April 20, 1926. 1,581,161

A. S. BLATTERMAN

MEANS FOR REDUCING INTERFERENCE AND OBTAINING SECRECY IN RADIO TRANSMISSION

Filed April 18, 1921 8 Sheets-Sheet 1

Fig 1

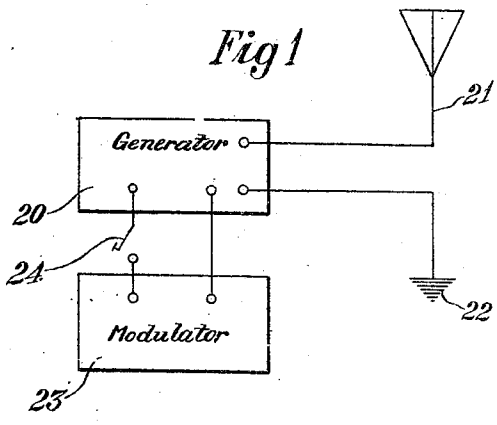
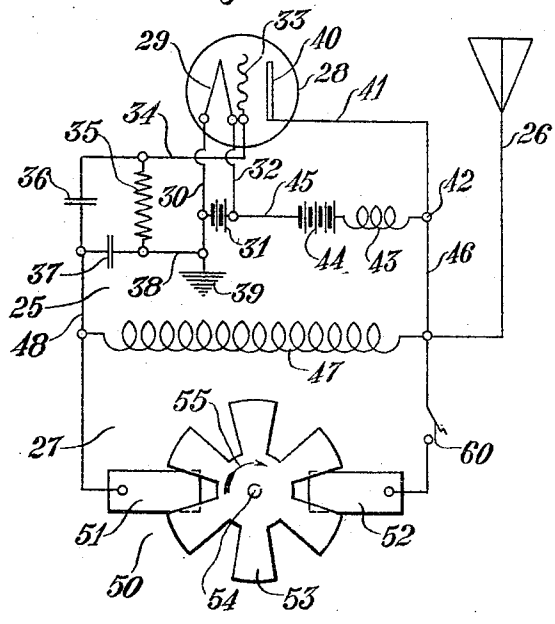


Fig 2



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MEANS FOR REDUCING INTERFERENCE AND OBTAINING SECRECY IN RADIO TRANSMISSION

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Fig 3

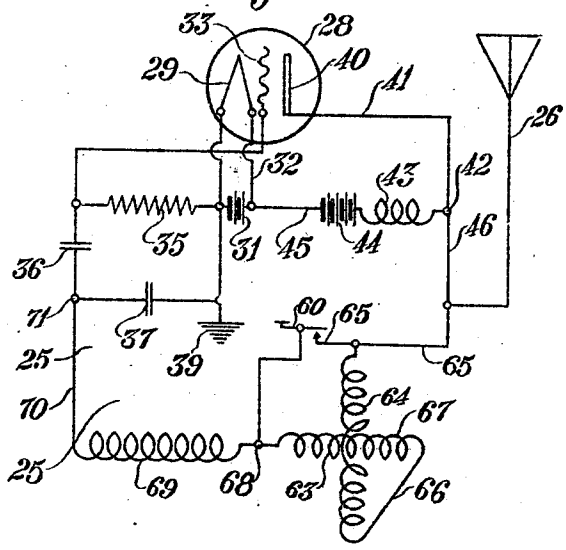
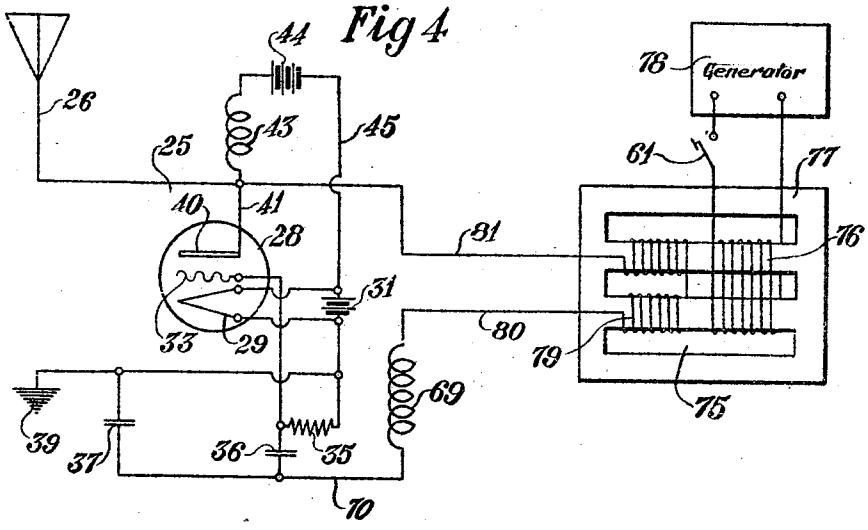


Fig 4



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MEANS FOR REDUCING INTERFERENCE AND OBTAINING SECRECY IN RADIO TRANSMISSION

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Fig5

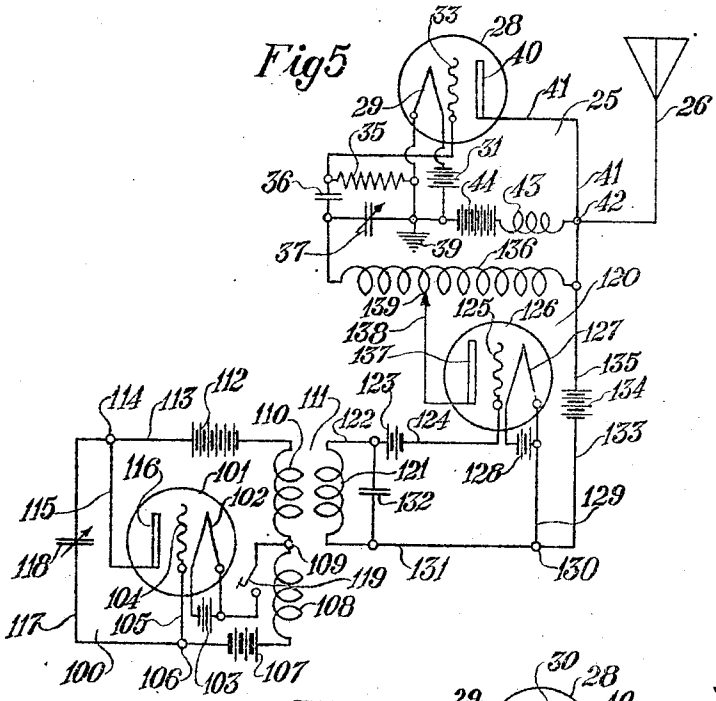
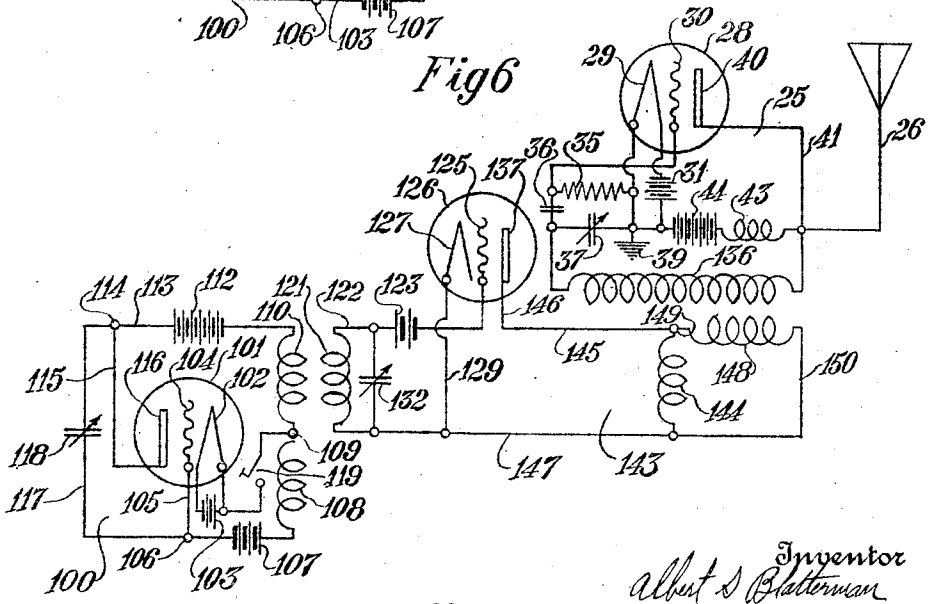


