June 12, 1934.

A. NYMAN

1,962,611

RADIO COMMUNICATION

Filed Sept. 8, 1926

4 Sheets-Sheet 1

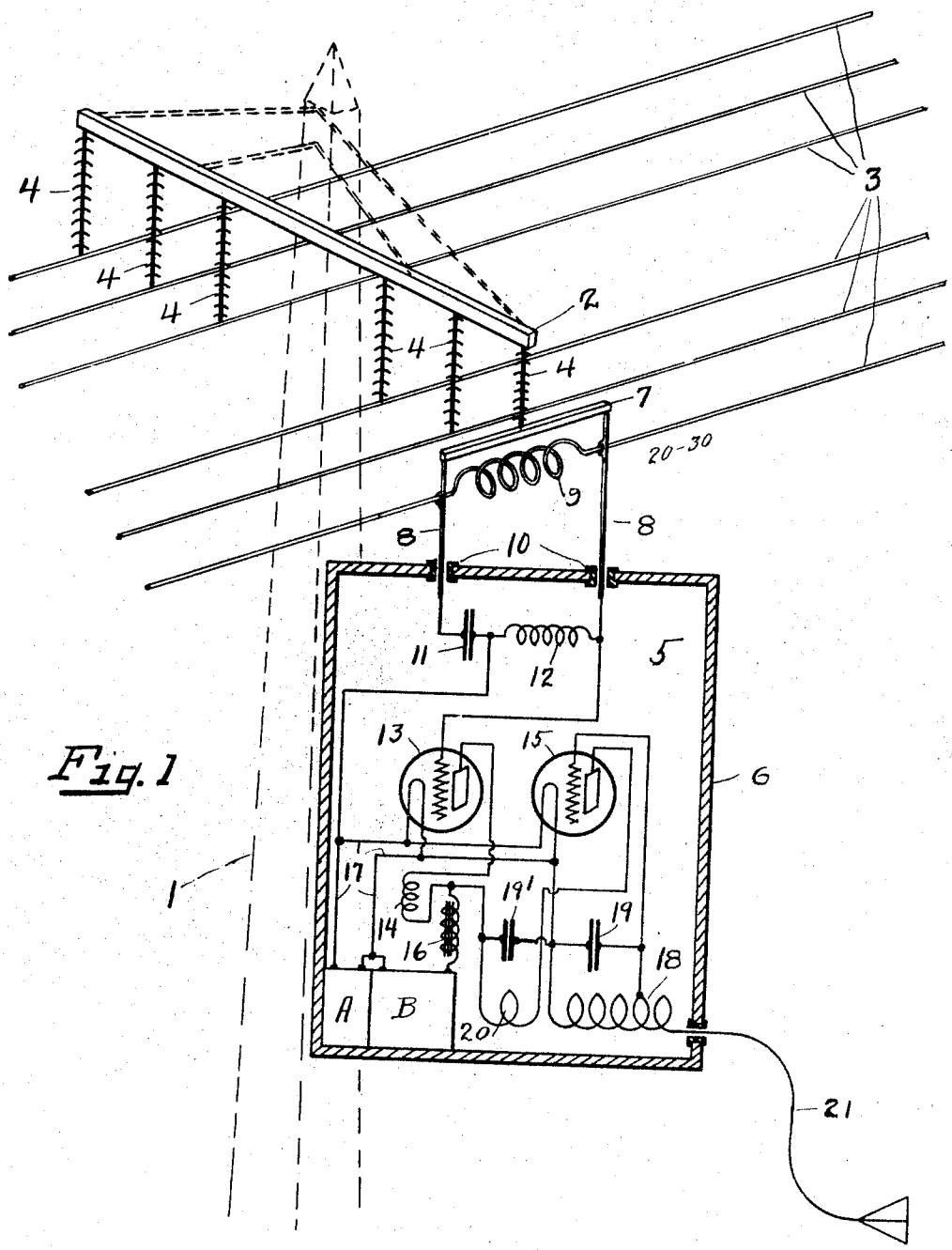


