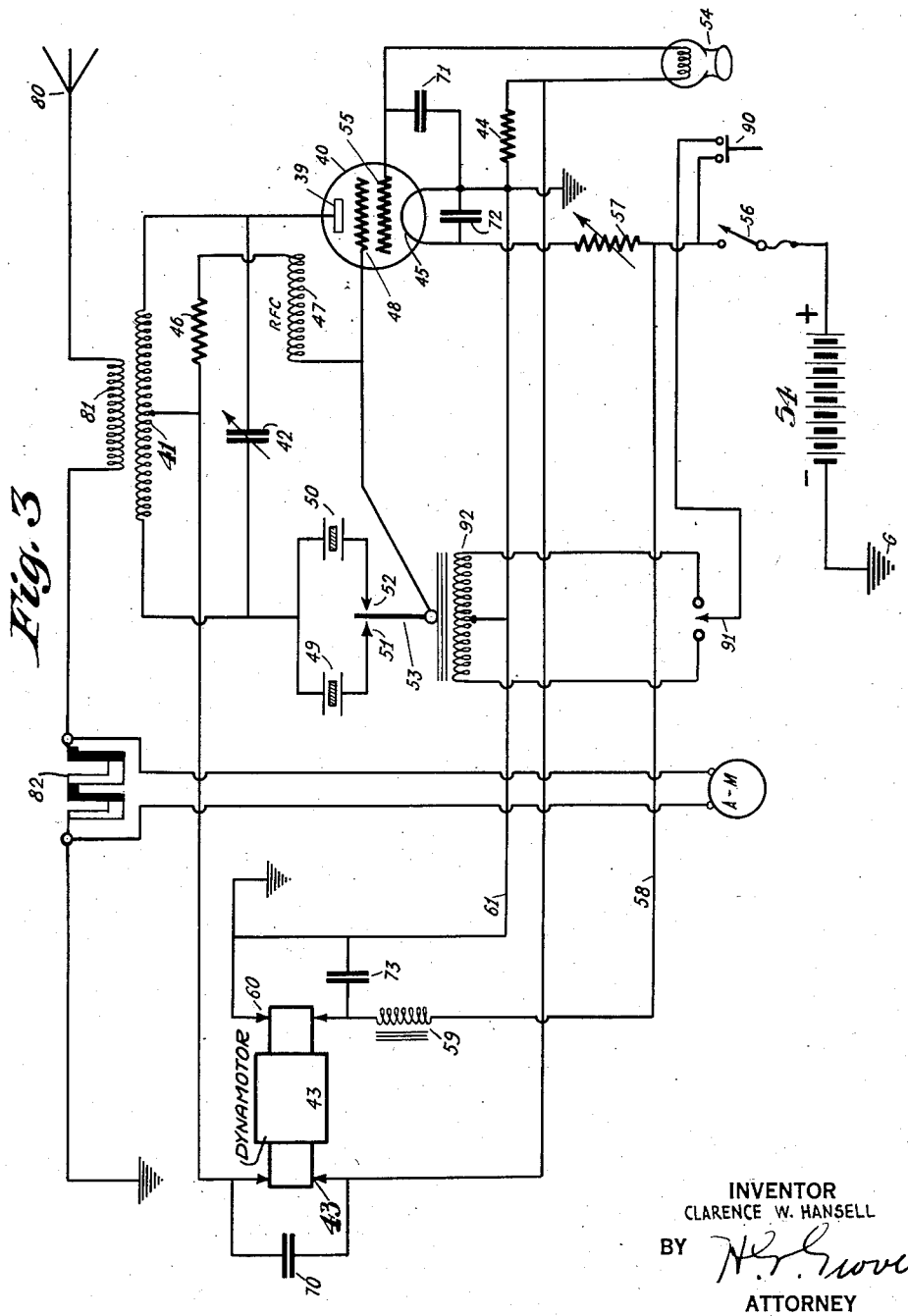


Fig. 3

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UNITED STATES PATENT OFFICE

1,985,924

TRANSMITTER

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8 Claims. (Cl. 250—17)

This invention relates to transmitting apparatus and more particularly to transmitting apparatus in which oscillations at carrier frequency are amplified, modulated in accordance with the wave form of the low frequency signal to be transmitted, and then supplied to an antenna system from which they are radiated.

The general methods of modulation known heretofore are first, grid modulation, that is, modulation of the carrier frequency energy by impressing oscillations at signal frequency on the grid circuit of the oscillation generator, and second, plate modulation of the carrier frequency energy, that is, impressing potentials on the anode of the oscillation generator which vary in or approximately in proportion to the signal oscillations. The first method has for various reasons well known in the art been practically displaced by the last method.

