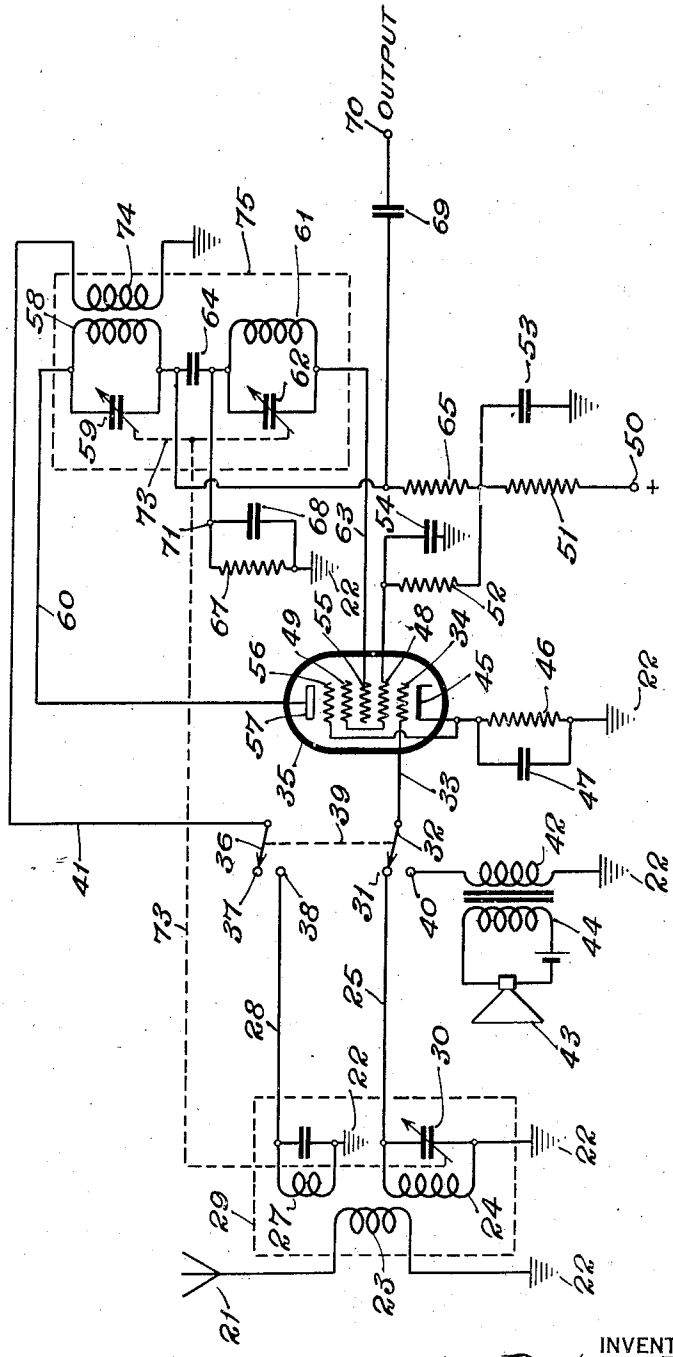
Jan. 2, 1945. R. H. GEORGE 2,366,329

ELECTRON TUBE CIRCUIT

Filed Dec. 31, 1942



INVENTOR

Roscoe H. George

BY W. B. Brueckmann

ATTORNEY

Patented Jan. 2, 1945

2,366,329

UNITED STATES PATENT OFFICE

2,366,329

ELECTRON TUBE CIRCUITS

Roscoe H. George, West Lafayette, Ind.

Application December 31, 1942, Serial No. 470,799

5 Claims. (Cl. 250—13)

This invention relates to electronic circuits, and particularly those of the amplifying detector type, and may also be considered as applying to circuits which are used in a transceiver device.

The apparatus and circuit herein to be disclosed is particularly adapted, however, for use in receiving arrangements where weak signal inputs are to be received and amplified, and wherein the receiving circuit is particularly sensitive. At the same time, the present invention is particularly desirable and useful as a detector and amplifier arrangement for use in aircraft and the like, where the detrimental effects of precipitation static, such as frequently practically disrupts communication, are substantially overcome.

