This Invention relates to radio apparatus and in particular to complete radio stations including transmitting apparatus and receiving apparatus.

An object of the present invention is to provide means through which the amplitude of the carrier frequency generated for transmission is controlled in accordance with the amplitude of the modulating frequency.

A further object of the present invention is to provide means associated with the signal modulating means and the carrier frequency generating means in the transmitter by which the amplitude of the carrier frequency generated is automatically controlled in accordance with the amplitude of the modulating frequency applied to the carrier frequency.

An additional object of the present invention is to provide means whereby the amplification factor of the receiver bears a definite predetermined ratio with respect to the amplitude of the modulating frequency in the transmitter.

Another object of the present invention is to provide means associated with the modulation frequency amplifier in the transmitter and with the radio frequency amplifiers in the receiver, whereby the amplification factor of the amplifiers in the receiver is automatically determined by the amplitude of the modulating frequency in the modulation frequency amplifier in the transmitter.

Another object of the present invention is to provide a novel transmitter and receiver in combination with novel control apparatus as briefly described above in which the weight of the entire apparatus is kept low by the elimination of the heretofore necessary heavy apparatus, as for instance choke coils having large iron cores, transformers, large power sources, etc.

Briefly, the first two objects are attained by the use of a biasing resistance in the grid-cathode circuit of the modulation frequency amplifier which is arranged to give self rectification of the signal frequency, in such a manner as to control the resistance of the anode cathode circuit of the modulation amplifier, thereby controlling the average potential applied from the anode of the modulation frequency amplifier to the element in the carrier frequency generator through which the carrier frequency is modulated in accordance with the signal frequency. This automatically controls the amplitude of the carrier generated.

An obvious advantage resulting from this arrangement is that there is a great saving in energizing current since the carrier frequency amplitude is low when the operator is not speaking and increases proportionately to the increase in amplitude of the modulating frequency impressed by the operator. This results directly in a reduction in size of the power sources necessary to energize the apparatus, and it is extremely important the weight of apparatus of this nature be kept as low as possible.

The second listed objects are attained by utilizing the potential fall in the resistance in the control electrode-cathode circuit of the modulation frequency amplifier referred to above to determine the potential of a control grid in the receiver or of the control grids in a tube or in tubes of the radio frequency amplifier circuits therein in such a manner as to prevent the radio frequency amplifiers from amplifying when the operator is speaking into the modulation frequency amplifier in the transmitter, and to insure that the receiver or the radio frequency amplifiers therein is or are highly responsive to signals received on the receiver antenna, when the operator is not speaking.

One advantage to be gained by the use of control apparatus of the nature described is that not only is the receiver rendered inoperative when the operator is speaking into the transmitter, but signals from the transmitter are prevented from reflecting back to the receiver and reaching the operator.

Numerous other advantages will become apparent from the reading of the following detailed description and therefrom when reading in connection with the attached drawing.

The invention may be used with any transmitter or receiver known heretofore but is particularly applicable to transmitters of the type disclosed in C. W. Hansell U. S. application No. 424,761, filed January 31, 1930.

The nature of the invention and the operation and utility thereof will be better understood by reference to the single figure in the drawing in which for purposes of illustration a transmitter T is shown at the left of the dotted line and a radio receiver R shown at the right of the dotted line.

It will be understood that the radio receiver and transmitter shown are merely shown for purposes of illustration since applicant’s novel method of apparatus for controlling the amplitude of the carrier frequency generated in accordance with the amplitude of the modulating frequency and method of and apparatus for automatically cutting off and on the receiver used, may be applied to other transmitters, as for instance, a transmitter of the type shown in copending application No. 424,761 filed January 31, 1930, and to any receiver in general use today, without de-
parting from the spirit of the present invention.

In the drawing, 1 indicates a thermionic oscillation generator, and 2 a modulation amplifier.

Anode potential is supplied to thermionic oscillation generator 1 through tank circuit 3 from a direct current source 4 which for purposes of illustration has been shown as a dynamotor or dynamotor generator, and from the same source 4 to the anode 5 of thermionic modulation amplifier 2 through a charging resistance 7. The anode cathode direct current circuits of the amplifier 2 and oscillation generator 1 are completed through bus bar 9 connected to the filament 10 and 11 of thermionic tubes 2 and 1 respectively.