The last mentioned method while in general use at the present time has various disadvantages. One of these is the large amount of power capacity necessary in the modulator tubes to obtain modulation by this method. For good quality it is usually necessary to use more tubes of a given size in the final stage of the modulation frequency amplifier than in the radio frequency amplifier. This necessitates the use of a number of tubes and consequently increases the amount of apparatus necessary to energize the tubes. This in itself is an undesirable feature in all cases and more so where the transmitter is to be used for aircraft work. In aircraft work one of the main requirements is apparatus of small bulk and light weight.

Briefly and broadly the primary object of this invention is to provide a transmitter which includes an oscillation generator, a novel amplifier and a novel and efficient means of modulating the carrier frequency in the amplifier in accordance with the signal frequency.

Another object of my invention is to provide such a device in which the radio frequency output current of the amplifier tube is as nearly as possible linear with respect to the modulation voltage.

An added object of my invention is to provide a transmitter, simple in nature, light in weight and efficient in operation.

A further object of my invention is to provide a thermionic generator which dispenses with many of the heretofore necessary choke coils and transformers used in the modulator circuits.

Another object of my invention is to provide devices of the above nature which will maintain a frequency constant enough for most purposes, but which may be readily adapted to use with a master oscillator or a crystal control or both.

Another object of this invention is to provide a transmitter of the nature designated above in which a single thermionic tube of the screen grid or four element type serves as an oscillation generator, an amplifier, and a modulator. The modulation frequency is impressed on the carrier wave generated and amplified by means of a thermionic tube having its anode circuit associated with the screen grid of the four element oscillator tube. Thus two tubes are all that are required in a transmitter constructed in accordance with my invention.

An added object of this invention is to provide a thermionic generator which requires but a single thermionic tube of the four-electrode type to produce, modulate and amplify the oscillations necessary in aircraft work.

A further object of my invention is to provide an oscillating amplifier of the above described type in which the anode circuit is of a nature to obtain the high amplification possible from a screen grid tube.

I have found that by modulating through the screen grid of a thermionic tube of the screen grid type, as set forth in detail hereinafter, considerably less modulating power capacity is required and only one source of anode voltage is required. Modulating the carrier frequency in this manner therefore reduces the number of tubes necessary and requires a single source of anode voltage. This consequently reduces the apparatus necessary. This in turn reduces the total weight of the transmitter, which is of extreme importance where, as pointed out above, the transmitter is to be used on aircraft.

Briefly the above objects are attained in accordance with one form of the present invention by the use of a novel transmitter in which a single screen grid tube serves the purpose of an oscillator, an amplifier and a modulator tube. The modulation frequencies may be impressed on the screen grid of this tube through a resistance coupled amplifier stage the input circuit of which is connected to a source of modulation energy.

This oscillator may be used as described above, or if conditions require, may be controlled as to frequency by a master oscillator or a piezo-electric crystal.

As will be obvious a considerable reduction in weight of apparatus is obtained by the use of a transmitter constructed as above since no modulation choke coils with their heavy cores are nec-

essary, a single tube operates as an oscillator amplifier and modulator and a single small tube fed by a telephone transmitter furnishes the modulating frequencies.

In the ordinary plate modulated radio telephone circuit the anode losses in the oscillator tube are highest when the losses in the modulator tubes are lowest and they are lowest when the modulator tube losses are highest. Therefore, by combining the two functions in a single tube we obtain more uniform anode losses in the tube throughout a cycle of modulation and do not increase the maximum losses very much above the value which would be reached if the tube were used as an oscillator or modulator alone.

In another form of my invention the use of the modulation frequency amplifier is done away with by connecting a high voltage microphone directly between the control grid and cathode of the four electrode tube which serves the purpose of oscillation generator, amplifier and modulator. In this form of the invention the frequency of the oscillation generator is controlled by means of the selected one of a plurality of calibrated piezo crystals. In this modification anode potential is supplied by means of an air-driven dynamotor while filament heating current is supplied by means of the battery used to energize the lighting circuits of the plane.

In this modification, by means of a novel switching arrangement, two frequencies can be used, one of which is used for calling and the other of which is used for working the station called. This is practical where the calling and working frequencies are not too widely separated. For convenience of operation a "start-stop" switch, a "wave-change" switch, a "send-receive" switch, a microphone and an antenna meter are located within easy access of the person or persons operating the transmitter. In actual practice I propose to locate the send-receive switch on the microphone and the other switches and the meter in some convenient place in the cockpit so that the radio apparatus as well as the plane may be operated by the pilot. In each of the above modifications the oscillations are fed from a tank circuit connected to the anode of the screen grid oscillating amplifier into the antenna system from which they are radiated.