Fig6



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MEANS FOR REDUCING INTERFERENCE AND OBTAINING SECRECY IN RADIO TRANSMISSION

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Fig 7

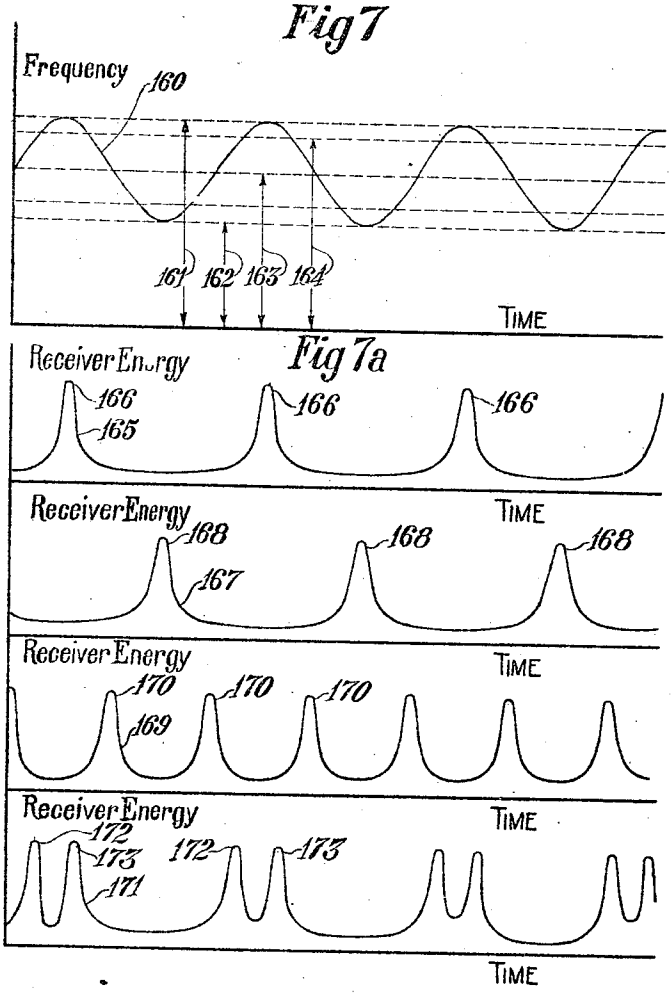


Fig 7a

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MEANS FOR REDUCING INTERFERENCE AND OBTAINING SECRECY IN RADIO TRANSMISSION

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Fig 8

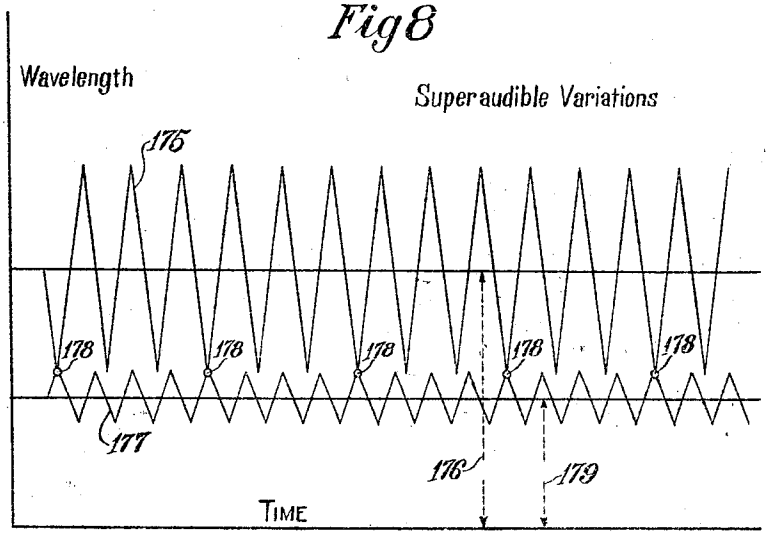
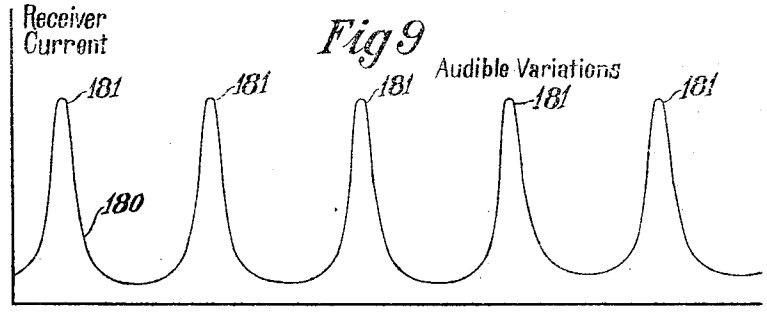


Fig 9



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MEANS FOR REDUCING INTERFERENCE AND OBTAINING SECRECY IN RADIO TRANSMISSION