Current from the source 4 is smoothed by means of a series inductance 14 and parallel condensers C1, C2 connected between the source 4 and the electrodes of thermionic tubes 2 and 1. The tank circuit 3 connected between the anode 5 and cathode 11 of thermionic oscillation generator 1 includes an inductance 15 tuned to the desired frequency by a variable condenser 16. This tank circuit may be associated with any type of antenna, as for instance, the double inductance 17 coupled through inductance 18 to the inductance 15 in the tank circuit. The frequency of the carrier wave generated in oscillation generator 1 is further controlled by a long line frequency control somewhat similar to the control disclosed in detail in James L. Finch et al. Patent No. 1,945,545, which is based upon United States application No. 363,660 filed May 16, 1929. The long line frequency control 19 is connected through a blocking condenser 20 to the grid 21 of the oscillation generator at one end and capacitively coupled to the aerial inductance 23 of the other end. This condenser 20 is coupled to the inductance 15 in the anode circuit of the thermionic oscillation generator 1.

As set forth in detail in application No. 363,660, filed May 16, 1929 if the line connecting the anode to the control electrode is made equivalent to an odd number of half wave lengths a potential variation on the anode will cause a corresponding potential change on the control electrode. There will be an 180° phase difference between said variations. This results in regeneration at the wave length chosen or the resistance and inductance which are maintained at constant frequency. In determining the electrical length of the line between the electrodes, the phase change in any condensers or inductive couplings in series with the line must be taken in consideration. As for example, in the present long line control, the line includes the condenser 20, lead 19, capacitive coupling between the terminal of 19 and inductance 18 and the coupling between 18 and 11. The sum total of the electrical length of this line should equal an odd number of half wave lengths to properly control the frequency of the oscillations generated. The tube capacity of thermionic generator 1 is tuned by means of a variometer 23 to give a resistive termination at the end of line 19 which should preferably be equivalent to the characteristic or surge resistance of line 19, so that the phase of radio frequency anode and control electrode voltage will be correct for the most efficient oscillation of thermionic generator 1.

Biasing potential is obtained for the control grid of thermionic oscillation generator 1 by using the characteristic or surge resistance of line 19, so that biasing potential drop in current, obtained by grid rectification, through a grid leak resistance R connected through a resistance or a second resistance R, between the filament 11 and control grid 21 of thermionic oscillation generator 1. The resistance R or resistance is of such a value as to prevent short circuiting of the radio frequency in the control electrode cathode circuit through the by-pass condenser 26 connected in parallel with resistance R. The biasing resistance R biases the control grid 21 of thermionic oscillation generator 1 to a point most suitable for oscillation generation.

The high frequency oscillations generated in thermionic generator 1 are modulated at voice frequency through the shield grid 27 which is connected to the anode 5 of modulation amplifier 2. Voice frequencies are impressed on the electrodes of amplifier 2 by means of the secondary winding 29 of a transformer 30 having its primary winding 31 connected to a microphone M. The secondary winding 29 of said transformer is connected through a biasing resistance R2 between the control grid 28 and filament 19 of amplifier 2. Alternating currents in the control electrode cathode circuit of the amplifier 2 are shunted around resistance R2 by means of a condenser C4. The resistance R3 is of such a value as to maintain the control electrode 28 of amplifier 2 at zero potential when the operator is not speaking. When the potential drop through the control electrode 28 of thermionic tube 2 is zero thermionic tube 2 has a low anode cathode space resistance. This results in a low potential being applied to the screen grid of the thermionic oscillation generator 1 and maintains the output of the oscillation generator 1 at a zero or a low value. When the operator speaks into the microphone thereby impressing modulating frequencies on the control electrode 28 of amplifier 2 the grid rectification action in amplifier 2 causes a direct current in the control electrode 28. The potential drop through R2 is applied in the control electrode of tube 2 impressing therefore a potential relative to the cathode of 2 which is proportional to the strength of the modulation frequency impressed on the input circuit of 2. This steady bias raises the average screen grid potential of the oscillation generator 1 and causes a carrier wave to be transmitted which is modulated by the voice of the operator. At the same time this biasing potential set up across R3 serves as a carrier for the amplification of the radio receiver which is shown at the right of the simple figure and which will now be described.