Essentially, the invention herein to be disclosed comprises a single tube functioning primarily as a detector and oscillator arrangement for receiving the signals. The tube essentially is of the multi-electrode type having certain of the electrodes associated with an input circuit, in which there may or may not be a buffer tube, as desired, and having other electrodes of the tube connected with an oscillatory circuit which, in turn, is connected with the output portion of the tube.

When the device is used as a transceiver arrangement, provision is made for introducing modulation signals upon one cold electrode of the tube, and then feeding back energy from the oscillatory circuit connected to other cold electrodes of the tube, so that the feedback energy is supplied to the antenna.

Under such circumstances, provision is made for switching the control circuits by suitable switches ganged together, so that for periods of reception no feedback energy is fed to the antenna, and for periods of transmission no energy from the antenna is supplied to the control tube.

Accordingly, among the objects of the invention are those of providing a transceiver arrangement which is particularly sensitive in its operation and which is extremely simple to operate and construct.

Other objects of the invention are those of providing a signal receiving circuit and detector amplifying system which is particularly sensitive, and in which stations having weak power and located in the frequency spectrum nearby high power stations can be distinguished readily from the high power stations.

Other objects of the invention are to produce a simplified electronic tube circuit usable both for receiving and transmitting, which is highly efficient in its operation and which operates and is constructed in an extremely compact space.

Another object of the invention is that of providing a method and circuit with high selectivity for efficiently detecting signals at low level without the use of regeneration, and, at the same time avoiding the susceptibility to shock excitation of high "Q" circuits, which effects are particularly noticed and encountered, for instance, in the case of precipitation static arising in connection with aircraft.

Other objects and advantages of the invention are those of overcoming certain defects of the prior art systems as are known, and, at the same time, providing a highly efficient operating circuit.

Other objects and advantages will become apparent from a consideration of the following specification and claims when read in connection with the accompanying drawing wherein the single figure thereof schematically represents one form of the invention.

Referring now to the drawing, signals may be received or transmitted from an antenna arrangement 21 which is connected to ground 22 by way of the antenna coupling coil 23. Under conditions when signals are to be received, the antenna coil 23 serves as a primary winding of a transformer whose secondary is represented by the coil 24 which has one terminal thereof connected to the conductor 25, and the other terminal connected to ground at 22.

When the arrangement is used for transmission purposes, then the antenna coil 23 serves as a secondary winding and receives its energy from the coil 27 which has one terminal connected to a conductor 28 and the other terminal connected to ground at 22.

In well known manner, shielding, conventionally indicated by the dotted outline 29, is provided for all of the antenna and energy transfer coils.

Assuming now, that the arrangement herein disclosed is to be used for reception, then the coil 24 may be tuned by means of a suitable tuning condenser 30 connected in shunt therewith. The condenser 30 is preferably (although not necessarily) ganged to operate simultaneously with condensers 59 and 62, later to be described. With the coil 24 and condenser 30 tuned to any desired resonant frequency, it is apparent that energy may then be fed by way of the conductor 25 through the contact point 31 and switch arm 32 to a conductor 33 which feeds its energy to the control electrode 34 of the therm-

ionic device 35. Under such circumstances, and assuming conditions of reception, the switch arm 32 is in its upper contact position, as indicated, so that it rests against the contact point 31. Similarly, since the device is assumed, in the diagrammatic showing of the drawing, to be in a state for receiving energy, the upper switch arm 36 is also adapted to rest against its upper contact point 37 rather than against the lower contact point 38, so that here is provided an open circuit to the coil 27.

In order to ensure this state of operation for conditions of reception, the switch arms 32 and 36 are moved in unison by means of the uni-control, conventionally shown by the dotted line 39, so that both switch arms move together against either the upper or the lower contact points.

For conditions of transmission, obviously the switch arms 32 and 36 will rest against the lower contact points 40 and 38 respectively, so that energy from the conductor 41 may be fed to the coil 27, and, similarly, energy introduced into the transformer secondary 42, which has one terminal connected to the contact point 40 and the other terminal connected to ground 22 may be fed into the conductor 33 and thence, upon the control electrode 34 of the thermionic device 35. For this state of operation, input signal energy which, for purposes of illustration may be assumed to be voice energy or audible signals, is applied to the pick-up device, conventionally represented as the microphone 43, and fed by way of the transformer primary 44 into the transformer secondary 42.