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Fig 10

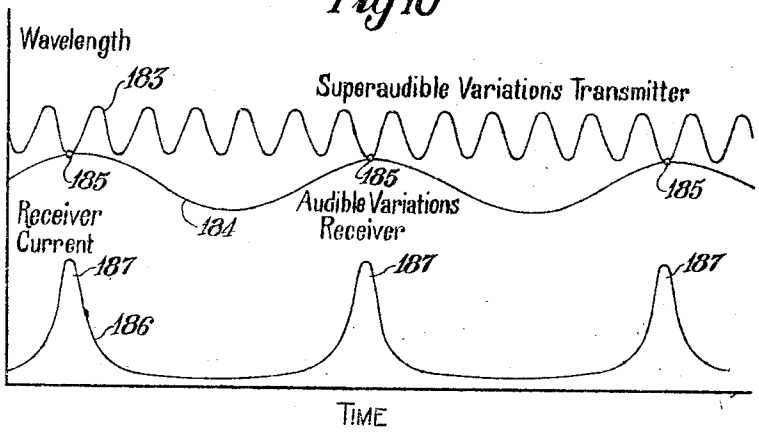
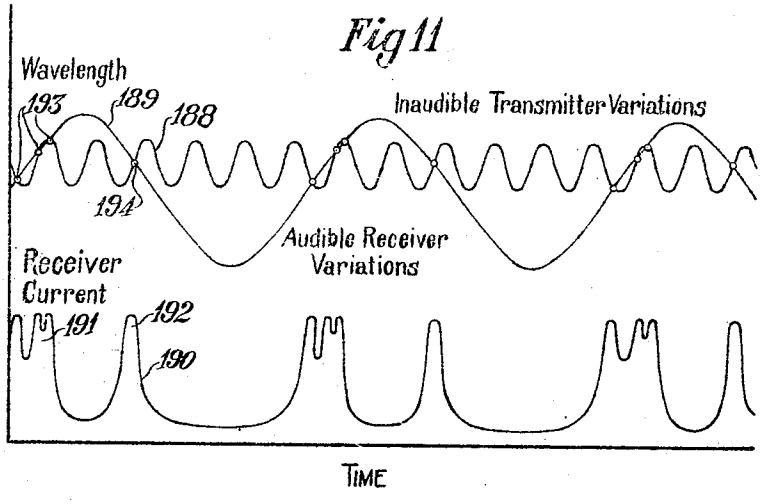


Fig 11



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MEANS FOR REDUCING INTERFERENCE AND OBTAINING SECRECY IN RADIO TRANSMISSION

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Fig 12

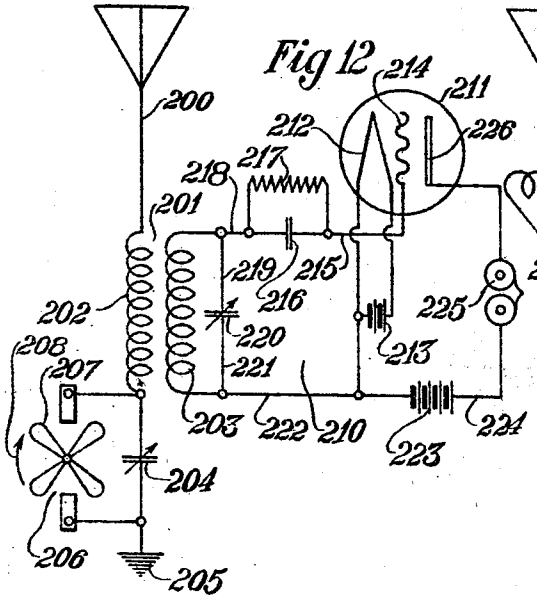


Fig 12a

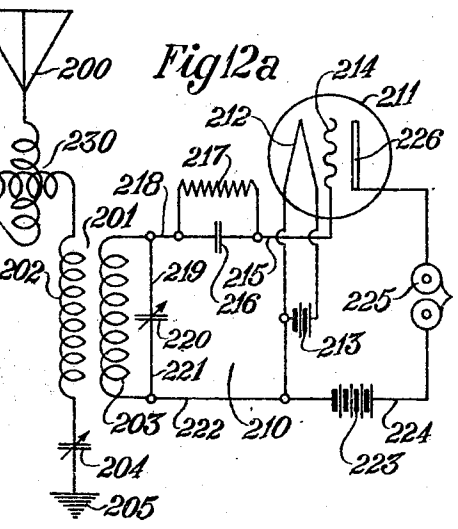
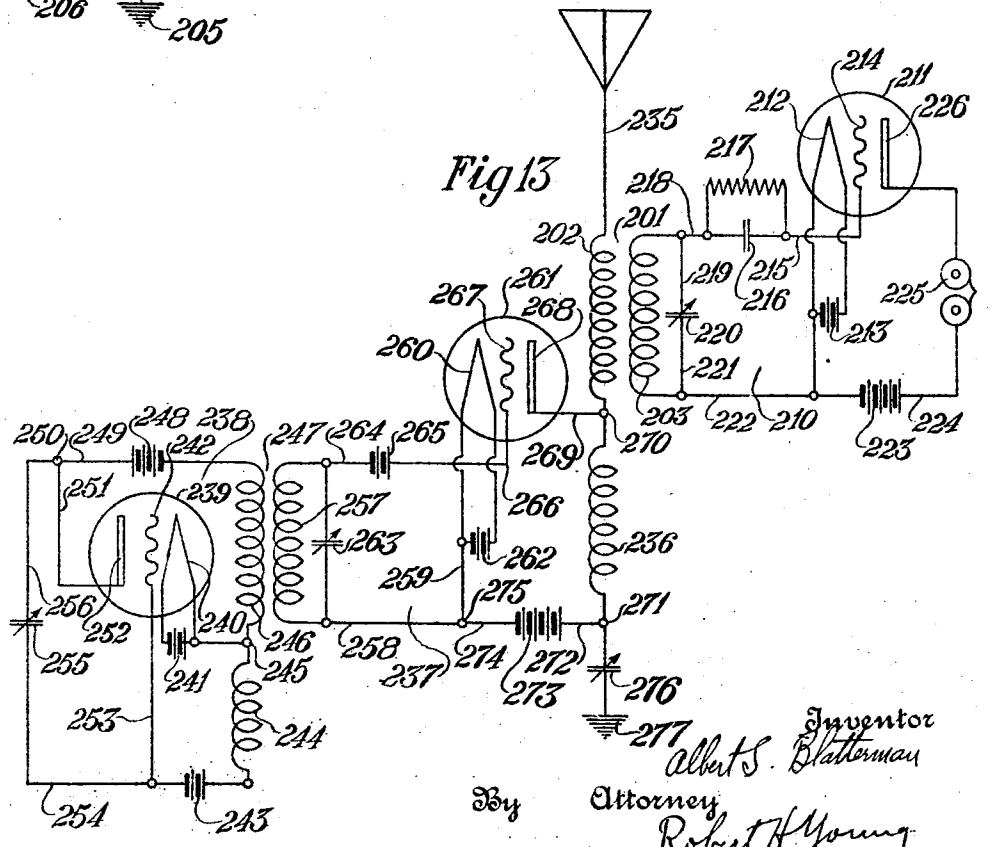


Fig 13



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MEANS FOR REDUCING INTERFERENCE AND OBTAINING SECRECY IN RADIO TRANSMISSION

