

May 10, 1932.

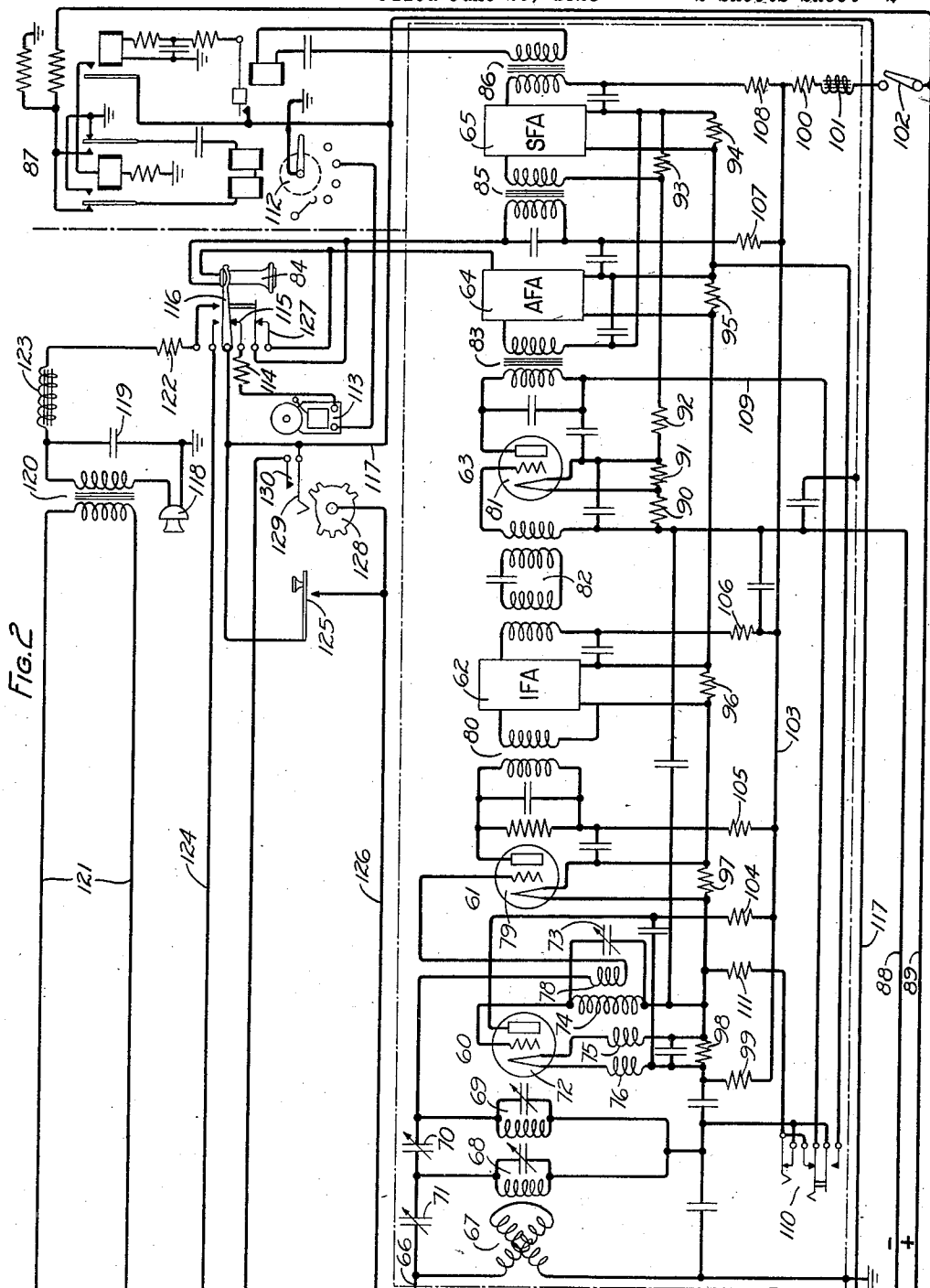
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1,857,819

RADIO TELEPHONE SYSTEM

Filed June 20, 1928

2 Sheets-Sheet 2



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RADIO TELEPHONE SYSTEM

Application filed June 20, 1928. Serial No. 236,352.