Further reference to the transmitter form of arrangement later will be made. For the present, it is assumed that signals are to be received so that the switch arms, indicated at 32 and 36, are against the upper contacts 31 and 37, so that signals received at the antenna 21 will be fed to the tube 35 and there will be an open circuit to the winding (inductance) 27.

It will be seen that under some circumstances it may be desirable to provide for preventing any re-radiation from the system, which would be particularly desirable where energy was to be picked up from a station of very weak power which is radiating energy in the frequency spectrum in a region very close to that of a station nearby which radiates energy at relatively high power, and which latter station might even be so strong as to give ordinary power detection whether desired or not. Under such circumstances, it is obvious that a buffer tube may be inserted in the lead 25 between the resonant circuit comprised of the coil 24 and the condenser 30, so that received energy will be fed by way of an amplifier, not shown, into the thermionic device 35 and any re-radiation will be prevented. However, for purposes of illustration, the inclusion of the additional amplifier becomes completely immaterial.

Therefore, it will be assumed that the connections are as shown, and, accordingly, the cathode 45 of the thermionic device 35 is assumed to be connected by way of the cathode resistor or bias element 46 to ground at 22. In order to reduce detector action when listening to a weak station relatively near a strong one in the frequency spectrum, there is usually provided a capacity element 47 which bridges the cathode resistor 46.

The thermionic device, as indicated, comprises a plurality of cold electrode elements by which the incoming signals are normally supplied to the control electrode 34 which may be herein considered as the #1 grid. The #2 grid 48, under such circumstances, functions as the anode for the receiver section of the tube and is connected internally of the tube, preferably with the #4 grid 49.

In order to apply suitable operating voltage to the #2 grid, connection is made to the terminal point 50 whereat positive voltage, relative to ground potential 22, is applied. Such voltage is then fed by way of the resistors 51 and 52, which are bridged by suitable capacities 53 and 54 so as to apply the necessary operating potential to the electrode member 48. Under these conditions, signals passing beyond the electrode 48 are applied to the #3 grid 55, with the #2 grid 48 serving substantially as a virtual cathode for the second section of the tube which will now comprise, in addition to the electrode 48, the electrode 55, the electrode 49, the suppressor electrode 56 and the anode or plate element 57.

For the purpose of generating oscillations and to provide the necessary heterodyning action, suitable oscillatory circuits are connected between the anode or plate 57 and the electrode member 55. These oscillatory circuits comprise the combination of the inductance element 58 and the capacity 59 connected in parallel therewith, and which are connected to the anode or plate 57 of the thermionic device 35 by way of the conductor 60, and a second inductance element 61 and parallely connected capacity element 62, which is connected to the electrode member 55 by way of the conductor 63.

The opposite ends of each of the resonant circuits comprising the inductance 58 and the capacity 59, and the inductance 61 and capacity 62 are connected together by way of the condenser 64, and the inductance elements 58 and 61 are preferably coupled together.

Suitable direct current voltages for the plate or anode 57 are applied by way of the load resistor 65 which connects to the positive terminal 50 through the resistor 51.

In order to provide for by-passing high frequencies, and also to provide a bias for the electrode 55, there is connected a resistor element 67 between the upper end of the oscillatory circuit comprising the inductance 61 and the condenser 62, and the element 67 connects to ground 22, as indicated. The usual by-pass condenser 68 shunts the resistor 67, and output energy, as it is developed across the oscillatory circuit, may be then taken from across the load resistor 65 by way of the coupling condenser 69 connected to the output terminal 70, or, where an output of the opposite polarity is desired, output signals may be derived by coupling through a condenser, such as the condenser 69, to the terminal point 71 across the resistor 67, as indicated.

For simplicity of operation, the variable condensers 30, 59 and 62 are preferably ganged together and operate in unison by means of the uni-control schematically represented by the dotted line 73. This makes the circuits comprising the condensers 30, 59 and 62 and the inductances 24, 58 and 61 respectively all tune simultaneously, as indicated. Suitable shielding for the coils 58 and 61, as well as the pick-up coil 74 later to be described, is provided by the schematically indicated shielding 75.