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Fig14

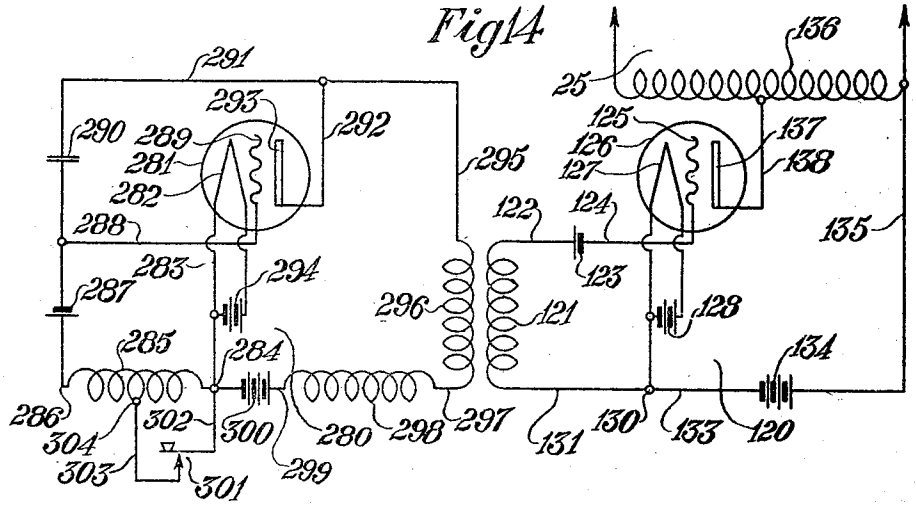


Fig15

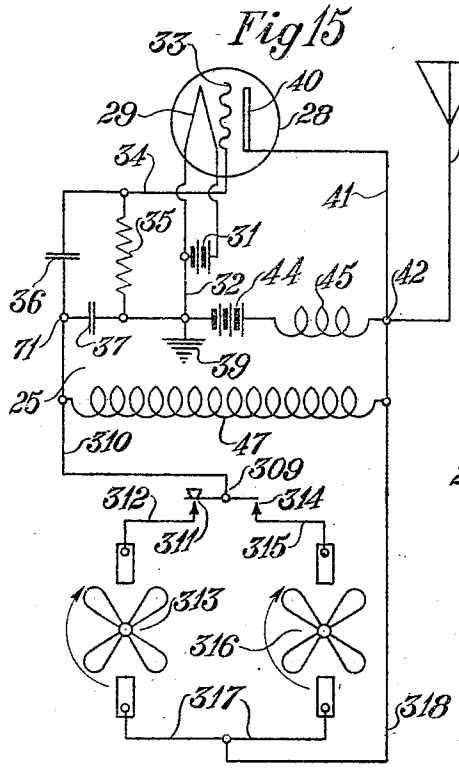
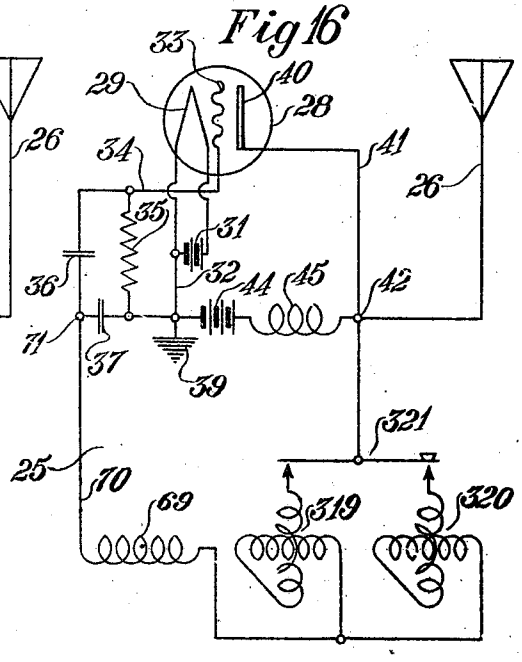


Fig16



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Patented Apr. 20, 1926. 1,581,161

UNITED STATES PATENT OFFICE.

ALBERT S. BLATTERMAN, OF LITTLE SILVER, NEW JERSEY.

MEANS FOR REDUCING INTERFERENCE AND OBTAINING SECRECY IN RADIO TRANSMISSION.

Application filed April 18, 1921. Serial No. 462,243.

To all whom it may concern:

Be it known that I, ALBERT S. BLATTERMAN, a citizen of the United States, residing at Camp Alfred Vail, Little Silver, in the county of Monmouth and State of New Jersey, have invented certain new and useful Improvements in Means for Reducing Interference and Obtaining Secrecy in Radio Transmission, of which the following is a specification.

This invention relates to a method of and means for reducing interference and obtaining secrecy in radio transmission.

An object of this invention is to provide improved procedure and arrangement for transmitting radio communication by modulated carrier waves whereby interference by other radio carrier waves and other forms of electrical oscillations is reduced to a minimum.

Another object of the invention is to provide a method and means for emitting radio carrier waves in a form whereby the waves are not detected by any receiving station other than the receiving station with which it is desired to communicate, thus insuring secrecy.

A further object is to provide improved procedure and arrangement for the reception of the modulated radio carrier waves of this invention.

In accordance with the invention, radio carrier waves are emitted and the signals are transmitted by varying the frequency of the radio carrier waves at an inaudible rate, preferably above audition. Such variation is preferably effected while maintaining the amplitude of the carrier waves substantially constant. The variation of the frequency of the carrier waves may be performed mechanically or may be performed electrically. The variation of the frequency of the carrier waves in transmitting the signals may be carried out by either varying the capacitance of the transmitting apparatus or by varying the inductance of the transmitting apparatus.

The reception of the transmitted signals may be effected by providing in the receiving apparatus means for changing the tuning at a frequency differing within the range of audition from the inaudible frequency of the modulation of the carrier waves.

Further features and objects of the invention will be more fully understood from the following description of several forms of my method and means for transmitting and for receiving communication and from the following accompanying drawings, in which

Fig. 1 is a diagram showing generally my transmitting method;

Fig. 2 is a diagram showing a transmitting circuit embodying my invention and in which the modulation at an inaudible rate is carried out by varying the capacity;

Fig. 3 is a diagram showing a transmitting circuit embodying my invention and in which the modulation at an inaudible rate is varied by varying the inductance;

Fig. 4 is a diagram showing a transmitting circuit embodying my invention and in which the modulation at an inaudible rate is obtained by varying the inductance by means of a form of so-called Alexanderson magnetic relay;

Fig. 5 is a diagram showing one preferred form of transmitting circuit embodying my invention;

Fig. 6 is a diagram showing another preferred form of transmitting circuit embodying my invention;

Fig. 7 is a diagram showing a form of curve of the modulation of the transmitted frequency;

Fig. 7[a] shows respectively curves of the variation of received energy for four different wave lengths to which the receiver may be attuned, such wave lengths being indicated in Fig. 7;

Fig. 8 is a diagram showing an upper curve representing a form of transmitted wave length varied at a desired superaudible frequency and a lower curve showing the receiver wave length varied at a desired superaudible frequency differing within audition from the said superaudible transmitter frequency of the upper curve;

Fig. 9 is a diagram showing the audible variation of receiver current correlative to the aforesaid curves shown in Fig. 8;

Fig. 10 is a diagram showing an uppermost curve of the superaudible transmitter variations of wave length; a second curve of audible frequency variations of the receiver wave length and a lowermost curve of audible variation of receiver current correlative to the upper two curves of this figure;

Fig. 11 is a diagram of three curves similar to those shown in Fig. 10;

Fig. 12 is a diagram of a receiving circuit embodying a main oscillating circuit and a capacitance modulator; Fig. 12ª is a diagram showing a modification of the receiving circuit shown in Fig. 12; Fig. 13 is a diagram of a receiving circuit embodying a main oscillation circuit and a vacuum tube modulator circuit; and Figs. 14, 15 and 16 show modified forms of transmitter circuits.

