Aug. 20, 1940. L. H. PADDLE 2,212,182

RADIO RECEIVING APPARATUS

Filed Aug. 27, 1938

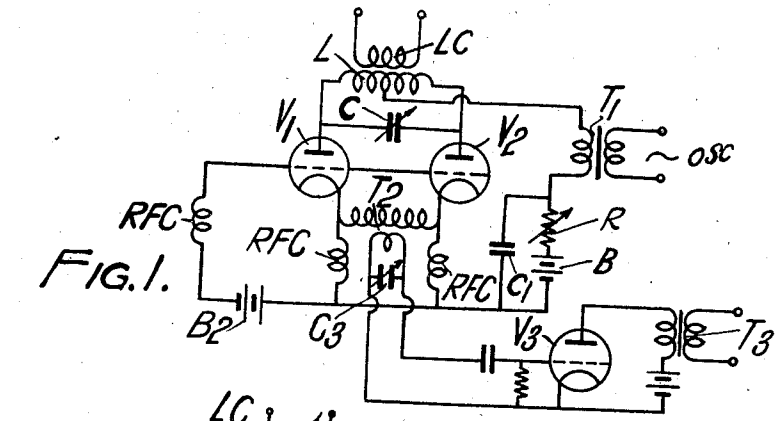


FIG. 1.

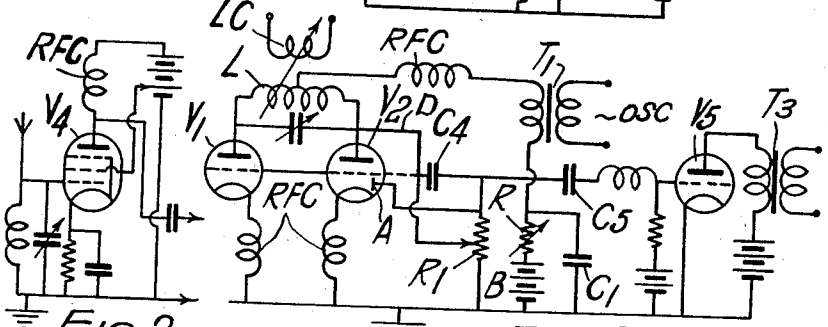


FIG. 2a.

FIG. 2b.

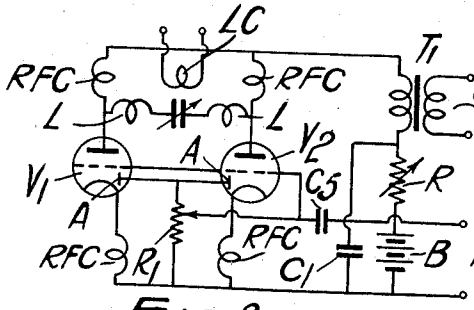


FIG. 3.

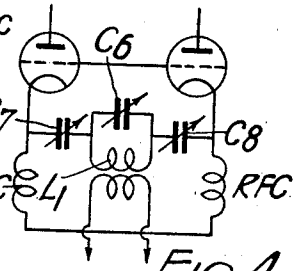


FIG. 4.

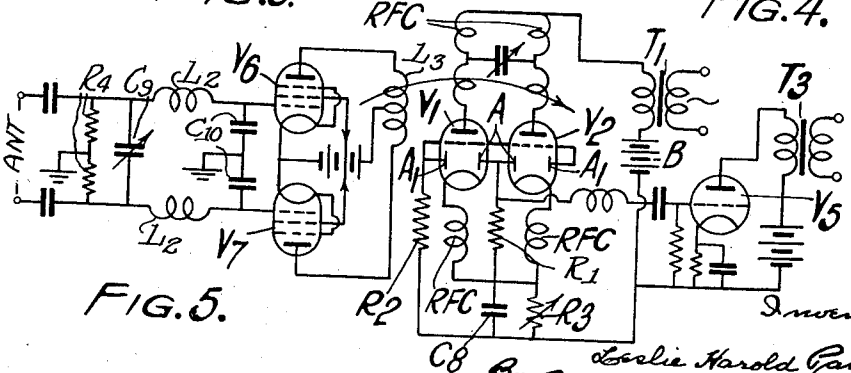


FIG. 5.

Inventor:
Leslie Harold Paddle,
By Potter, Pierce & Schaffler,
Attorneys.

Patented Aug. 20, 1940 2,212,182

UNITED STATES PATENT OFFICE

2,212,182

RADIO RECEIVING APPARATUS

Leslie Harold Paddle, West Norwood, London, England, assignor to Telephone Manufacturing Company Limited, London, England

Application August 27, 1938, Serial No. 227,205
In Great Britain September 2, 1937

11 Claims. (Cl. 250—20)

This invention relates to electrical communication systems, and more specifically to ultra-short wave radio systems employing super-regenerative receivers.