Fig. 1

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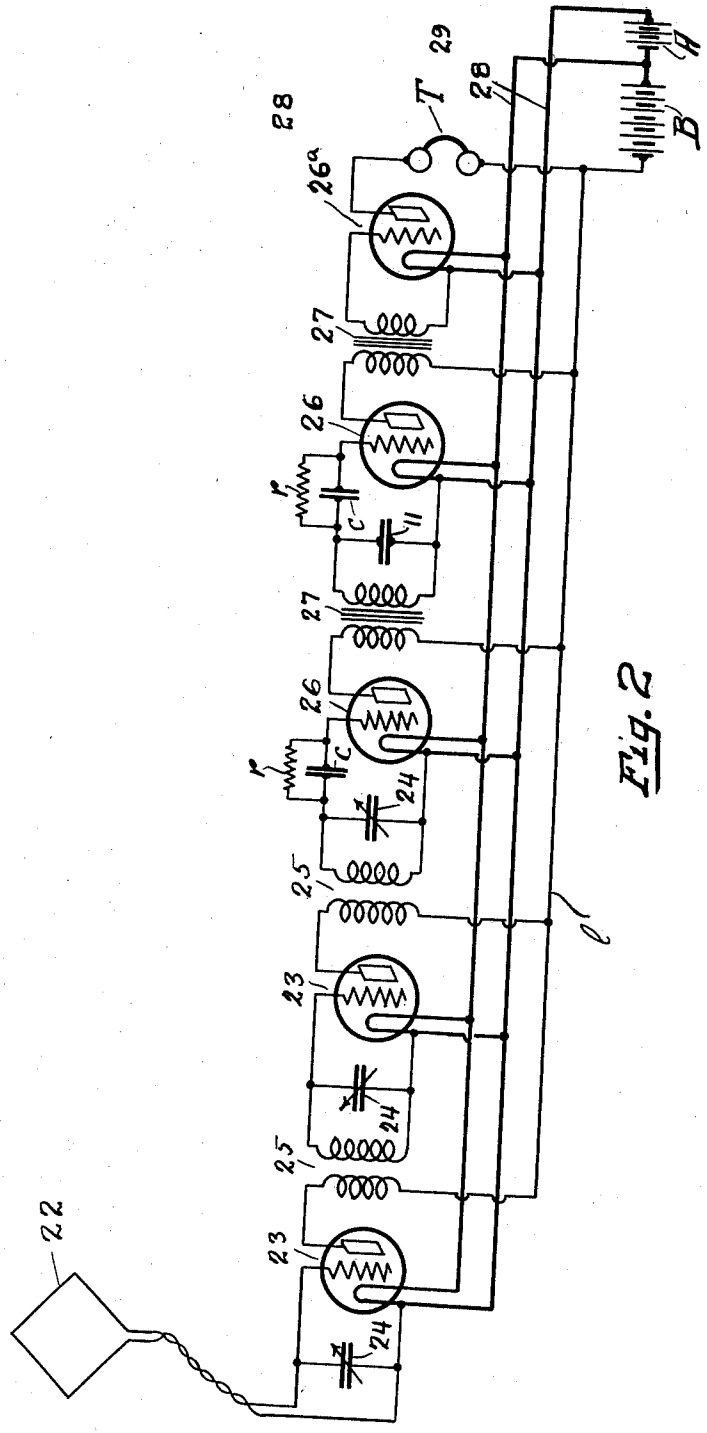