Under conditions where it is desired to transmit from the system rather than to receive, the switch arms 32 and 36 are thrown against the lowermost contact elements or points 40 and 38

so that now the coil 24 and the condenser 30 are disconnected from the control electrode or #1 grid 34, and, instead, the pick-up device 43 is connected thereto.

Under these conditions, energy is fed from the inductance 58 to the resonant circuit comprising the inductance element and the capacity element 59, into the coil 74, with the inductance 58 serving as the primary and the coil 74 as the secondary, and thence, this energy, under such circumstances, feeds through the conductor 41, the switch arm 36 to the lower contact point 38 and into the conductor 28 to feed into the antenna 21 by way of the coupling provided between the windings 27 and 23 respectively. At the same time, modulation signals are applied to the control electrode 34 of the tube 35 by way of the pick-up device 43 and the transformer windings 44 and 42 through the contact point 40 to the switch arm 32, and thence, by way of the conductor 33, so that the energy output in the oscillator section of the tube, as it appears in the winding 74, will be modulated in accordance with the modulations appearing on the pick-up device 43. At the same time, however, no energy is fed from the winding 23 into the winding 24 which could be transferred to the control electrode 34 because the switch arm 32 is removed from the contact 31.

It is, of course, apparent that there is preferably a relatively tight coupling between the windings 58 and 61 and the resonant circuits 58 and 59 on the one hand, for instance, and 61 and 62 on the other hand should be tuned to approximately resonance with the signal frequency which it is desired to receive, and, accordingly, it will be seen that the received signal is really substantially in phase with the oscillator which is tuned to the carrier. However, even if the oscillator is not exactly tuned to the carrier, it will substantially lock in on the proper frequency, although beat frequencies may be developed. However, where the variance becomes too great, the oscillator will not lock in at the proper frequency of its own accord, and where beats are developed, then the beat frequency is high and is not heard. Wherever the oscillator locks in with the carrier, the output energy, as it appears at either the terminal points 71 or 70, is of a useful nature, and stations of relatively weak intensity, even though located in the spectrum relatively near high power stations, are readily distinguishable.

Considering now, further, the operation of the system and particularly the operation as applied to reception, the incoming signal, as selected by the tuned circuit 24—30, is fed through the conductor 25, the switch arm 32 and the conductor 33 to the #1 grid 34 of the tube 35. The portion of the tube including the #1 grid 34 and the #2 grid 48, which latter element acts as an anode for the first section of the tube, amplifies the signal. In this way, any electron current which passes through the #2 grid 48, where it can be acted upon by the #3 grid 55 of the oscillator circuit, already has the amplified incoming signal riding upon it. Consequently, if the oscillator circuit is tuned to approximately the same frequency as that of the received signal, there is a very strong tendency for the oscillator to lock in with the ripple on the electron current caused by the received signal energy. Under these circumstances, if the oscillator grid, that is, the #3 grid 55 in the tube 35, is suitably biased and the proper amount of energy is fed to it from the oscillator circuit, the plate current of the oscillator tube section will be driven to zero during the negative swing on the grid. During the positive swing of the oscillator grid, the plate current has the positive peaks of the amplified signal riding on it, and since the negative portion of the received signals has been eliminated, the signal is efficiently detected. Furthermore, if the oscillator grid is properly biased, it can be seen that amplification takes place, as in the first detector of a superheterodyne.

Therefore, with the arrangement disclosed, it is believed that the signal can be considered as twice amplified. At the same time, linear detection and high selectivity is provided, so long as the interfering signals are not sufficiently strong to cause detection action as the #1 grid 34 of the tube 35. The high selectivity occurs, it is thought, by virtue of the fact that good detection occurs only when the local oscillator is operating substantially exactly at the carrier frequency and in phase with the carrier.

Certain modifications of the invention of course are obvious and will become apparent to those skilled in the art to which the invention is directed, and it is believed that any and all of these modifications, such as fall fairly within the spirit and scope of what has herein been set forth, may be made provided they fall fairly within the scope of what is hereinafter claimed.