Referring to the drawings, I have indicated in Fig. 1 at 20 any suitable form of generator of radio frequency alternations to which is suitably connected or coupled the antenna circuit 21 and shown grounded at 22. Such generator of radio frequency alternations emits by means of the antenna 21 carrier waves of any desired frequency. Suitably coacting with such generator 20 I provide a suitable device 23 as is set forth more particularly hereinafter, for varying the frequency of the oscillations of the generator 20 at an inaudible rate and preferably at a superaudible rate. The key 24 may be arranged in the connection between the modulator 23 and the generator 20, as indicated. Thus, upon closing the key 24, such transmitter unit emits oscillations having a frequency varied at a rate without the range of audition.

From the above it will be noted that notwithstanding the possibility by accident or design of an operator attuning his receiver set to a frequency of the emitted signaling waves, the operator would not become aware of the transmitted signals, since the vibrations of the recording device in his receiver would either be beyond the audition of the operator or the detecting device would not be operated at all.

In Fig. 2, I have shown diagrammatically the transmitter oscillation circuit 25 suitably coupled with the antenna 26 and the frequency of the oscillations set up by the oscillation circuit 25 is modified at a superaudible rate by means of the circuit 27 embodying a capacitance modulator.

In such oscillation circuit 25 I have included a suitable vacuum tube 28 comprising the filament 29 one terminal of which is connected through the lead 30 to one pole of the heating battery 31 and whose other terminal is connected by the lead 32 to the opposite pole of the heating battery 31. The grid electrode 33 of the vacuum tube 28 is connected by the conductor 34 to one terminal of the resistance 35, shunting the condensers 36, 37, the other terminal of the resistance 35 being connected by the lead 38 to the conductor 30. The ground of the oscillation circuit is indicated at 39. The plate 40 of the vacuum tube 28 is connected by the conductor 41 at 42 to the choke coil 43 and thence to the battery 44, connected by the conductor 45 to filament lead 32. The conductor 46 connects the conductor 41 with the antenna circuit 26. The inductance 47 is connected at its one end to the conductor 46 and at its opposite end to the conductor 48 connected to the condensers 36, 37.

At 50 I have indicated a capacitance modulator of the mechanical type and as shown embodies a condenser, comprising a plurality of sets of spaced condenser plates indicated diagrammatically at 51, 52, coacting with a multi-sectored disk rotor 53 mounted on a suitable shaft 54 and rotated in either direction, as for example in the direction of the arrow, 55, to rotate the condenser sectors of the rotor 53 into and out of condenser relation with the plates of the respective sets 51, 52, at a superaudible rate. Such capacitance modulator may be formed of a plurality of multi-sectored disks respectively interleaving the condenser plates 51, 52, to obtain the desired capacitance values at any desired speed of rotation of the rotor 53. The signaling device is indicated at 60 in Fig. 2 at a position for connecting in and out of circuit the modulator 50 with the oscillation circuit 25.

As is indicated in Fig. 2 such capacitance modulator 50 is in shunt relation with the inductance 47 whereby the frequency of the oscillation circuit is varied in accordance with the changes in the capacitance of the modulator at the desired superaudible rate.

In Fig. 3 I have shown a form of oscillation circuit similar to that shown in Fig. 2 and like parts are indicated by similar reference numbers. The arrangement in Fig. 3, however, differs from that of Fig. 2 in respect to the variation of the oscillation frequency by means of the variable inductance 63 instead of the variable capacitance 50. As one form of connecting such variable inductance 63 with the inductance 69 of the oscillation circuit 25, I have shown the variable inductance 63 and the signalling key 60 arranged so that upon depressing the key 60 the modulating inductance 63 is connected serially with the inductance 69 in the oscillating circuit and upon the rise of the key 60 the modulating inductance 63 is short-circuited. The variable modulating inductance indicated generally at 63 may comprise the coil 64, one end of which is connected by the conductor 65 to the oscillation circuit 25, its opposite end being connected by the lead 66 to one end of the coil 67 in variable inductive relation with the coil 64. The terminal of the coil 67 is connected by the lead 68 with the inductance 69, thence through the conductor 70 at 71 with the condenser 37. Upon mechanically varying the inductive relation of the coils 64, 67, to one another at the desired speed exceeding audition and upon depressing the key 60 the frequency of the oscillations set up in the oscillating circuit 25 is varied at the superaudible rate.

Such variable inductance device may be in the form of one winding wound on a slotted stator and the other winding wound on any suitable rotor and connected together in any suitable manner whereby the inductance of the device attains maximum and minimum inductance values successively upon rotation of the rotor relative to the stator.

In Fig. 4 I have indicated a transmitter system embodying the oscillation circuit 25 corresponding generally to the oscillation circuit shown in the arrangements of Figs. 2 and 3, and like elements are indicated by the same reference numbers.

The arrangement in Fig. 4 embodies, however, an inductance varying device of the so-called Alexanderson magnetic type of relay indicated generally at 75. Such magnetic relay embodies the controlling coil 76 wound on the laminated core 77, the ends of the coil 76 being connected to any suitable generator 78 of superaudible modulating frequency upon operation of the key 61.

The winding 79 of the magnetic relay 75 has one of its terminals connected by the lead 80 to one end of the inductance 69, similarly as in Fig. 3, whereas the other terminal of the winding 70 is connected by the lead 81 to the conductor 41, whereby the inductance coil 79 of the magnetic relay is connected in series with the inductance 69 and the capacitance elements of the oscillation circuit. The generator circuit 78 may be a vacuum tube oscillation circuit or contain a high frequency alternator.

Pursuant to the objects of my invention, a portion of the reactance of the oscillating circuit may be shunted by ohmic resistance which may be varied in a substantially harmonic manner to oscillate between predetermined high and low values at the desired superaudible rate, whereby the frequency of the radiated waves is varied at the superaudible rate. As one example, advantage is taken of the impedance between the plate electrode and the filament electrode of a three electrode vacuum tube being practically pure resistance and a function of the plate voltage, filament heating current, and a grid voltage and upon varying any one of these three factors in accordance with my invention, the effective reactance of the oscillating circuit is varied at a superaudible rate in the transmission of the signals.

More specifically, a part of the inductance of the main oscillating circuit may be shunted by the plate to filament circuit of another vacuum tube, the grid of which is fed from an auxiliary vacuum tube circuit oscillating at the superaudible frequency at which it is desired to vary the frequency of the main oscillating circuit. The resistance between the plate and the filament of the vacuum tube shunting the main oscillating circuit in such case is varied between wide limits by the variation of the grid potential impressed by the oscillations of the superaudible frequency circuit.

As one example, I have shown in Fig. 5, the main oscillating circuit 25 arranged similarly to the main oscillating circuit shown in Figs. 3 and 4 hereinabove, and like elements are indicated by the same reference characters.

Coacting with such main oscillation circuit 25 is arranged the superaudible frequency circuit 100 comprising the vacuum tube 101 having its filament electrode 102 heated by the battery 103. The grid electrode 104 is connected to one terminal of the battery 107 and from the other terminal of the battery 107 to one end of the inductance coil 108, connected in series at 109 with the primary coil 110, of the coupling 111, the opposite end of the coil 110 being connected through the battery 112, conductor 113 at 114 to the conductor 115 leading to the plate electrode 116 of the vacuum tube 101. The grid conductor 105 is connected through the conductor 117 to the condenser 118 and to the plate conductor 115. The key 119 is connected between the point 109 and the lead of the filament 102. The modulator tube circuit 120 is arranged to connect the superaudible frequency circuit 100 with the main oscillation circuit 25, and as one form of such connection I have shown the secondary coil 121 inductively coupled with the coil 110, one terminal of the coil 121 being connected by the conductor 122 to the battery 123 and thence to the grid conductor 124, leading to the grid 125 of the modulator tube 126. The filament electrode 127 of the modulator vacuum tube 126 is heated by its battery 128 and connected by its conductor 129 at 130 to the conductor 131 leading to the secondary coil 121 of the transformer coupling 111.