A more complete understanding of my invention and its advantages will be had from the following detailed description thereof and from said description when read in connection with the drawings through which like reference numerals indicate like parts; and in which,

Figure 1 shows a novel transmitter which uses a single four-electrode oscillation generator, modulated through a single three-electrode tube;

Figure 2 is a typical characteristic curve showing the relation between the amplitude of the radio frequency output of the oscillator used in the apparatus shown in Figure 1 plotted against the voltage applied to the grid of the tube applying the modulation frequency to the oscillator; and,

Figure 3 shows a novel arrangement which uses but a single tube.

Referring to the drawings and in particular to Figure 1 thereof 1 indicates a four-electrode tube which generates in a well known manner oscillations at a frequency determined by the constants of the oscillation circuit connected between the anode 2 and cathode 3 of tube 1. This circuit includes the tank circuit composed of an inductance 4 and variable condenser 5 connected in parallel through the high voltage winding 6 of a direct current generator 27 between the anode and cathode electrodes of 1. The tank circuit inductance 4 connected between the output elements of thermionic tube 1 is coupled to an inductance 7 in series with the antenna circuit 8 G.

The grid circuit of 1 consists of a radio frequency choke coil 9 in series with condenser 10 shunted by high resistance 11 and connected through biasing resistance 12 between the grid 13 and cathode 3 of thermionic tube 1. To insure sustained oscillation of tube 1 a coupling condenser 14 is connected between grid 13 and one end of inductance 4 as shown in Figure 1.

Modulating frequencies are provided by means of a microphone 15 connected in series with biasing resistance 16 between the control electrode 17 and cathode 18 of modulation frequency amplifier 19. The modulation frequency repeated and amplified in thermionic tube 19 and appearing on the anode 20 thereof is impressed on the screen grid electrode 21 of thermionic tube 1 through a resistance 22. To prevent oscillations at radio frequencies appearing on the screen grid 21 of thermionic tube 1 from being introduced into modulation amplifier 19 a by-pass condenser 23 is connected between screen grid 21 and the cathode circuit of thermionic tube 1. Anode space current in thermionic tube 19 is obtained from high voltage winding 6 of dynamotor through a charging resistance 24. Heating current for the filaments of thermionic tubes 1 and 19 is provided directly from the direct current source 25 when the switch 26 is closed. Source 25 also provides current for operating the dynamotor 27. To lower the voltage applied to the filament of tube 19 which may require less voltage than tube 1 and to protect the filament of tube 19 a resistance 29 is shunted across the filament terminals of tube 19. For further protection of the entire low voltage circuit a fuse 30 is connected in series with one side of filament heating current circuit. Radio frequency currents are shunted around the high voltage winding 6 of dynamotor 27 by means of a by-pass condenser 31 in parallel with said winding.

In operation when the switch 26 is closed the windings of dynamotor 27 are energized thereby setting the dynamotor in operation. Simultaneously the filaments of tubes 1 and 19 are energized and high potential voltage is supplied to the anodes of tubes 1 and 19 from the high voltage winding 6 while resistance 16 and 12 insure that the proper biasing potentials are applied to the control grid electrodes of 1 and 19. Due to the coupling between the anode and cathode circuits of oscillation generator 1 oscillations are produced at a frequency determined by tank circuit 4, 5. These oscillations are modulated in accordance with voice frequencies impressed by means of microphone 15 on the input elements of amplifier 19. The carrier frequency modulated in accordance with said voice frequencies is set up in antenna circuits 8, 7, G from which it is radiated.

By the use of a standard tube of low impedance sufficient modulation for practical purposes may be obtained. This will be seen from Figure 2 which is a curve showing the relation between the amplitude of radio frequency output, that is, the amplitude of the oscillations in the antenna circuit with reference to the negative voltage applied by means of the potential drop across resistance 16 to the control electrode of 19.

In Figure 3 is shown an arrangement whereby the need of a modulator amplifier tube is eliminated. This is attained by interchanging the use of the screen grid and control grid of the four electrode tube, as will be more fully pointed out hereinafter.