Fig. 2

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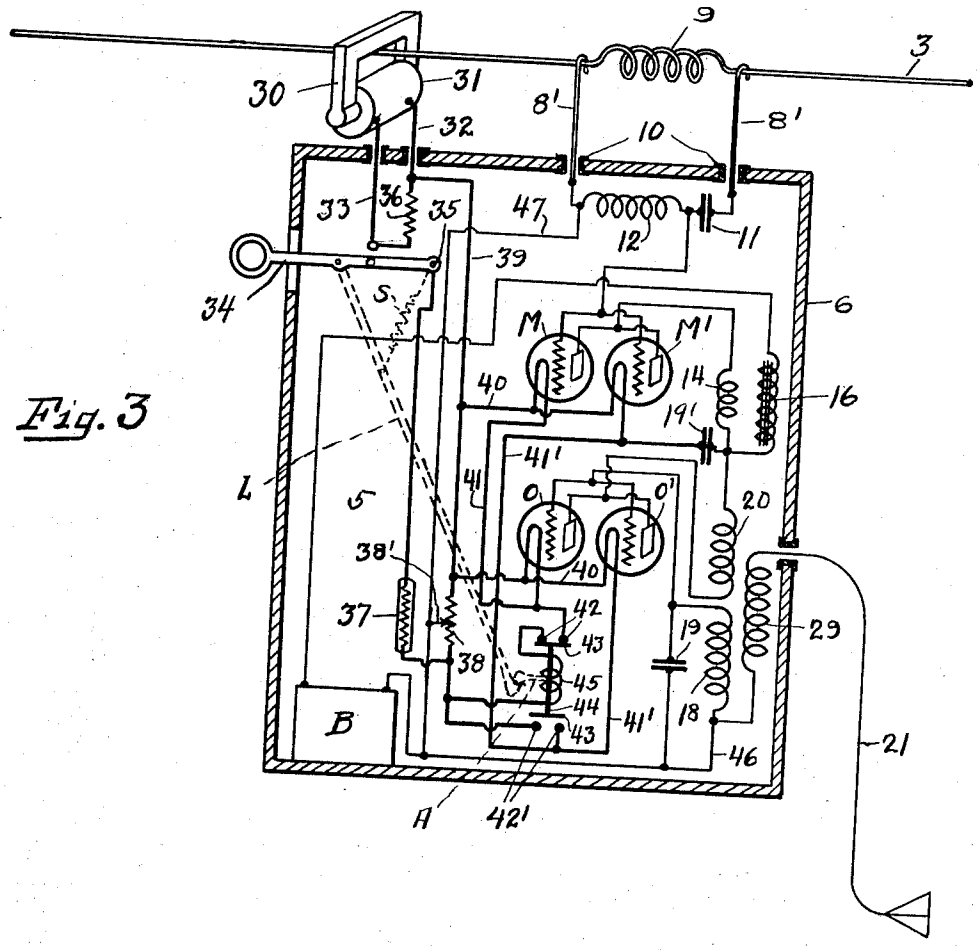


Fig. 3

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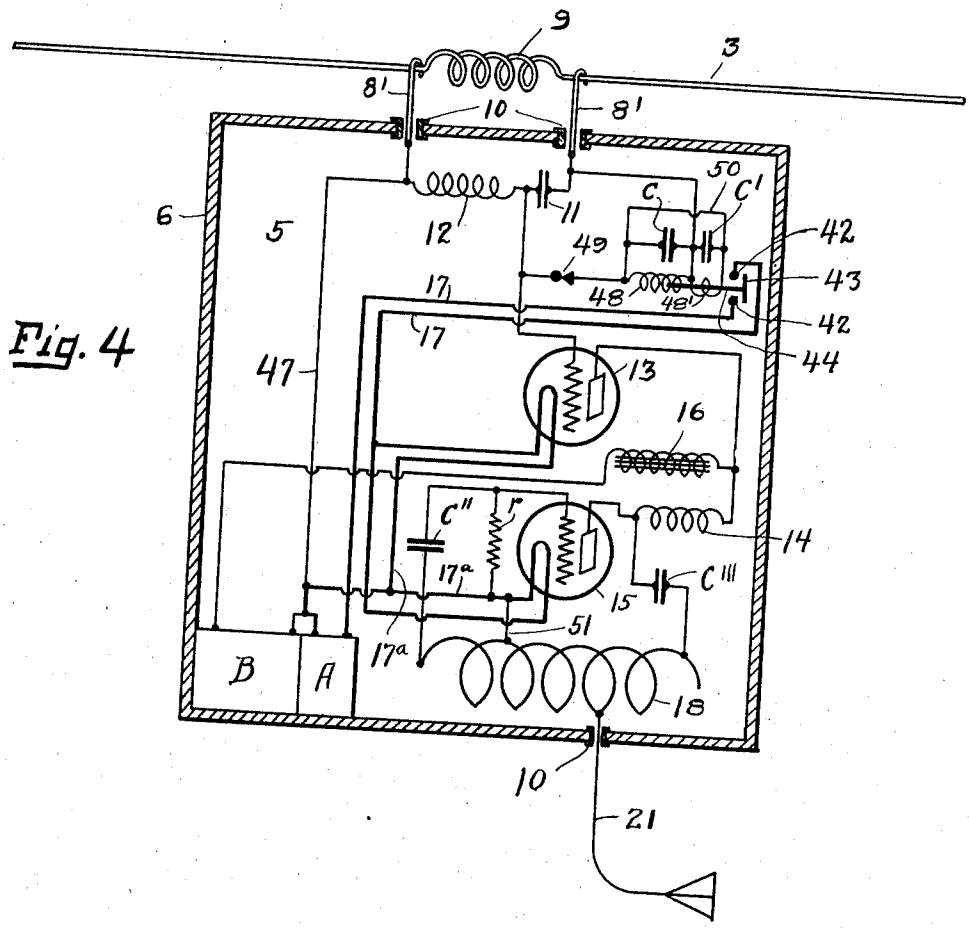
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4 Sheets-Sheet 4