The condenser 132 is connected in shunt with the secondary coil 121. The filament conductor 129 is also connected at 130 to the conductor 133 through the battery 134 and the conductor 135 to one terminal of the inductance 136 of the main oscillation circuit 25 and the plate electrode 137 of the modulator vacuum tube 126 is connected by the conductor 138 to the adjustable contact 139 of the inductance 136.

In Fig. 6 I have shown another form of transmitter arrangement embodying a main oscillation circuit 25, a portion of whose inductance 136 is coupled inductively to a modulator circuit comprising the vacuum tube 126, energized by an auxiliary vacuum tube circuit 100 oscillating at the desired superaudible frequency. In Fig. 6, the superaudible frequency circuit 100 corresponds generally to the superaudible oscillation circuit 100 shown in Fig. 5, and like parts are indicated by the same reference numbers. The modulator tube circuit is in-

dicated at 143 and corresponds to the modulator circuit 120 of Fig. 5 excepting that the modulator circuit 143 of Fig. 6 is provided with the inductance 144 connected at one end by the conductor 145 to the terminal 146 of the plate electrode 137 and its opposite end connected by the conductor 147 to the lead 129 connected to the terminal of the filament electrode 127 of the modulator vacuum tube 126. The coupling winding 148 has its one end connected at 149 to the conductor 145 and its opposite end connected by the conductor 150 to the conductor 147. Such coupled winding 148 is inductively related to a portion of the inductance 136 of the main oscillating circuit 25. Accordingly, upon the oscillations of the superaudible frequency circuit 100 being impressed on the modulator circuit 143 inductively coupled with a portion of the inductance 136 of the main oscillating circuit 25, such portion of the inductance is effectively shunted by the plate and filament circuit of the modulator circuit 143 and the frequency of the main oscillation circuit 25 is varied at the superaudible rate of the superaudible oscillation circuit 100.

In the diagrams given thus far the signalling key has been shown as effectively connecting the modulator in and out of circuit or else it renders the modulator alternately operative and inoperative. With such arrangements a wave of steady frequency is radiated upon the back or up stroke of the key and may be heard at receiving stations which employ the ordinary types of circuits and apparatus. This arrangement does not therefore give complete secrecy nor freedom from interference although the signals produced on such ordinary receivers will obviously be generally unintelligible.

An improved method of keying giving greater secrecy and less interference is obtained by arranging the circuits so that manipulation of the key causes the frequency of modulation to change abruptly from one selected super-audible value to a distinctly different super-audible value. To this end the modulator oscillation circuit 100 of Fig. 5 or Fig. 6 may be rearranged slightly as regards the key 61 as shown in Fig. 4. Herein it will be seen that the key when depressed short circuits a portion of the inductance of the super-audible frequency modulating oscillation circuit, thus changing the frequency of that circuit. The receiver being adjusted in this case as hereinafter described, to respond when this latter super-audible modulating frequency is present in the transmitter, fails to respond when the key is raised to change the modulating frequency, and signaling by the key is thus rendered effective.

When mechanical modulation is employed as in Figs. 2 and 3, the effects just described may be produced by providing two distinct rotary modulators having different rotative speeds or in any event, different rates of reactance variation, and the key arranged to switch the main oscillating circuit from one modulator to the other. A suitable arrangement of this kind employing capacitance modulation is shown on Fig. 2 and similarly keying for the case of inductance modulation is shown on Fig. 3.

In order to more fully explain the operation of my system of communication, to better illustrate its advantages of secrecy and reduced interference, and in order to introduce the several receiver arrangements which I have evolved, I have illustrated in Fig. 7 the curve 160 representing the modulation at the desired super-audible frequency of the frequency of the main radio oscillations of the transmitter drawn to rectangular coordinates designated "Time" and "Frequency", respectively.

I have also indicated in Fig. 7, four different fixed wavelengths respectively designated 161, 162, 163 and 164 lying within the range of values of transmitted wavelengths to any one of which an ordinary type receiver may be tuned.

In Fig. 7ª I have shown four curves respectively drawn to rectangular coordinates of "Time" and "Receiver energy," the uppermost curve 165 representing the variation of energy in an ordinary type receiver circuit which is tuned to the wavelength represented in Fig. 7 at 161. It will be noted that there is a gush of energy through the receiver circuits every time the transmitted wavelength passes through the wavelength value to which the receiver is tuned.

The curve 167 corresponds to the wavelength 162 of Fig. 7 and shows the variations of receiver energy in gushes through the receiver circuits. The peaks 168 of this curve 167 are of regular recurrence, similarly to those of the curve 165.

The curve 169 of Fig. 7ª corresponds to the wavelength 163 represented in Fig. 7 and its peaks 170 are of uniform recurrence and incidentally their recurrence is more frequent than those corresponding to the curves 167 and 165.

The curve 171 corresponds to the wavelength 164 of Fig. 7, and this curve embodies peaks 172, 173, which respectively recur regularly but the interval between each peak 172 and its immediately preceding peak 173 does not correspond to the interval between the peak 172 and its immediately succeeding peak 173, so that the gushes of energy through the receiver are of irregular recurrence as compared with the preceding cases.

In all of these four cases illustrated it will be apparent that the rate at which the gushes of energy in an ordinary type receiver circuit follow one another is inaudibly high

because of the super-audible rate of variation of the transmitter wavelength. For this reason a receiving operator using receiving apparatus and circuits of the usual type would not become aware of the transmission and to this extent my transmitting system achieves secrecy.

It will further be apparent, since my transmitting system does not employ a fixed wavelength but a continuously varying wavelength with such variation occurring at a super-audible rate, that it will produce a minimum of interference with other transmissions either of similar types or of the usual fixed wavelength type.

In order to receive and translate modulated radio waves transmitted in accordance with my invention as hereinbefore set forth, special arrangements of the receiving circuits are necessary. One such arrangement which may be employed comprises the well known method of double detection wherein the oscillations in the main receiver circuits recurring in groups at a super-audible rate are substantially rectified at a first detecting device into whose output circuit is introduced oscillating energy from a local source having super-audible frequency differing within audition from the super-audible frequency of recurrence of the receiver energy gushes so as to produce heterodyne response at audible frequency through a second detector. Otherwise a chopper or tikker may be used to make audible signals according to methods already well known in the art.

I have, however, devised other useful and improved methods for accomplishing the reception of carrier waves whose frequencies are continuously varied at the selected super-audible rates. Thus I have in one instance provided for the reception of such carrier waves by a receiving set embodying a main tuned oscillation circuit and a modulator circuit connected to or coupled with the main oscillation circuit, similar to the arrangement of the modulator circuit 100 shown and described hereinabove in connection with the transmitters shown respectively in Figs. 5 and 6, and operated in a similar manner, for varying the wavelength of the main tuned oscillation circuit of the receiver at a rate differing from the rate of change of the wavelength of the transmitted carrier waves within the range of audition. Such receiver circuits are described more fully hereinafter. Their functioning will be understood from Figs. 8 and 9.