Referring in particular to Fig. 3, 40 is a thermionic tube which not only generates the carrier frequency but also is associated with means whereby the carrier frequency generated is modulated in said tube. In this modification the alternating current plate circuit includes a tank circuit comprising an inductance 41 tuned by a variable capacity 42. Anode potential is provided by connecting the mid tap of inductance 41 through the high voltage winding 43 of dynamotor 43 and resistance 44 to the negative terminal of the filament 45. Potential is applied to the grid electrode 48 by connecting said electrode to the high voltage winding 43 through a charging resistance 46. Radio frequencies are prevented from entering the winding 43 by inserting a radio frequency choke 47 in said last named connection. Oscillations in the alternating current anode circuit or tank circuit are insured by a circuit including one or the other of a pair of piezo electric crystals 49, 50 arranged to connect the free end of winding 41 to the grid electrode 48. The frequency of said oscillations is determined by one or the other of said pair of crystals 49 and 50 arranged through contacts 51 and 52 and armature 53 to be connected in series between the last named grid and the free end of inductance 41. The dielectric capacity of each crystal should balance the capacity of the tube to prevent undesired oscillations or parasitics to be set up in the circuits.

The oscillations generated in thermionic tube 40 are also modulated therein. This is accomplished by connecting a high voltage microphone 54 in series with the impedance between grid electrode 55 and filament 45 through resistance 44 which serves to apply the proper biasing potential to electrode 55. Any radio frequency currents appearing in this circuit are shunted around the high voltage winding by means of a bi-pass condenser 71.

Current for heating the filament 45 of thermionic tube 40 is obtained from the lighting battery 54 when the switch 56 is closed thereby completing the circuit from the battery, through the filament to ground. The voltage applied across said filament is regulated by a variable resistance 57.

When the switch 56 is closed, current from the battery also flows from battery 54 through switch 56, conductor 58 and audio frequency choke coil 59 to the motor of dynamotor 43 energizing winding 60 of dynamotor 43 thereby putting the dynamotor in operation and generating the high voltage direct current in winding 42 which is applied to the anode and control electrodes of 40. Radio frequency disturbances are eliminated from the high voltage winding of the generator, the high voltage winding of the microphone and from the battery 54 by means of condensers 70, 71 and 72 respectively while condenser 73 and choke coil 59 prevents modulation from the commutator of the dynamotor 43 returning to the battery and the vacuum tube circuits. An antenna circuit comprising an antenna 80 is coupled by means of winding 81 in series therewith to the inductance 41 of the tank circuit. A thermo-couple 82 is provided so that the antenna current may be observed by means of an ammeter A. M. connected in shunt to said thermo-couple. The desired crystal for controlling the frequency of the oscillation generator is put in circuit automatically when contact 90 is closed and manually operated switch 91 is moved into one of its closed positions, thereby including one half of the solenoid winding 92 in series with battery 54. This energizes winding 92 and operates the armature 53 associated therewith in one direction or the other closing contact 51 or 52 thereby putting either crystal 49 or 50 in series between the space charge grid 48 of 40 and one end of the inductance 41 the other end of which is connected to the plate 39.

In operation switch 56 is closed. This energizes the filament of oscillation generator 40. However, since the send-receiver switch 90 is still open thermionic tube 40 does not generate oscillations since winding 92 is not energized and consequently armature 93 remains in the open position breaking the grid circuit. However, when 90 is closed and 91 is moved into position to insert the desired crystal in series with the grid circuit of the oscillation generator 40 oscillations are generated at a frequency determined by the crystal put in circuit. These oscillations after being modulated in accordance with modulation frequencies impressed by the high voltage microphone 54 on the grid 55 of tube 40 are impressed by means of the tank circuit 41, 46 on the aerial 80 through inductance 81. The modulated oscillations are radiated from 80. In actual operation crystals 49 and 50 may be selected so that one is used for the calling frequency while the other is used for the signalling frequency. As pointed out above this is practical where said frequencies are not widely separated.

In actual operation it may be sometimes desired to stop signalling for a short time as for instance long enough to receive a signal, that is, to stop the generator from generating oscillations without disconnecting the dynamotor from the batteries. This is desirable since it is preferable that the heating circuits for 40 are not allowed to cool during receiving of signals. By means of the send-receive switch 90 the oscillation circuits may be interrupted without interrupting the energizing circuits for 40.

Although for purposes of illustration I have shown the at present preferred form of my invention and set forth the operation thereof, I do not wish to limit myself thereby except as marked out in the claims appended hereto.

I claim:

1. Radio apparatus including a thermionic oscillation generator including a four electrode tube of the screen grid type, means associated with the control grid of said tube and with the anode of said tube for generating oscillations at carrier frequency means including a resistance and a source of signal frequency connected with the screen grid electrode of said tube for modulating said carrier frequency oscillation in accordance with the signal to be transmitted, a load circuit and means for impressing the modulated oscillations on said aerial circuit.