This invention relates to radio telephone systems and has for an object to simplify the calling or signaling circuits of such systems.

One method which has been found satisfactory for signaling in connection with radio telephone transmitters consists in generating an audio frequency calling tone and employing that tone for modulating the radio frequency carrier wave.

Heretofore, this method of signaling has required the use of a separate calling tone generator, or additional elements adapted to be associated with those included in the circuits of an amplifier or modulator and switching means for connecting the additional elements into the tube circuits, whereby the amplifier or modulator operates to generate low frequency oscillations which are used to modulate the carrier for calling purposes.

In the specific embodiment herein shown and described this invention comprises a radio telephone transmitter employing modulator circuits of the so-called Heising constant current type, disclosed in U. S. Patent 1,442,147, January 16, 1923. The radio frequency carrier current is generated by a space discharge oscillator, controlled by a piezo electric crystal, and amplified in an electric discharge amplifier.

Voice frequency waves are impressed upon the input circuit of an electric discharge modulator, the plate of which is connected to the plate of the radio frequency amplifier through a high frequency choke coil.

The amplifier and modulator are supplied with space current from a common source through a low frequency choke coil which operates to maintain constant the total direct current supplied to the amplifier and modulator.

When voice frequency waves are supplied to the input of the modulator, voice frequency currents are established in the output circuit and, due to the effect of the constant current choke coil, the current supplied to the space path of the amplifier is varied in accordance with the voice frequency currents, thus producing voice frequency variations in the amplitude of the radio frequency waves supplied to the antenna.

For call signaling purposes a relay is provided to connect a condenser in shunt to a portion of the low frequency or constant current choke coil and to connect the tuned circuit thus formed across the input electrodes of the modulator. In this manner the modulator is caused to produce oscillations in the audio frequency range which are used to modulate the radio frequency carrier in the same way as the voice frequency currents. Thus, a portion of the constant current choke coil is associated with a condenser and is transferred to the input circuit of the modulating tube which operates to generate a calling signal tone.

At the receiving station the telephone and calling signal receiving circuits are connected together and to the output of the radio receiver. The call signal receiving circuit is tuned to be sharply selective of the calling tone, while the switchhook for the telephone receiver is provided with a contact for short-circuiting the telephone receiver when the switchhook is down. This provides a very simple method of eliminating interference between the call signal and telephone receiving circuits.

The invention will be more readily understood by reading the following detailed description in connection with the drawings in which Figs. 1 and 2 placed end to end show a combined transmitting and receiving radio telephone system embodying the features of this invention.

Fig. 1 shows a radio telephone transmitter and Fig. 2 shows a radio telephone receiver both of which are adapted to be controllably connected to an antenna 1.

Power for energizing the tubes of the two circuits is supplied from a double current generator having a 400 volt armature 2 and a 24 volt armature 3.

The transmitter circuit comprises a piezo electric crystal controlled space discharge oscillator 4, a radio frequency amplifier 5 and a modulator 6.

The oscillator 4 is a shielded unit comprising a three-electrode vacuum tube 7 having a piezo-electric crystal 8 connected between its cathode and grid for controlling the fre-

quency of the waves generated. The piezo-electric crystal 8 is maintained at a substantially constant temperature by means of an electric heating coil 26 connected to the 24 volt armature 3 through a thermostat 27.

The primary winding 9 of an output transformer 10 is connected between the anode and cathode of the tube 7. The secondary winding 11 of the transformer 10 is connected to the three-electrode vacuum tube 12 employed in the amplifier circuit 5. One terminal of the secondary winding 11 is connected through a blocking condenser 13 to the grid of the tube 12. The other terminal of the winding 11 is connected through a neutralizing condenser 14 to the plate of the tube 12, and the mid-point of the winding 11 is connected to the cathode of tube 12. This type of circuit is disclosed and claimed in Rice Patent 1,334,118 of March 16, 1920. When the constants of the circuit are properly proportioned, the production of parasitic oscillations in the circuit of tube 12 is prevented.