Fig. 4



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UNITED STATES PATENT OFFICE

1,962,611

RADIO COMMUNICATION

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Application September 8, 1926, Serial No. 134,294

12 Claims. (Cl. 259—6)

I have invented improvements in radio communication; particularly the sending and receiving of radio messages. The invention aims to provide a method and apparatus by which messages can be conveniently and inexpensively sent along electric conductors extending over a greater or less distance to carry electrical current from one point to another, such conductors being generally known as electrical transmission lines.

A further object of the invention is to provide for the sending and receiving of wired radio messages over electrical transmission lines by apparatus comprising portable devices which can easily be connected to the transmission line at any desired point and operated to enable wired radio messages to be sent to that point and easily received anywhere within a prescribed radius of the vicinity thereof.

The nature of the invention is set forth in the following description, taken with the drawings which illustrate in preferred form the apparatus by which my invention is practiced, and in the appended claims the novel features of the invention are fully pointed out. But I of course reserve the right to make changes in the shape, size and arrangement of the parts or manner of proceeding that come within the principle of the invention, and are embraced within the meanings of the broad terms in which the appended claims are expressed.

On the drawings:

Figure 1 shows how radio messages may be sent along a power line to a given point and there distributed;

Figure 2 shows diagrammatically the kind of receiving set which is employed; and

Figures 3 and 4 are modifications of the apparatus shown in Figure 1.

The same numerals identify the same parts throughout.

Referring first to Figure 1, I show at 1 a pole or tower having a cross-arm 2 at the top to support the electric conductors 3 of a power transmission line, these conductors being suspended from the cross-arm 2 by strings of insulators 4. It is well-known that electric waves of high frequency will travel along such a line without interfering with the power which the line transmits. Through the medium of such waves messages can be sent and received at any desired point to which the line may extend. In practice, I arrange for the reception of messages individually along the line 3 at any desired number of points; the messages reaching the points in question and being there distributed through the vicinity, so that persons in the neighborhood of such points may receive such messages. One of such points of distribution is indicated in Figure 1, where 5 indicates local transmitting apparatus illustrated as being disposed in a casing 6, suspended from one of the conductors 3. For this purpose I hang a suspension bar 7 at the end of one string of insulators 4, and from the ends of this bar hang rods 8 which pass into the casing 6. These rods may be fastened rigidly to the casing and will be in contact with the adjacent conductor 3, as by having openings through which this conductor passes. Between the rods 8, the conductor 3 will be coiled up in the form of a winding 9. The casing 6 may be of any suitable material, but in the event that it is made of metal, the rods 8 will pass into it through insulating bushings 10, and the inner ends of these rods will be connected by a condenser 11 and coil 12 in series. Thus electric waves passing along the conductor 3 having coil 9 in the line thereof will set up oscillations in the local circuit comprising this coil with the condenser 11 and coil 12, and such oscillations can be radiated by the apparatus in the casing 6, so that the messages can be picked up by anyone for whom they are intended within a predetermined distance.