In Fig. 8 I have shown the curve 175 representing the variations of wavelength of the transmitted oscillations varied at the selected super-audible frequency and drawn to rectangular coordinates of "Time" and "Wavelength." The mean wavelength of the curve 175 is represented by the coordinate 176. Below the curve 175 I have shown the curve 177 representing the variation of wavelength to which the receiver set is instantaneously tuned. The variations of receiver wavelength are adjusted to occur at a super-audible frequency differing from the super-audible frequency of the transmitted waves 175 within the range of audition. It will be noted that the curve 177 intercepts the curve 175 at the instants 178. Only at such instants 178 therefore is the receiver circuit in tune with and responsive to the transmitted waves.

The mean wavelength of the receiver set is indicated by the ordinate 179.

In Fig. 9 I have drawn the variation of receiver current or receiver energy with "Time" to rectangular coordinates, and the curve 181 represents the variation of receiver energy for the case of transmitter super-audible frequency variation corresponding to the curve 175 and the receiver super-audible frequency variation represented by the curve 177. The peaks 181 of the curve 180 correspond to the coincident points 178 of Fig. 8 and recur at a regular rate within audibility, thereby enabling the operator to readily detect the transmitted signals.

In accordance with my invention, reception of the transmitted signals is also effected by varying the wavelength to which the receiver is tuned at a rate within audibility and in such manner that there is coincidence with the wavelength of the modulated transmitted waves but once for each cycle of the receiver wavelength variation. Reception of this character is illustrated in Fig. 10, the uppermost curve 183 representing the variation of wavelength at the super-audible rate of the transmitted waves, the curve 184 representing the variation of wavelength of the receiver varied at an audible rate and selecting the receiver wavelength to be coincident with the variable wavelength of the modulated transmitted waves for a single instant only during each cycle of the variation of the receiver wavelength, which locations of coincidence are indicated at 185, 185, etc. The variation of receiver current is shown by the curve 186 the peaks 187 of which recur uniformly and at a rate within the range of audition.

In illustration of a further condition which may exist in the practical application of my audible frequency wavelength varying receiver, I have indicated in Fig. 11 by the curve 188 the variation of wavelength of the transmitted carrier waves at the super-audible rate, and by the curve 189 the variation of wavelength tuning of the receiver at an audible rate, the range of wavelength tuning of the receiver being selected to give coincidence of transmitter and receiver wavelengths at several instants within the

range of variation of the transmitted waves during each complete cycle of the receiver wavelength. In this instance, the variation of current in the receiver set and passing through the detecting device thereof is represented by the curve 190 which has in this instance a group of peaks 191 followed successively by a single peak 192. The several peaks of the group of peaks 191 correspond to the several points of wavelength coincidence 193 indicated on the upper curve, whereas the peak 192 corresponds to the point of coincidence 194.

It will be evident that for proper functioning in this method of reception it is necessary for the variation of receiver tuning to be so arranged as to be without the range of transmitter wavelengths during a large portion of the audio frequency cycle of receiver wavelength variation.

It will now be understood that the type of receiver which I have invented using audio frequency variation of tuning is less preferred than the receiver using the super-audible frequency variation of tuning, because of possible interference on the former receiver from ordinary fixed wavelength type transmitters. Furthermore it will be understood that the audio frequency tuning variation type of receiver cannot be used when keying at the transmitter is provided for by switching from one to another super-audible modulating frequency as exemplified in Figs. 14, 15 and 16 set forth more particularly hereinafter. In this case it is necessary to use super-audible variation of receiver tuning. Such receiver, as has been pointed out, has a concomitant advantage in that it reduces the possibility of interference from other radio carrier waves.

The most preferred form of my invention, therefore, comprises generally a transmitter with wavelength continuously varied at a super-audible rate, which rate is changed to a different value by operation of the sending key; and a receiver whose tuning is similarly varied at a super-audible rate differing within audition from the super-audible rate of the transmitter wavelength variation employed when the key is depressed. The variations of transmitter and receiver wavelengths may be accomplished either mechanically or electrically as hereinbefore described.

Any of the auditions represented by the Figs. 8 to 11 inclusive, can be produced at will by the receiving operator upon adjusting the main tuning elements of the receiver set to thereby vary the mean wavelength of the receiver set to the desired mean wavelength value.

It is advantageous to vary the mean oscillation frequency of the receiver set at an audible rate, particularly as set forth hereinabove in connection with the curves of Figs. 10 and 11, and thus facilitate detection by the receiving operator by reason of the simplicity of apparatus and circuits, and the manipulation thereof, whereby uniformity of recurrence in the receiver response through a wide range of pitch of tone is attained.

It will also be apparent when using a type of receiver employing superaudible variation of wave-length, such as that described in connection with Figs. 13 and the curves of Figs. 8 and 9, that the possibility of interference from transmission oscillations of the ordinary type, with fixed frequency, is greatly reduced and such ordinary transmissions are thereby unlikely to affect or interfere with the transmitted oscillation waves modulated in accordance with my invention.

In Fig. 12, the receiving set comprises the antenna 200 which may be coupled through the electro-magnetic coupling 201 comprising the primary winding 202 in the antenna circuit and the secondary winding 203. The antenna circuit also comprises the variable condenser 204 and ground 205. Shunted about the condenser 204 is arranged the variable capacitance 206 constructed and operated similar to the variable capacitance shown and described in connection with the transmitter set illustrated in Fig. 2. Upon rotating the rotor condenser plates 207, say in the direction of the arrow 208, the wave length of the antenna circuit determined by the inductance 202, capacity 204 and other reactance values of the antenna circuit, is varied upon the rotation of the variable capacitance 206.

The receiver circuit 210 closed through the secondary winding 203 may be of any approved type of receiver circuit but as illustrated embodies the detector vacuum tube 211, whose filament electrode 212 is heated by the battery 213; the grid electrode 214 is connected by the lead 215 to the condenser 216 and resistance 217, connected in shunt relation with one another, and connected by the conductor 218 to one terminal of the secondary winding 203 and by the conductor 219 through the variable condenser 220, conductor 221, thence through the conductor 222 to the lead of the filament electrode 212. To the conductor 222 is also connected the positive pole of the battery 223, whose positive pole is connected through the telephone 225 to the plate electrode 226 of the vacuum tube 211.

The receiver arrangement shown in Fig. 12^a corresponds to that shown in Fig. 12 and like elements are designated by the same reference numbers; however, the varying of the wave length of the receiver set in Fig. 12^a is effected by means of the variable inductance device 230, corresponding in construction and operation to the variable inductance device shown and described in connection with the transmitter set illustrated in

Fig. 3. The closed receiver circuit 210 corresponds to that shown in Fig. 12 and accordingly the detail description for these elements appearing hereinabove will suffice also in connection with Fig. 12a.