The primary winding 9 of the transformer 10 consists of two coils placed one on each side of the secondary winding 11, the two halves being wound in opposite directions and connected in parallel aiding relation. A symmetrical winding arrangement of this kind results in a balancing of the capacity between the windings so that both ends of the secondary coil have the same capacity to ground. By the use of this type of transformer the adjustment of the neutralizing condenser 14 is made substantially independent of frequency over a comparatively wide range of frequencies.

The output circuit of the amplifier 5 comprises a tuned plate circuit for the tube 12 consisting of variable condensers 16 and 17 and inductance 18. Condenser 17 also serves as a coupling condenser to the antenna 1. A loading coil 19 and an antenna tuning condenser 20 are included in the antenna circuit. The modulator circuit 6 is of the constant current type disclosed and claimed in the above noted Heising patent. This circuit comprises a three-electrode vacuum tube 22 the grid and cathode of which are connected to the secondary winding of an input transformer 23.

The plate of the tube 22 is connected to the plate of the amplifier tube 12 through a high frequency choke coil 24.

Space current for the tubes 7, 12 and 22 is supplied through a low frequency constant-current choke coil 25 as hereinafter described in detail.

Heating current for the cathodes of tubes 7, 12 and 22 is supplied from the 24 volt armature 3.

The tube 7 is continuously energized to generate oscillations. Under normal operating conditions the power supply to the tubes 12 and 22 is disconnected, and heating current

is supplied to the cathode of tube 7 over the following circuit: From the positive terminal of the armature 3, through switch 28, resistance 29, resistance 30, left-hand contact and armature of relay 31, and cathode of tube 7 to the grounded negative terminal of the armature 3.

When the relay 31 is actuated by removing the receiver from the switchhook of the telephone set, as hereinafter described, the armature of relay 31 is moved to engage with the right-hand contact, so that the connection through resistance 30 to the cathode of the tube 7 is broken. When this occurs, heating current is supplied to the cathode of tube 7 as follows: from the positive terminal of the armature 3, through switch 28, resistance 29, cathode of tube 22, cathode of tube 12, right-hand contact and armature of relay 31, and cathode of tube 7 to the grounded negative terminal of armature 3.

Plate current for the tubes 7, 12 and 22 is supplied from the 400 volt armature 2 through an inductance-capacity filter which serves to suppress commutator ripples. The negative terminal of the armature is connected to the series cathode circuit through conductor 32 and resistances 33 and 34.

Space current is supplied to the tube 7 from the positive terminal of the armature 2 through filter 35, conductor 36, right-hand armature of relay 37, choke coil 25, conductor 38 and primary winding 9 to the plate of the tube, across the space path within the tube to its cathode and via ground 34a, resistances 34 and 33, conductor 32 to the negative terminal of the armature 2. When no signals are being transmitted the plate current supply for the tubes 12 and 22 is disconnected.

The system is provided with a push button. As will be hereinafter described, when the push button is actuated the relay 39 is energized to connect the transmitter to the antenna 1 by means of its upper contact, and its lower contact completes the circuit from the upper terminal of the retard coil 25 to the common plate circuit of the tubes 12 and 22. Resistance 43 and condenser 44 prevent arcing at the contacts of relay 39.

Resistances 33 and 34 are connected in the common space current circuits of the tubes 7, 12 and 22 between the negative terminal of armature 2 (through lead 32) and the series cathode circuit at ground 34a.

The grids of tubes 7 and 22 are connected to the terminal of resistance 34 nearest the negative terminal of armature 2 through retard coil 40 and resistance 41 in series for tube 7 and the resistance 50 for tube 22. The grids of these tubes are thus maintained at a negative potential with respect to the cathodes by the potential drop in resistance 34. Similarly, the grid of the tube 12 is connected to the terminal of resistance 33 nearest the negative terminal of armature 2 through retard

coil 42, maintaining that grid at a negative potential by the drop in both resistances 33 and 34. Condenser 51 provides a by-pass around resistances 33 and 34 for alternating currents.