I prefer to make the appliances within the casing 6 radiate say from one thousand to two thousand kilocycles. The electric waves travelling along the conductors 3 will have a frequency of twenty to thirty kilocycles, and perhaps more, longer waves being more suitable for transmission along the wires, because they follow the wires and are radiated away from them to a less extent than the shorter waves. The apparatus in the casing 6 should therefore receive at twenty to thirty kilocycles or over, and radiate at a much shorter wave length. I further dispose in the casing 6 a modulator and oscillator so that the frequency of the oscillations on the conductors 3 can be converted and given a higher value as required.

The modulator is shown as having the form of a vacuum tube 13 with its grid connected to one end of the coil 12, and its filament connected to the other end of the coil 12 between same and condenser 11. The plate of the modulator tube 13 is connected to a choke coil 14 and thence to the plate or anode of the oscillator which likewise in the form of a vacuum tube and is shown at 15. The two heated cathodes of the tubes 13 and 15 are joined in parallel by two wires 17 running to a battery A. To the grid of the oscillator

tube 15 is joined a coil 18 at one point, the one extremity of this coil being united to the cathode of the tube 15, the wires leading from the coil to the grid and cathode of the tube 15 being bridged by a condenser 19, and in the line of the conductor joining the plate of the tube 13 and the choke coil 14 to the plate of the tube 15, is a coil 20 in inductive relation to the coil 18. The remaining extremity of the coil 18 is led out through the casing 6 to make pendant antenna 21. The battery B which energizes the anodes of the tubes 13 and 15 is connected at one extremity to the battery A and at the other extremity to an iron core inductance 16, connected to the conductor extending between the two plates at a point between the choke coil 14 and coil 20. At 19' is a condenser connected to the condenser 19, and to a conductor between the coils 16 and 20.

With this arrangement electric waves are picked up and used to modulate the output of the transmitting set within the casing 6. The tube 15 generates oscillations of one thousand to two thousand kilocycles, modulated by tube 13, to conform to the message sent on the longer wave of twenty to thirty kilocycles. From tube 15 these oscillations are passed to the antenna 21 and radiated throughout the vicinity.

The casing 6 and contents may be made up in the form of a convenient instrument to be hung at ten mile intervals along the line, so that men along the line supervising the insulation of it, or inspecting it, or keeping it in repair, can receive messages from the point of origin. The antenna 21 can transmit a distance of say one to ten miles from the sending instrument 6. This method affords a very important advantage over the usual device by which a portable set is usually connected to a temporary antenna in close proximity to the transmission line.

Figure 2 shows the circuits of a portable receiving set which can be carried about by a person to whom messages are to be sent, and used by such person to receive such messages say anywhere from a radius of a given number of miles from the antenna 21. This set includes a loop antenna 22 connected at its terminals to the grid and filament of a tube 23. Across the leads of this loop is connected a variable condenser 24. The anode of this tube 23 is joined to the primary of a transformer 25, the other end of this primary winding being connected through a lead *l* to a battery B. The secondary of this transformer is connected to the grid and filament of a second tube 23 and is shunted by another variable condenser 24. The anode of the second tube 23 is connected to the primary of a transformer, the remaining terminal of which is also joined to the lead *l*. The circuits leading from the loop antenna 22 to these tubes 23 and transformers 25 are tuned to receive at one thousand to two thousand kilocycles and from the second transformer 25 the impulses are passed to a detector tube 26. The secondary of this second transformer 25 is connected to the grid and filament of this detector tube and is bridged by a variable condenser 24. Between the tube 26 and transformer 25 is a leak resistance *r* and condenser *c*. From the anode of the detector tube 26 extends a lead to the primary of an iron core transformer 27, also connected to the lead *l*, and the secondary of this transformer 27 is joined to the grid and cathode of another detector tube 26. Across the secondary is a condenser 11 and this condenser and secondary are tuned to twenty to thirty kilocycles, and connected to the second detector tube 26 through a leak resistance *r* and condenser *c*, the same as the first tube 26. In the second tube 26 the electrical oscillations are detected at twenty to thirty kilocycles and from this second tube they are passed to another transformer 27. The plate of the second tube 26 is joined to the primary of a second transformer 27 which is also connected to the lead *l*, and the secondary of this second iron core transformer 27 is joined to the grid and filament of the last vacuum tube 26*a*, the anode of which is connected to a telephone receiver T, joined like the lead *l* to the battery B. Two leads 28 unite the filaments of all of the tubes in parallel and connect them to a battery A, which is also joined to the adjacent terminal of the battery B. Hence, the electric oscillations, by the time they reach the telephone receiver T, have been amplified and detected at two thousand to three thousand kilocycles, then amplified at twenty to thirty kilocycles and finally converted to audio frequency in the tube 26 so that the messages can easily be received by the receiver T.