The radio receiver which is shown merely for purposes of illustration includes an aerial 50 connected through an inductance 51 to the bus bar 90. The inductance 61 forms the primary of a transformer having a secondary winding 52 connected between the control grid 53 and cathode 54 of the first radio frequency amplifier 56. Means for preventing electrical disturbances in aerial 50 from reaching the secondary winding 52 is provided in the form of an electrostatic screen 55 located between primary winding 51 and secondary winding 52, the screen 55 being grounded to the bus bar 90. The output circuit of the amplifier 56 includes an inductance 57 tuned by means of a condenser 58 connected through a resistance 60 and the power source to the anode 59 and cathode 54 of the amplifier 56. The resistance 60 in series with the power source 4 reduces the voltage to a value which is applicable to the anodes of the tubes used as the radio frequency input. The secondary winding 59 of amplifier 56 is connected through a coupling condenser 61 to the control electrode of a second radio frequency amplifier 63. This amplifier 63 is similar to the prior amplifier just discussed and further description thereof is thought unnecessary except
to note that the control electrode of the radio frequency amplifier 63 is supplied with biasing potential through an impedance 62 whereas the control electrode of the amplifier 56 is supplied with biasing potential through the secondary winding 53 of the transformer.

The voltage of the source 4 is rising to a value injurious to the current smoothing device or to the thermionic tubes when the oscillation generator 1 and amplifier 2 are operating. A resistance 68 is connected across the direct current line as shown, one terminal of the resistance being connected to the low voltage end of the resistance 60. Any radio frequencies present in the source 4 due to the oscillation in generator 2 are shunted around the resistance 68 by means of condenser 69.

The radio receiver may have several stages similar to the stages described above and the radio frequency amplifier stages may feed into any known form of detector.

The control electrode cathode circuit of each of the radio frequency amplifiers in the radio receiver comprises a potential source 64, lead 65, resistance 62 of the transmitter and thence through bus bars 9 and 90 to the cathodes of the respective receiver amplifier tubes.

The specific radio receiver and detector forms no part of the present invention and illustrations thereof other than as given above are thought unnecessary.

The input winding 52 of the amplifier 56 and the inductance 62 of the amplifier 63, connected to the control grids of the radio frequency amplifier 56 and 63 respectively, are connected through a biasing battery 64 to the terminal of resistance 64 described above in connection with the description of the transmitter T for a purpose which will now be set forth.

When the oscillation generator 1 is not being modulated at radio frequencies the potential of the grid of the oscillator generator 1 is maintained at zero and little or no carrier frequency is transmitted. The potential drop across the resistance 62 is small and the battery 64 applies to the control electrodes of the radio frequency amplifiers 56 and 63 respectively, a negative potential such that the amplification factor of each of the amplifiers in the receiver is high and signals are received in the radio receiver.

When the operator speaks the voice modulation current flowing in the control grid cathode circuit of the modulation amplifier 2 causes a relatively heavy direct current to flow through resistance R2 thereby causing a potential drop through R2. This potential drop is added to the potential applied by 64 to the control electrodes of the amplifiers in the radio receiver, and maintains said electrodes at a negative potential with respect to their cathodes to prevent reception of signals in said receiver. In other words, by application of a novel arrangement of the control electrodes of the radio frequency amplifiers are maintained at such a value that signals are not received while the operator is speaking but are received when the operator is not speaking.

To repeat briefly the operation of applicant's novel combination of transmitter, receiver and automatic control means therefore, assume the operator is not speaking into the microphone, no current is flowing in R4, the control electrode of the modulation frequency amplifier is at or near zero potential, the amplifier has low anode cathode resistance, the screen grid of the oscillation generator is at low potential and little or no carrier frequency oscillations appear in the output circuit thereof.

The receiver amplifiers are biased only by battery 64 and are sensitive to signals.