The actual biasing potential applied to the grid of the tube 12 is increased by the voltage drop across the filament of tube 7 and the biasing potential applied to the grid of tube 22 is augmented by the voltage drop across the filaments of tubes 7 and 12.

To produce a calling signal tone the relay 37 is energized over a circuit to be hereinafter described. The operation of this relay transfers the positive high voltage lead 36 from the lower terminal of the coil 25 to the mid-terminal 45 thereof, connects the series circuit including condenser 46 and resistance 47 in shunt to the lower half of the coil 25, and connects the grid of the tube 22 through resistance 48 and stopping condenser 49 to the lower terminal of coil 25. Under these conditions, condenser 46 and the lower half of coil 25 form a resonant grid circuit for the tube 22, tuned to the required frequency for the calling signal, and a feed back connection is provided due to the coupling between the two halves of the coil 25.

The tube 22, therefore, operates as a tuned grid circuit oscillator producing the desired calling tone, which modulates the high frequency output of amplifier tube 12 in the same way as does the voice output of the tube 22 when it is operating as an amplifier.

The receiving circuit shown in Fig. 2 is of the double detection type comprising a heterodyne oscillator 60, a high frequency detector 61, an intermediate frequency amplifier 62, an audio-frequency detector 63, an audio-frequency amplifier 64 and a signal frequency amplifier 65.

The receiving circuit is connected to the antenna 1 through a conductor 66 and the upper contact and upper armature of relay 39. A variometer 67 is provided for tuning the antenna circuit. Two parallel resonant circuits 68 and 69 coupled through a condenser 70 provide high frequency selectivity. The selective circuits are coupled to the antenna through the condenser 71.

The heterodyne oscillator circuit 60 is of the type described and claimed in the co-pending application of H. T. Friis, Serial No. 104,619, filed April 26, 1926.

The oscillator circuit comprises the three-electrode vacuum tube 72, the plate and grid of which are connected together through a tuning condenser 73. An inductive winding 74 is connected in shunt to the condenser. Inductive windings 75 and 76 are connected in the cathode heating current leads and are closely coupled to the winding 74 to provide an effective connection between the winding 74 and the cathode. These windings also serve to maintain the alternating current po-

tential of the cathode above ground, thus permitting the rotary plates of the tuning condenser 73 to be maintained at ground potential, whereby the tuning of the oscillator may be adjusted without introducing disturbances due to the capacity-to-ground of the individual who makes the adjustment.

An output winding 78 loosely coupled to the winding 74 provides a means for introducing the oscillations generated in the oscillator 60 into the grid circuit of the tube 79 employed in the high frequency detector circuit 61. The output of the detector tube 79 is coupled to the input of the intermediate-frequency amplifier 62 through a transformer 80.

The intermediate frequency amplifier may comprise one or more amplifier stages. The output of the last stage is coupled to the grid circuit of a vacuum tube detector 81 employed in the audio-frequency detector circuit 63 through an intermediate-frequency filter 82. The output of the detector is coupled to the audio-frequency amplifier 64 through a transformer 83.

The output circuit of the audio-frequency amplifier 64 comprises a telephone receiver 84 and the primary winding of an output transformer 85 connected in series. The secondary winding of the transformer 85 is connected to the input of the signal frequency amplifier 65, the output of which is connected through a transformer 86 to the signal receiving circuit 87, to be hereinafter described.

Cathode heating current, space current and grid biasing potential for the tubes included in the receiving circuit are supplied from the high voltage armature 2, through the leads 88 and 89. The cathode heating circuit may be traced from the lead 88, through resistance 90, resistance 91 and cathode of tube 81 in parallel, resistance 92, resistance 93, resistance 94, resistance 95, resistance 96, resistance 97, resistance 98, resistance 99, lead 103, resistance 100, retard coil 101 and switch 102 to the positive lead 89. The cathodes of the tubes in the signal-frequency amplifier, audio-frequency amplifier, intermediate-frequency amplifier, high frequency detector and heterodyne oscillator are connected in shunt to the resistances 94, 95, 96, 97 and 98, respectively.