Figure 3 shows another form of instrument for taking oscillations from the line wires and converting them from the lower to the higher frequency. The instrument comprising a casing 6 and apparatus therein is suspended from rods 8' which engage one of the line wires 3 at the two extremities of the coil 9. Over the line also is hung a closed magnetic core 30 of a transformer 31, to supply filament current. The terminals of this transformer are connected to wires 32 and 33, and the circuit of the current for the filament of the tubes is controlled by a switch 34, pivoted at its inner end 35 and connected to a shunt resistor coil 36 which is across the conductors 32 and 33 of the transformer core 31 when 34 is closed. This switch projects through an opening in the casing to the outside and terminates in an eyelet, so that it can be reached from the ground by a pole with a hook and moved up and down as desired. From the pivot 35 of the switch 34 extends a lead to an automatically adjustable resistance 37 to keep the current constant. The transformer 31 is put in operative relation by moving the switch 34 up so as to bridge over the space between the lower end of the lead 33 and the adjacent terminal of the shunt resistor 36. The current originating in the transformer 31 will be in proportion to the current in the conductor 3, and the resistor 36 and resistance 37 will keep the current through the filaments of the modulator and oscillator tubes constant. At 38 is another resistance coil, connected by lead 39 to the lead 32, between the coil 36 and transformer 31, and from this lead 39 extend wires 40 to the filaments of the modulator and oscillator tubes M and O. A conductor 41 also connects these filaments in parallel with each other to fixed switch contacts 42 bridged by a switch member 43 on a plunger 44 operated by a coil 45. This solenoid 45, when the switch contacts 42 are closed, is in series with the wire 41 and connects with the common terminal of the resistance 37 and resistor 38. The solenoid 45 has an arm A projecting therefrom, to be engaged by a hook on the lower end of the link L connected to the lever 34. A spring S attached to the arm and lever in the angle between them holds the hook on the link L in engagement with the arm A. Hence, when the lever 34 is moved upward, the plunger 44 is moved upward to make the switch member 43 bridge the contact 42. One terminal of the coil 12 is connected to the grid of the modulator

tube M, and the other terminal is connected to one terminal of the battery B, and by lead 38' to the center point of resistor 38. The anode of the tube M is connected through the choke coil 14 and an iron choke coil 16 to the positive terminal of the battery B. The anode of the oscillator tube O is connected through a tickler coil 20 to a point between the high frequency coil 14 and the iron coil 16. The grid of the modulator tube M is connected to the coil 12 of the pickup system, while the grid of the oscillator O is connected to the primary of the oscillating transformer 18. The opposite terminal of this transformer is connected to the negative end of the battery. The pendant antenna 21 is connected through the secondary coil 29 of the oscillation transformer to lead 46 on the negative side of the battery B. The other extremity of the coil 12 is also connected to lead 46. A condenser 19 bridges the coil 18, and an iron core inductance 16 is connected to a point between the coils 14 and 20, and the other terminal of the battery B. The lead which connects the coil 12 to the battery is shown at 47.

When the switch arm 34 is moved upward, current from the transformer 31 flows through the lead 39 to the filament of the tube M and the filament of the tube O, returning by way of contacts 42, solenoid 45, resistance 37 and the lead 33. The oscillations from wire 3 are used to modulate the output by means of the tube M. The modulations are applied to the oscillator tube O and the signals are thus converted to a higher frequency and then radiated from the antenna 31 which is inductively coupled to the instrument.