In receivers of this type, as is well known, a thermionic valve stage has input signals applied to a circuit thereof the resistance of which is made nearly zero or in some cases slightly negative, and the resistance of this circuit is then cyclically varied—by means of a further oscillation—between a slightly positive and a slightly negative value. The operation of the circuit is not clearly understood, but it is generally accepted that during the one half cycle of the further oscillation, which for the sake of convenience may be identified as the quenching oscillation, the circuit has a negative resistance, during which time the amplitude of the input signals is building up to a limiting value determined by valve saturation and circuit conditions, during the succeeding half cycle of the quenching oscillation the stability of the circuit is restored by the resistance of the circuit being made positive. The output of the valve stage includes, however, a signal which is the original modulation frequency of the input signal.

While this may represent the operation of such a receiver on certain frequencies, it is believed that on ultra-high frequencies, that is above 30 megacycles per second, there is a secondary effect which takes place and modifies considerably the operation of the stage.

Since the input circuit is invariably oscillatory it follows that the building up of the voltage in the circuit to the limiting value occurs gradually with each cycle of the input signal during the half cycle of the quenching oscillation, and it seems therefore that the circuit does not reach the limiting condition of saturation sufficiently rapidly to destroy the characteristic modulation; it will be apparent that no modulation output can be obtained once this limiting value is reached. This is borne out by the observed fact that if too high a quenching voltage is used, causing saturation at an early point in the quenching cycle, the output becomes distorted.

On the other hand, when using the super regenerative receiver on ultra short wavelengths it is believed that saturation is much more rapidly reached and that this accounts for the fact that when a super regenerative receiver is used on these wavelengths there is a diminished output when the input circuit is accurately tuned to the incoming signal. It is found that there are two or more tuning points, separated from the position of true resonance.

It is believed that in the ordinary receiver this saturation effect is normally allowed to appear, and the system operates by virtue of a beat effect or heterodyne between the local quench oscillation and the input signal, the heterodyne being demodulated within the valve to obtain the desired signal and not, as is generally supposed, the signal itself.

According to the present invention, therefore, there is provided a system which takes advantage of the true super regenerative effect on these ultra high frequencies, and the invention consists of a receiving device comprising a thermionic valve, means for supplying a desired signal to a circuit associated with said valve, the resistance of said circuit being low or zero, means for cyclically varying the resistance of said circuit through zero, an output circuit from said valve responsive at the frequency of the desired signal and a demodulator or the like fed from said output circuit.

With the present invention there is provided a receiver of the type in which one (or more) valves are employed and which are brought to the point of oscillation by means of an external inductance or tuned circuit operating in conjunction with the internal capacity of the valves. Preferably two (or more) valves are employed and are brought to the point of oscillation by the connection of an inductance between the two anodes and a small or preferably negligible inductance between the grids, or vice versa. Means are also incorporated whereby, through the Miller effect in the valves, regeneration takes place; such means may consist of chokes or tuned circuits included in the cathode leads of the valves. An oscillating voltage is also impressed upon the valve or valves, this voltage for maximum sensitivity being such that the circuit operates in a super-regenerative manner, that is the circuit is alternately caused to stop and start oscillating at signal frequency in accordance with the oscillating or quenching voltage of lower frequency.

According to a further feature of the invention, in a receiver of the type described, demodulation is obtained by electrodes associated with the detector stage itself, and preferably there is arranged within the envelope of one or both of the two valves an auxiliary anode which operates with the cathode to form a demodulator; moreover this auxiliary anode is arranged with its circuit so that the direct current component of

its rectified output, or a part thereof, is impressed upon the grid or grids of the valves.

According to another feature of the invention, in a circuit of this general type there is employed in conjunction with the valve stage two demodulating or rectifying devices, one of which is used to derive the demodulation component of an applied signal and the other is used for the purpose of controlling the grid potential in order to obtain an automatic gain control operation.

In the accompanying drawing there are shown circuit diagrams of radio receiving systems incorporating the present invention, which are given by way of example only as indicating some of the possible forms of the invention.