In the receiver arrangement shown in Fig. 13, the antenna 235 is coupled with the closed detector circuit 210 through the variable electro-magnetic coupling 201 similarly as above, and similar elements are designated by the same reference characters. The antenna circuit 235, in the arrangement shown in Fig. 13, however, comprises also the inductance 236 connected in the modulator circuit 237 which in turn is suitably electrically connected with the superaudible oscillation circuit 238. Such receiver arrangement corresponds in principle to the principle of the transmitter arrangement shown in Fig. 6, with such modifications for applying the principle of receiving as accord with the procedure described hereinabove in connection with Figs. 8 and 9.

The superaudible oscillation circuit comprises the vacuum tube 239 whose filament electrode 240 is heated by the battery 241; the grid electrode 242 is connected to one terminal of the battery 243 and from the other terminal of the battery 243 to one end of the inductance coil 244, connected in series at 245 with the primary coil 246 of the coupling 247, the opposite end of the coil 246 being connected through the battery 248, conductor 249 connected at 250 with the conductor 251 leading to the plate electrode 252. The grid lead 253 is connected through the conductor 254 to the condenser 255, thence through the conductor 256 to the plate lead 251.

The secondary 257 of the coupling 247 is connected at one end through the conductor 258 to the filament lead 259 of the filament electrode 260 of the modulator vacuum tube 261. The filament battery is indicated at 262. The variable condenser 263 is connected in shunt with the secondary winding 257 and the opposite terminal of the secondary winding 257 is connected by the conductor 264 through the battery 265 to the lead 266 of the grid electrode 267 of the modulator vacuum tube 261. The plate electrode 268 is connected by its lead 269 at 270 to the antenna circuit, thence through the inductance 236 connected at 271 to the conductor 272 leading through the battery 273 and conductor 274 connected at 275 to the filament conductor 259. The inductance 236 is connected through the variable condenser 276 to ground 277.

Accordingly, upon the receiving antenna being activated by the transmitted carrier waves, the frequency of which is varied at a superaudible rate, the wave length of the receiver antenna circuit being varied at the proper superaudible rate by means of the superaudible oscillation circuit 238 and modulator circuit 237, the detection of the transmitted signals is effected through the receiver circuit 210, in accordance with the principles of reception set forth hereinabove relative to the aforesaid reception curves.

In Fig. 14 I have shown another form of transmitter arrangement embodying the modulator circuit 120 corresponding generally to the modulator circuit 120 of the arrangement shown in Fig. 5 and like parts are designated by the same reference numbers.

Such modulator circuit 120 is connected, in the arrangement shown in Fig. 14, to a portion of the main inductance 136 of the main oscillation circuit 25. The superaudible frequency circuit is indicated at 280 and comprises the vacuum tube 281 whose filament electrode 282 is connected by its lead 283 to the end 284 of the inductance 285, whose opposite ends 286 is connected through the battery 287 to the lead 288 of the grid electrode 289 of the vacuum tube 281. The grid electrode 289 is connected through its lead 288 to the condenser 290 and thence by the conductor 291 and lead 292 to the plate electrode 293 of the vacuum tube 281. The filament electrode 282 is heated by its battery 294. The plate electrode lead 292 is connected by the conductor 295 to one terminal of the primary winding 296 in inductive relation with the secondary winding 121 of the modulator circuit 120. The opposite terminal of the primary winding 296 is connected by the lead 297 to one terminal of the inductance 298 whose opposite terminal is connected by the lead 299 through the battery 300 to the filament lead 283 at 284.

The key 301 is connected on one side by the conductor 302 at 284 to one end of the inductance 285 and at its other side is connected by the conductor 303 to a selected tap 304 on the winding of the inductance 285.

Accordingly, upon closing the key 301, the portion of the turns of the inductance 285 between its one end 285 and the tap point 304, is short-circuited, thereby reducing the effective inductance of the superaudible oscillation circuit and thereby changing from one superaudible frequency to a different superaudible frequency, and accordingly modifying at two superaudible rates the frequency of the main oscillation circuit 25.

In Fig. 15 I have shown another form of transmitter circuit in which the operation of the key changes the superaudible frequency from one superaudible value to another superaudible valve. In this transmitter circuit, the general arrangement is that shown in Fig. 2 hereinabove set forth and corresponding elements are designated by the same reference numbers. However, in the arrangement shown in Fig. 15, the key 309 is connected by the lead 310 to one end of the inductance 47 of the main oscillation cir-

cuit 25, and the contact 311 of the key 309 is connected by the lead 312 to the mechanically rotated capacitance modulator 313 rotated at a given speed and corresponding generally to the capacitance modulator 50 of the arrangement shown in Fig. 2. The contact point 314 of the key 309 is connected by the lead 315 to the capacitance modulator 316 rotated at a different speed. Such capacitance modulator 316 corresponds also to the capacitance modulator 50 of the arrangement shown in Fig. 2. The two capacitance modulators 313 and 316 are connected by the common conductor 317 to the conductor 318 leading to the opposite end of the inductance 47. When the switch 309 is in open position, the circuit through the capacitance modulator 316 is completed and when the key 319 is depressed, the capacitance modulator 313 is connected in circuit, in substitution of the capacitance modulator 316.

In the other modified form of transmitter circuit shown in Fig. 16, the two superaudible frequencies are effected by inductance modulators 319 and 320 respectively corresponding to the inductance modulator shown in Fig. 3. The main oscillation circuit 25 of Fig. 16 corresponds generally to the main oscillation circuit 25 in Fig. 4 and corresponding elements are designated by the same reference numbers.

In the arrangement shown in Fig. 16, upon the rise of the key 321, the inductance modulator 319 is connected in circuit and the inductance modulator 320 disconnected from the circuit and upon the depression of the key 321 the inductance modulator 320 is connected in circuit and the inductance modulator 319 disconnected from circuit, corresponding to the operation of the key 319 in the arrangement shown in Fig. 15 relative to the two capacitance modulators 313 and 316.

From the above it will be understood that I have provided radio transmission apparatus and a method of transmission of radio signals, the detection of which is impossible by use of an ordinary radio receiver set operated in the usual manner. In the usual operation of a receiver set the main oscillation circuits of the receiver are tuned or at least approximately tuned to the fixed carrier frequency of the transmitted waves; and if such usual procedure of tuning of the receiver set is carried out in an attempt to detect waves transmitted in accordance with my invention, the operator would not receive any message whatsoever, since the telephone receiver or other detecting device of the receiver set would either not be operated at all or be vibrated at the superaudible rate, and therefore not within audition of the operator.

Whereas I have described my invention by reference to specific forms thereof, it will be understood that many changes and modifications may be made without departing from the spirit of the invention, as described by the appended claims.

I claim:

1. A transmitter circuit comprising the combination of a main oscillation circuit including inductance and capacitance, a modulation circuit comprising means for varying the frequency of said main oscillation circuit at an inaudible rate and a signalling device for changing the said inaudible rate of frequency variation of the said main oscillation circuit in signaling.

2. A transmitter circuit comprising the combination of a main oscillation circuit including inductance and capacitance, a modulation circuit comprising means for varying the frequency of said main oscillation circuit at an inaudible rate and a signalling device including a reactance element for changing the said inaudible rate of frequency variation of the said main oscillation circuit in signaling.

In testimony whereof I affix my signature.

ALBERT S. BLATTERMAN.