I provide a duplicate modulator tube M' and a duplicate modulator tube O'. The tubes M and M' have their grids and anodes connected in parallel, and so have the grids and anodes of the tubes O and O'. The filaments of the tubes O' and M' are united at one terminal to one terminal of the filaments O and M, and their other terminals are united by wires 41' to switch contacts 42' to be bridged by a member 43' at the lower end of the plunger 44. If in operation the filaments of the tubes M or O burn out, the coil 45 becomes partially de-energized so that the plunger 44 can drop and bridge the contacts 42', and thus the filaments of the tubes M' and O' can be heated. On the upward movement, the lever 34, as stated above, actuates the link L to lift the plunger 44 and bridge the contacts 42. This movement makes the lower end of the link L slip past the arm A, but the plunger 44 is now held up by the coil 45. If either of tubes M and O burn out and the coil 45 becomes de-energized, the plunger 44 can drop to bridge the contacts 42', and thus put the tubes M' and O' into circuit. Between the filament of the tube M' and the lead between the coils 14 and 20 is a condenser 19'. The rods 8' have hooks to hang the casing 6 on the conductor 3.

A further form of instrument for taking oscillations from the line 3 is shown in Figure 4, where the casing 6 and contents are hung as before on rods 8' from the wire 3. A lead 47, as before, connects one end of the coil 12 to common terminals of batteries A and B, and the other end is joined to the grid of the modulator tube 13. This instrument is arranged to be started by an impulse along the transmission line to operate a mechanical switch and close the filament circuits of the modulator and oscillator. The switch comprises two coils 48 and 48' in parallel, connected through a crystal detector to the terminal of the coil 12 which lies between the coil and the condenser 11. The common terminal of the coils 48 and 48' are connected to the opposite terminal of the condenser 11, or between this terminal and the rod 8' leading to the line 3. A condenser C bridges the coil 48. From the terminal of the coil 48 connected to the detector 49 a lead 50 runs to the terminal of the coil 48' opposite to that connected to the coil 48, and this coil is also bridged by a condenser C'. The coil 48 and associate condenser may be tuned to a frequency of say ten cycles, and the coil 48' and its associate condenser C tuned to say twelve cycles. The twenty kilocycle oscillations of the wire 3 which have been modulated at, for example, ten cycles are demodulated by the detector 49 to ten cycles to energize the coil 48. This coil will actuate a plunger 44, carrying a switch member 43 to bridge two fixed contacts 42. One of these contacts is connected by a wire 17 to the other terminal of the battery A, and the other contact is connected by wire 17 to the two filaments of the modulator tube 13 and oscillator tube 15. Conductors 17*a* join the other terminals of the filaments to the terminal of the battery A, joined to the battery B. Hence, when a ten cycle current passes through the coil 48, the switch member 44 will close the filament circuit, and the tubes 13 and 15 will be energized. The terminal of the coil 12, connected to the condenser 11, is united to the grid of the tube 13, the plate of which is connected through a choke coil 14 to the plate of the oscillator tube 15. The grid of this oscillator tube is connected through a condenser C'' to one terminal of the coil 18, united to a pendant antenna 21. The outside terminal of this coil is united through a condenser C''' to the plate of the tube 15, and a point between the extremities of the coil is united by a lead 51 to the filament of the tube 15. The terminal of the battery B opposite to that connected to the coil 12 is joined to the lead between the plates of the tubes 13 and 15 through an iron core inductance 16. A twelve cycle signal will take effect through the coil 48', which is wound in the opposite direction with respect to the coil 48, and move the plunger to carry the member 43 away from the contact 42. The circuit connected to the antenna is the well-known Hartley oscillating circuit. With the instrument shown in Figure 4, connection can be made with a transmission line at any desired point, and the apparatus can be moved at will.

The ten cycle calling signal and the twelve cycle disconnecting signal are transmitted as a modulation of the twenty or thirty kilocycle sending wave. Instead of the disconnecting signal, the plunger 44 may be pulled by a spring against the action of coil 48. When the ten cycle signal ceases, the plunger is pulled out and the filament circuit opened. In this latter case, coil 48' and condenser C' may be omitted.

Having described my invention, what I believe to be new and desire to secure and protect by Letters Patent of the United States is:—

1. A signaling system comprising a transmission line, means for superposing a modulated carrier current on said line, and a radio transmitting set operatively associated with said line to broadcast signals transmitted by the carrier and normally in inoperative condition, said set comprising means for receiving said carrier current, means controlled by said carrier current for automatically putting said transmitting set into operative condition and causing it to send out radio frequency waves, and means for modulating the

radio frequency waves in accordance with said modulated carrier.