The plates of the oscillator tube, the high frequency detector tube, and the various amplifier tubes are connected to the lead 103, through the resistances 104, 105, 106, 107 and 108, respectively. The plate of the audio-frequency detector tube is connected through conductor 109, middle contact of jack 110 and resistance 111 to the common terminals of the resistances 97 and 98.

The grid of the oscillator tube 72 is connected to the negative side of the cathode of that tube to give a desired biasing potential. The biasing potential for the grid of the tube

81 is determined by the drop in resistance 90, that for the audio-frequency amplifier tube by the drop in the resistance 94, and that for the signal frequency amplifier by the drop in resistance 93.

Gain regulation is obtained by means of a circuit of the type disclosed and claimed in the copending application of Bruce, Serial No. 158,169, filed December 31, 1926. In this circuit, regulation is obtained by determining the bias on the grid of the high frequency detector tube 79 from the IR drop in the resistance 111 included in the plate circuit of the audio-frequency detector tube 81.

The connection from the grid of the tube 79 is made through winding 78, inductance coil of resonant circuit 69, upper contact of jack 110 to the terminal of the resistance 111, adjacent the plate of the detector tube 81. By means of this connection any increase in the strength of the received signal wave will tend to increase the plate current of the detector 63, thus raising the negative bias on the grid of the detector tube 79 and driving the operating point of that tube toward cut-off on its grid voltage-plate current characteristic.

By properly selecting the value of resistance 111, the audio-frequency current, supplied to the signaling devices 84 and 113, may be maintained substantially constant in spite of the fact that fading may cause the received high frequency wave to vary in amplitude over a relatively wide range.

The automatic gain regulator is rendered inoperative by inserting a plug in the jack 110, and the value of the biasing potential applied to the grid of the detector tube 79 is fixed. When the plug is inserted, the circuit through resistance 111 is opened, and the grid of the detector tube 79 is connected to the power supply circuit at the common terminals of the resistances 94 and 95 through the lower contact of jack 110. This procedure is desirable when the heterodyne oscillator 60 is to be adjusted.

The tone signal receiving circuit 87 is of the type described and claimed in Demarest et al., Patent 1,657,498 of January 31, 1928, to which reference is made for a more detailed description. When the combination of pulses to which the selector 112 is adjusted is received, the selector is stepped around to close a circuit from ground through its contact arm, winding of bell 113, resistance 114, contact 115 of telephone switchhook 116, conductor 117 to the positive terminal of low voltage armature 3. The bell 113 is thereby energized to indicate that the station is being called.

The telephone set comprises a transmitter 118, a receiver 84 and a switchhook 116. The alternating current circuit of the transmitter comprises condenser 119 and the primary winding of transformer 120. The secondary

winding of transformer 120 is connected through the leads 121 to the primary winding of the input transformer 23 of the amplifier 6 included in the transmitting circuit.

When the receiver 84 is removed from the switchhook, direct current is supplied to the transmitter 118 from the lead 117, through switchhook 116, resistance 122 and retard coil 123 in series. Simultaneously, operating current is supplied from lead 117, through the switchhook and lead 124 to relay 31, to energize the transmitting circuit. When it is desired to talk, push button 125 is operated to supply operating current to relay 39 from lead 117, through connection 126.

When the receiver is placed on the hook the above mentioned circuits are opened and contact 127 is closed to short circuit the receiver, so that it does not respond to received calling signals.

To initiate a call the operator removes the receiver from the switchhook and listens to make sure that the radio channel is not busy. The operation of the switchhook energizes the transmitting circuit as above described. After determining that the channel is free, the operator actuates the signaling key 128 which is provided with two contacts.

When the key 128 is actuated one of its contacts closes and remains closed to complete a circuit, while the other contact operates to intermittently close and open a second circuit in the desired sequence to supply code impulses corresponding to the station to be called.