2. In a radio transmitter an oscillation generator including a thermionic tube having an anode, a cathode, and a plurality of auxiliary electrodes, means including a circuit connected between one of said auxiliary electrodes and the cathode of said tube and coupled to a circuit connected between the anode of said thermionic tube and the cathode thereof for generating oscillations at high frequency therein, means connected with one of

said circuits for determining the frequency of said oscillations, means for modulating said high frequency oscillations with signals through a high resistance connected to the other auxiliary electrode of said tube, an antenna circuit coupled to said anode cathode circuit, and means for applying high potential to the anode cathode circuit of said tube and energizing the auxiliary electrode thereof including a high voltage winding of a dynamotor.

3. Radio frequency oscillation generating apparatus including a thermionic tube having an anode, a cathode, and a plurality of auxiliary electrodes, means including a circuit connected between one of said auxiliary electrodes and the cathode of said tube and coupled to a circuit connected between the anode of said thermionic tube and the cathode thereof for generating oscillations at high frequency, a piezo electric crystal associated with said oscillation circuit to determine the frequency thereof, said crystal having a capacity sufficient to balance the capacity between the electrodes in said tube, means associated with another of said auxiliary electrodes for modulating said high frequency, and a load circuit associated with said anode cathode circuit.

4. Radio apparatus including a thermionic high frequency oscillation generator having an anode, cathode and auxiliary electrodes, a circuit connected between the anode and cathode of said thermionic tube, a circuit connected between one of the said auxiliary electrodes and said cathode, means for tuning said circuits to the desired frequency, means for coupling said last named circuit to said anode cathode circuit, a plurality of frequency determining means associated with said auxiliary electrode cathode circuit, means for modulating the high frequencies generated in said circuits including apparatus responsive to modulating frequencies connected through a resistance between the other auxiliary electrode of said thermionic tube and its cathode, a dynamotor having a high voltage winding connected between the anode cathode of said thermionic tube, a source of cathode potential, including a battery having one terminal connected to the cathode through a switch and the other terminal grounded, means for stopping oscillations in said circuits without de-energizing the electrodes thereof, and a relay for controlling the frequency determining means.

5. Means for producing high frequency oscillations and for impressing signal modulations on said oscillations comprising, a thermionic tube including an evacuated closure member, an anode, a cathode and a pair of auxiliary electrodes therein, an oscillation circuit connected between said anode and cathode, a circuit connected between one of said auxiliary electrodes and said cathode, a source of potential, a dynamotor energized by said source, a circuit connecting said source of potential to said cathode to energize the same, a high voltage winding on said dynamotor, said high voltage winding being connected with said first two named circuits to apply energizing potentials to the electrodes in said circuits, said circuits being coupled together to produce sustained oscillations in said tube and said circuits, and means for modulating the oscillations produced by signal potentials including a source of signal potentials and a resistance in series between the cathode and the other auxiliary electrode.

6. Means for producing high frequency oscillations of constant frequency comprising, a thermionic tube having an anode, a cathode and a plurality of auxiliary electrodes, an inductance connected between the anode and cathode of said tube, a source of potential in said connection, a plurality of piezo-electric crystals, a switching device having a movable contact connected with an auxiliary electrode in said tube and a plurality of fixed contacts, each connected with one of the electrodes of one of said crystals, a connection between the other electrode of the other of said crystals and said inductance, and a circuit for applying direct current potentials from said source to said auxiliary electrode connected with the movable member of said switch, whereby when said switch is in contact with one of said fixed contacts oscillations are produced in said circuit, the frequency of which oscillations is determined in part by the piezo-electric crystal connected by said switch between said auxiliary electrode and said inductance.

7. A signalling system comprising an oscillation generator as recited in claim 6, and means for modulating the oscillations generated thereby including, a source of modulating potentials, and a resistance connected between the cathode and the other auxiliary electrode of said tube.

8. Signalling means including, a thermionic tube having an anode, a cathode, and a plurality of grid electrodes, an oscillation circuit connected between the anode and cathode of said tube, said oscillation circuit including frequency determining means, a source of direct current potential connected with the anode and cathode of said tube, a circuit connected between one of said auxiliary electrodes and said cathode, a coupling between said last named circuit and said first named circuit to insure production of oscillations in said tube and said circuits, and means for modulating at signal frequency the oscillations so produced comprising, a second thermionic tube having anode, cathode and control grid, a source of modulating potentials connected between the control grid and cathode of said last named tube, a resistance connecting the anode of said last named tube to the other auxiliary electrode in said first named tube, and a resistive connection between the anode of said last named tube and said source of direct current potential.

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