2. A signaling system comprising a transmission line, means for superposing a modulated carrier current on said line, and a plurality of distantly separated radio transmitting sets situated along said line and coupled thereto to locally broadcast signals transmitted by the carrier, each set comprising a circuit tuned to the frequency of the carrier to be received, means controlled by said carrier for putting said sets into operative condition and automatically generating and sending out radio frequency waves, and means for modulating the radio frequency waves in accordance with said modulated carrier.

3. A signaling system comprising a transmission line having a modulated carrier current superposed thereon, a plurality of radio broadcasting sets situated at intervals along the line and associated therewith, means within said radio sets automatically actuated by the carrier current to put the sets in operative condition to broadcast locally, said radio sets comprising means for retransmitting modulations of said carrier at radio frequencies.

4. A radio signaling system comprising a plurality of radio broadcasting sets situated at intervals, a transmission line associated with said radio sets and having signal-modulated carrier currents impressed thereon, means within each of said radio sets responsive to the carrier currents to put the sets in operative condition, and means for modulating the outputs of said radio sets in accordance with the signals.

5. A signaling system comprising a plurality of radio transmitting sets situated at intervals, a transmission line associated with said transmitters and having a modulated carrier current superposed thereon, automatic means within said transmitters operable by the carrier current for putting the sets in communicative relation with said transmission line, and means whereby a signal transmitted by the carrier current over said line to the stations will be retransmitted therefrom through the medium of electromagnetic waves.

6. In a signaling system, a radio set comprising broadcasting apparatus normally in inoperative condition, a transmission line associated with said radio set and having a modulated carrier current superposed thereon, said set comprising means actuated by the carrier current to put the broadcasting apparatus in operating condition, and means to modulate the output of said set in accordance with the modulated carrier current received.

7. In a signaling system, a radio transmitting set operatively coupled to a transmission line, automatic receiving apparatus within the set adapted to close a circuit for broadcasting electromagnetic waves, said apparatus being responsive to a given carrier current superposed upon the transmission line, and means to modulate the output of the transmitting set in accordance with the modulated carrier current received.

8. In a signaling system, a plurality of radio sets comprising transmitting apparatus situated along a transmission line, means within the sets whereby said radio transmitting apparatus can be rendered operative to send out a given frequency, said means being responsive to a modulated carrier current of a given frequency superposed upon the transmission line, and means for modulating the output of the transmitter in accordance with the modulated carrier current received.

9. In a signaling system, a plurality of radio broadcast transmitters, a transmission line multiply associated with said transmitters, means for superposing a modulated carrier current upon the transmission line, means within the radio transmitters responsive to said carrier current for putting the same into communicative relation with the transmission line, and means within the transmitters for modulating their outputs in accordance with the modulated carrier current, whereby the carrier current signals can be sent out from all of said radio transmitters simultaneously.

10. A signaling system comprising a plurality of low powered radio transmitting sets each having a limited broadcast area, and situated at intervals along a transmission line and operatively associated therewith, means within each of said sets whereby the same can be rendered operative or inoperative for transmitting purposes, said means being responsive to a modulated carrier current of a given frequency superposed upon the transmission line, and means for modulating the outputs of said sets in accordance with the modulated carrier current to simultaneously broadcast from said sets the signals carried by the modulated carrier.

11. A signaling system comprising a transmission line having a carrier current superposed thereon, an inductance in series with the line, a transmitting set having a circuit tuned to the frequency of the carrier current to be received and connected across said inductance, means within the set responsive to the carrier current to put the set in operative condition to broadcast radio frequency waves, and means for modulating the radio frequency waves in accordance with signals carried by the carrier current.

12. The method of transmitting signals which consists in impressing a carrier current upon a transmission line carrying direct or low frequency currents, modulating said carrier in accordance with signals to be transmitted, receiving the modulated carrier at various points simultaneously along the line, converting said modulated carrier into radio frequency currents, locally broadcasting said signals at each of said points along the line, separately modulating said carrier, and causing the latter modulations to start and stop the conversion of carrier currents into radio frequency currents.

ALEXANDER NYMAN.