In the embodiment of the invention shown in Figure 1 use is made of thermionic valves which are arranged in the manner disclosed in Patent No. 2,067,679, whereby the valves tend to oscillate. The anode-grid paths are in series, and an inductive element is included in the series circuit so formed. In this specific example use is made of two valves V_1, V_2 having their anodes joined to the terminals of an inductance L, tuned by means of a series or, as shown in Figure 1, a parallel variable condenser C, the grids of the valves being directly joined. The cathodes of the valves are connected through impedances, preferably chokes RFC which permit them to oscillate relatively in potential. The input circuit, for example the aerial, is coupled by means of the mutual inductance of a coupling coil LC adjacent the anode coil L. The regeneration which takes place in this valve stage is controlled by variation of the anode supply voltage from battery B by means of a resistance R, a by-pass condenser C_1 being included. Also included in the anode supply circuit is a means, such as the secondary winding of a transformer T_1, by which a quenching oscillation from a local generator OSC may be impressed upon the valve stage. Thus the valves may be brought to a condition of incipient oscillation and then periodically brought into oscillation and non-oscillation by the application of the quench signal.

The grid circuit of the valves is completed through an impedance such as RFC and a bias battery B_2.

The output from the stage is obtained by means of a transformer T_2 arranged between the cathodes of the valves, the secondary winding of the transformer, tuned to the frequency of the desired signal by condenser C_3 or not, as desired, feeding a grid leak demodulator valve V_3 from which the modulations of the original signal are obtained by an output transformer T_3.

It is found that this circuit provides an excellent degree of automatic gain control, and one which is very satisfactory in operation. For example, it has been found possible to obtain an output constant to within half a decibel over an input range of 26 decibels.

In the embodiment of the invention shown in Figure 2*b* the receiver comprises two valves which are arranged in the manner described above, one or both of the valves having an auxiliary anode A arranged in association with the cathode so as to provide a diode rectifier therewith. Input is applied from a receiving aerial to the inductance arranged between the anodes or, preferably, the received signal is applied to a buffer amplifier valve V_4 of the screen grid acorn type, Fig. 2*a*, the output of which is applied across the choke RFC connected in the cathode lead of the valve V_1.

The output from the valves V_1 and V_2 is applied from either the anode of the valves or from the grids to the auxiliary anode A, through a suitable condenser C_4 if necessary, and a load resistance R_1 is arranged between the auxiliary anode and an "earthy" point of the receiver. The auxiliary anode A may be fed from the anode of valve V_2 by connecting condenser C_4 to the anode by the lead D. Whether the auxiliary anode A is fed from the anode or the grid of valve V_2, the unidirectional voltage produced across this resistance R_1 or a part thereof is then fed back to the grids of the valves with decoupling if necessary. The alternating voltage appearing across the load resistance R_1 and representing the modulation component of the received modulated carrier wave signal is fed through a condenser C_5 to the grid of a suitable amplifying valve V_5 or other output circuit.

If desired, an auxiliary anode may be incorporated in each valve and push pull demodulation used. An example of such an arrangement is shown in Figure 3. This circuit is generally similar to that shown in Figure 2*b* except that a series tuned anode circuit is used and that the demodulating diodes are fed from the cathodes. With this circuit the two anodes A are joined together and the load resistance R_1 is connected between the anodes and "earth" as before. It will be remembered that the cathodes of the valves V_1 and V_2 are out of phase. When one anode is positive with respect to its associated cathode (and is then passing current) the other anode will be negative with respect to its associated cathode and at that instant the anode-cathode capacity of the passive diode will feed voltage to the conducting diode. At the next half cycle the position will be reversed, but the current through the load resistance will be in the same direction at all times.

It will be appreciated that in some circumstances a direct electrical connection exists between the auxiliary anode and one of the grids for example, if the whole of the voltage across the resistance R_1 is applied permanently to the grid; in such a case it may be possible for the anode to be physically associated with the grid.

As an alternative to taking the output from the grids or anodes of the two valves, a tuned circuit may be connected between the cathodes as indicated in the fragmentary circuit diagram of Figure 4, the circuit forming the output impedance. This tuned circuit may conveniently consist of a parallel tuned circuit L_1, C_6 in series with two small condensers C_7, C_8. Such a circuit may be adjusted to give a very sharply tuned output load. Figure 4 may be used either with a separate demodulator valve as shown in Figure 1, or with the auxiliary anode demodulation described with reference to Figures 2*b* and 3.

Figure 5 illustrates an embodiment of the present invention in which there is provided a valve stage comprising two triode valves V_1, V_2 as before but each valve includes two auxiliary anodes A, A_1 associated with the cathode thereof. Two of the auxiliary anodes, one in each valve, are joined and are returned through a load resistance R_1 to an "earthy" point of the cathode circuits, for example to the common, low potential ends of the chokes RFC included in the cathode leads. One or both of the second pair of anodes are connected to the grids and are also connected, through a second load resistance R_2,

to a point of the circuit negative with respect to the mean potential of the cathodes; for example a variable resistance R_3, shunted by a condenser C_8, may be arranged between the low potential ends of the cathode chokes and the negative terminal of the high tension supply B, and the second load resistance R_2 is then returned to the negative terminal of the variable resistance.