The first contact, i. e., between the arm 129 and the drum of the key, is in parallel with the push button 125 and serves to complete the circuit through the antenna relay 39, whereby the transmitter is connected to the antenna 1.

The second contact, i. e., between the arm 129 and the contact 130, serves to complete the circuit of the relay 37 and thereby changes the connections of the amplifier 6. The amplifier is therefore caused to oscillate and generate the calling signal tone as above described. When the key returns to its zero position both contacts are opened and the antenna relay is released.

What is claimed is:

1. In a wave transmitting system an electric discharge device for supplying high frequency waves, a variable impedance device having an input circuit and an output circuit and arranged to supply low frequency waves for modulating the high frequency waves, a source for supplying current to the output circuit of said variable impedance device, an inductance coil connected in series with said source in said output circuit, and means for connecting a portion of said coil in the input circuit of said variable impedance device to produce a low frequency signaling tone.
2. In a wave transmitting system an elec-

tric discharge device for supplying high frequency waves, a second electric discharge device having an input circuit and an output circuit and arranged to supply low frequency waves for modulating the high frequency waves, a source of space current for said devices, an inductance coil connected in series with said source in the space current path common to said devices, and means for connecting a portion of said coil in the input circuit of said second device to produce a low frequency signaling tone.

3. In a wave transmitting system, an electric discharge device for supplying a carrier wave, a second electric discharge device having input and output circuits and arranged to supply a message wave for modulating the carrier wave, a low frequency inductance coil, a source of current for supplying space current through said inductance coil to the space current path of said second device, capacity means, and switching means for associating said capacity means with a portion of said inductance coil and for connecting the combined capacity and inductance in the input circuit of said second device to cause the generation of a low frequency signaling tone for modulating the carrier wave.

4. A radio telephone system comprising an electric discharge device for supplying a radio frequency carrier wave, a second electric discharge device having an input circuit and an output circuit and arranged to supply speech waves for modulating the carrier wave, a low frequency inductance coil, a source of current for supplying space current through a circuit including said inductance coil to the space current path of said second device, a condenser, a relay for associating said condenser with a portion of said inductance coil and for connecting the combined condenser and inductance to the input circuit of said second device to cause the generation of a low frequency signaling tone, and a signaling key for causing the operation and release of said relay in a predetermined sequence.

5. A radio telephone system comprising an antenna, a transmitting circuit, a receiving circuit, and a relay for controlling the connection of said circuits to said antenna, said transmitting circuit comprising an electric discharge device for supplying a radio frequency carrier wave, a second electric discharge device having input and output circuits arranged to supply speech waves for modulating said carrier wave, a low frequency inductance coil, a source of current for supplying space current through a common circuit including said inductance coil to the space current paths of said devices, a condenser, a second relay for associating said condenser with a portion of said inductance coil and for connecting the combined condenser and inductance in the input circuit of

said second device to cause the generation of a low frequency signaling tone, and a signaling key arranged upon the initiation of its operation to operate the first mentioned relay to connect the transmitting circuit to the antenna, and during its operation to alternately cause the release and operation of the second mentioned relay.

6. In combination, a telephone set comprising a telephone transmitter, a telephone receiver and a switchhook, an antenna, an electric discharge device for supplying radio frequency waves to said antenna, a second electric discharge device having an input circuit and an output circuit, connections from said transmitter to the input circuit of said second device, a source of current, an inductance coil through which space current is supplied from said source to said discharge devices, means for causing the low frequency output of said second discharge device to modulate the high frequency output of said first discharge device, switching means for connecting a portion of said inductance coil in the input circuit of said second device whereby low frequency oscillations are produced for signaling, a radio receiving circuit, a calling signal circuit selectively responsive to the calling signals to the substantial exclusion of waves of other frequencies, means connecting said calling signal circuit and said telephone receiver together to the output of said radio receiving circuit, and means operated by said switchhook for short-circuiting said telephone receiver when the switchhook is down.

In witness whereof, I hereunto subscribe my name this 18th day of June, 1928.

FRANCIS F. MERRIAM.