Having described my invention, what I claim as new and desire to have protected by Letters Patent is:

1. In combination, an antenna member, a multi-electrode thermionic device including a cathode, an anode and a plurality of additional cold electrodes, tuned input means to supply signal energy upon one of the cold electrodes of said thermionic device to control the electron current flow from the cathode to another of the cold electrodes, a feedback oscillatory circuit tuned to substantially the input frequency and connected between the anode and another of the cold electrodes of said thermionic device, a load circuit connected to derive energy from the oscillatory circuit, and means for influencing the current flow in the oscillatory circuit by electronically coupling the output signal energy from the said first portion of the thermionic device into the portion of the device influenced by the oscillatory circuit.

2. In combination, a receiving antenna member tuned to receive modulated signal energy of a predetermined frequency, a multi-electrode thermionic device including a cathode, an anode and a plurality of additional cold electrodes, means to supply the received signal energy upon one of the cold electrodes of said thermionic device to control the electron current flow from the cathode to another of the cold electrodes and thereby to provide an amplified signal output, a feedback oscillatory circuit connected between the anode and another of the cold electrodes of said thermionic device, means to tune the oscillatory circuit to a frequency substantially corresponding to that received, a load circuit connected to derive energy from the oscillatory circuit, means for subjecting the current flow in the oscillatory circuit to the influence of the amplified signal current to provide for detecting the signal current by electronically coupling the output signal energy from the said first portion of the thermionic device into the portion of the device influenced by the oscillatory circuit, and means to derive amplified-detected output signal energy from the load circuit.

3. In combination, an antenna member, a multi-electrode thermionic device including a cathode, an anode and a plurality of additional cold electrodes, a source of signal energy, means to supply signal energy from the source upon one of the cold electrodes of said thermionic device to control the electron current flow from the cathode to another of the cold electrodes, a feedback oscillatory circuit tuned to a predetermined carrier frequency connected between the anode and another of the cold electrodes of said thermionic device, a load circuit connected to derive energy from the oscillatory circuit, means to feed said energy to the antenna, and means for influencing the current flow in the oscillatory circuit by electronically coupling the output signal energy from the said first portion of the thermionic device into the portion of the device influenced by the oscillatory circuit whereby modulations of the carrier frequency energy are applied to the antenna.

4. In combination, a receiving antenna member tuned to receive modulated signal energy of a predetermined frequency, a multi-electrode thermionic device including a cathode, an anode and a plurality of additional cold electrodes, means to supply the received signal energy upon one of the cold electrodes of said thermionic device to control the electron current flow from the cathode to another of the cold electrodes and thereby to provide an amplified signal output, a feedback oscillatory circuit connected between the anode and another of the cold electrodes of said thermionic device, means uni-controlled with the tuning of the receiver circuit to tune the oscillatory circuit to a frequency substantially corresponding to that received, a load circuit connected to derive energy from the oscillatory circuit, means for subjecting the current flow in the oscillatory circuit to the influence of the amplified signal current to provide for detecting the signal current by electronically coupling the output signal energy from the said first portion of the thermionic device into the portion of the device influenced by the oscillatory circuit, and means to derive amplified-detected output signal energy from the load circuit.

5. In combination, an antenna, a multi-electrode thermionic device having at least a cathode, an anode and a plurality of cold electrodes, a first input circuit including a tunable resonant circuit to receive energy from said antenna, a second input circuit including a source of modulation signal energy, switching means to supply signal energy from one only of the said input circuits upon one of the cold electrodes of said thermionic device to control the electron flow between the cathode and another of said cold electrodes for signal energy amplification, a plurality of coupled oscillatory circuits connected to the anode and another of said cold electrodes of said tube whereby oscillations are produced by said tube in said circuits and the output signal amplified energy from the first portion of the tube is electronically coupled to influence the oscillations developed, a first load circuit and a second load circuit, said second load circuit being coupled to feed energy into the antenna, and a second switching means for connecting the second load circuit to the antenna during the time periods when the second source of signal energy is connected to the control electrode of the thermionic device and for disconnecting the second load circuit from the antenna at periods when the first of said signal input circuits is connected to the control electrode to supply energy from the antenna to the control electrode of said thermionic device.

ROSCOE H. GEORGE.