The operator now speaks into the microphone. Current flows in R4 biasing the control grid of the modulation frequency amplifier changes. The potential applied to the screen grid of the carrier frequency generator increases—carrier frequency oscillations are generated and radiated from the antenna circuit. Simultaneously a negative potential equal to the potential drop through R4 is added to the negative potential applied by the biasing battery 64 to the control electrodes of the amplifiers in the radio receiver. The control grids are maintained at such a value as to prevent reception of signals in the receiver.

Although for purposes of illustration I have shown the at present preferred form of my invention it must be understood that I am not to be limited by the descriptions as set forth in the foregoing specification but only by what appears in the appended claims.

I claim:

1. In signalling apparatus a transmitter including a thermionic oscillation generator, a low frequency thermionic modulation frequency amplifier having its anode connected to an electrode in said oscillation generator, means for impressing voice frequency between the input electrodes of said modulation frequency amplifier, a biasing resistance connected between the input electrodes of said modulation frequency amplifier, a radio receiver including thermionic tubes, means for applying a normal biasing potential to the control electrodes of the thermionic tubes in said receiver and means for altering the potential applied to the control electrodes of said tubes including a connection between the control grids of the tubes in the radio receiver and the biasing resistance in the modulation frequency amplifier in the transmitter.

2. A duplex signalling station comprising a transmitting aerial, a thermionic oscillation generator connected therewith, a voice frequency amplifier connected with said thermionic oscillation generator, a receiving aerial, a thermionic receiver including a plurality of cascaded amplifier stages connected with said receiving aerial, a resistance connected in series with the direct current input circuit of said voice frequency amplifier, for utilizing the potential drop in said resistance when the direct current components of voice frequencies flow therein to increase the amplification factor of said amplifier and render said oscillation generator operative when signal currents flow in said input circuit and a connection between said resistance and said receiver amplifier stages for rendering said receiver inoperative when signal currents flow in said input circuit.

3. A signalling station comprising a transmitter including a thermionic oscillation generator having coupled anode and control electrodes and an auxiliary electrode, a modulation frequency amplifier tube having its anode electrode connected with the auxiliary electrode of said thermionic oscillation generator to control the potential thereof, a modulation frequency responsive device connected in series with a resistance in the input circuit of said modulation frequency amplifier, a thermionic receiver including a plurality of cascaded amplifier stages having input and output circuits, and means comprising a connection between the resistance in the input circuit of said modulation frequency amplifier and the input cir-
4. A signalling station comprising a transmitting aerial, an oscillation generator of the thermionic tube type having its output electrode coupled with said aerial, a signal frequency amplifier having input and output electrodes and input and output circuits, signalling means in series with a resistance in the input circuit of said signal frequency amplifier, means connected with the output circuit of said amplifier for determining the conductivity of said oscillation generator, a receiving aerial, a thermionic receiver including a plurality of cascaded amplifier stages having input and output circuits, and a connection between the input circuit of one or more of said last named amplifier stages and the resistance in the input circuit of said signal frequency amplifier.

5. A signalling system comprising, a thermionic tube having high frequency input and output circuits in which oscillations to be modulated appear, a signal frequency thermionic amplifier connected with said tube and circuits for modulating the oscillations in said circuits, said thermionic amplifier having energizing circuits including a direct current input circuit, a receiver including thermionic signal repeating means, a resistance connected in said direct current input circuit of said signal frequency amplifier, means for utilizing the potential drop in said resistance when components of signal frequency flow therein to render said first named tube more efficient when signal frequencies flow in said input circuit, and a connection between said resistance and said thermionic repeating means in said receiver for rendering said repeating means inoperative when signal currents flow in said input circuit of said amplifier.

6. In combination, a constant frequency generator including a thermionic tube having input electrodes, output electrodes and an auxiliary electrode, said output electrodes being connected in an oscillation circuit, said input electrodes being connected to a linear conductor, a terminal of which is capacitively coupled to said oscillation circuit, said conductor being of a length to insure oscillations in said oscillation circuit of the desired frequency, a thermionic modulation frequency amplifier having input and output electrodes, a source of modulating frequency connected with said input electrodes, and a circuit between said output electrode of said modulation frequency amplifier and said auxiliary electrode in said first named thermionic tube for rendering said generator operative when the input of said modulation frequency amplifier is energized by modulating frequencies and vice versa.

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