The circuit is believed to operate in the following manner: The two valves are brought to the point of incipient oscillation by virtue of the anode-grid feed-back as previously described, and the oscillation is periodically initiated and quenched by the applied quenching oscillations, and a highly sensitive amplifying condition is thereby produced. When a modulated carrier wave signal is applied to the stage the first pair of anodes serves to produce the modulation component of the signal, which appears across the load resistance R_1 and which may be passed to a subsequent amplifier. As with the circuit of Figure 3 this demodulation occurs by virtue of the fact that the cathodes operate in opposite phase, and when one anode is not passing current the capacity between it and its cathode serves to feed the other anode, which is then passing current.

The second pair of anodes is directly connected to the grids and these anodes operate to rectify the signal on said grids. The direct current component of rectification which appears across the associated load resistance R_2 is impressed as a bias upon the grids, so as to provide automatic gain control. However, owing to the fact that the load resistance is returned to a point negative with respect to the cathode such rectification occurs only when the signal between grids and cathodes exceeds a figure determined by the value of the negative bias. The variable resistance R_3 thus affords a means by which the initial gain of the system may be controlled (as it controls the grid potential) and it also controls the "delay" voltage of the automatic gain control system.

The second pair of anodes have been described as being directly connected to the grids, but if desired they may be fed from any appropriate point of the circuit, for example from a main anode or the grids through an isolating condenser, and the rectified voltage may be applied from the load resistance to the grids through a decoupling circuit.

In feeding a circuit of the type described from an open aerial it is sometimes found that the aerial constants are reflected into the stage, giving rise to certain small difficulties. To overcome these, there is arranged a buffer stage consisting of a pair of "acorn" pentode valves V_6, V_7 connected in a conventional push-pull amplifier circuit, between the aerial feeder and the super-regenerative stage. The valves V_6, V_7 are fed from input terminals ANT through a tuned, balanced input circuit comprising inductances L_2, L_2 and tuning condenser C_9. The grids of the valves are balanced with respect to earth by condenser C10, C10 and the direct current grid-cathode paths of the valves are completed through resistances R_4. An output inductance L_3 is coupled to the tuning inductance of the valves V_1, V_2.

With the circuit described it has been found that the anode current is very small—considerably less than one milliampere—and it has been possible to dispense with a high tension supply and to use only the applied quenching oscillation for producing the necessary anode current.

What I claim and desire to secure by Letters Patent is:

1. A radio receiver comprising at least two thermionic valves each having a grid and an anode electrode cooperating with a cathode electrode, circuit elements connecting the anode-grid paths of said valves in series in a circuit resonant at a desired signal frequency, a quenching oscillator circuit and a signal input circuit coupled to said resonant circuit, impedance connected between the cathodes of said valves to permit the development of an oscillatory potential between said cathodes, a signal frequency output circuit connected to the like electrodes of two valves, and a demodulator fed from said output circuit.

2. A radio receiving system as claimed in claim 1, wherein said output circuit is connected between the cathodes of the tubes.

3. A radio receiving system as claimed in claim 1, wherein said output circuit comprises a transformer tunable to the signal frequency and connected between the cathodes of the tubes.

4. A radio receiving system as claimed in claim 1, wherein said demodulator comprises an auxiliary anode within one of said valves and cooperating with the cathode electrode thereof to form a diode rectifier.

5. A radio receiving system as claimed in claim 1, in combination with means for automatically varying the bias on a grid electrode in accordance with the magnitude of the incoming signal.

6. In a super-regenerative radio receiver, a pair of thermionic valves each including a grid electrode and an anode electrode cooperating with a cathode electrode, an auxiliary anode in at least one of said valves and cooperating with the cathode thereof to form a diode rectifier, a circuit resonant at a desired signal frequency and including the grid-anode paths of said valves in series, a quenching oscillator circuit and a signal input circuit coupled to said resonant circuit, circuit elements of high impedance at signal frequencies connected between said cathodes, and an input circuit for said diode rectifier connected to one of the electrodes of at least one of said valves.

7. In a super-regenerative receiver, the invention as claimed in claim 6, wherein said rectifier input circuit is connected to an anode electrode.

8. In a super-regenerative receiver, the invention as claimed in claim 1, wherein said rectifier input circuit is connected to a grid electrode.

9. In a super-regenerative receiver, the invention as claimed in claim 6, wherein said rectifier input circuit is connected through said circuit elements to both cathodes.

10. In a super-regenerative receiver, the invention as claimed in claim 6, wherein both of said valves have an auxiliary anode, and the auxiliary anodes are both connected to said rectifier input circuit.

11. In a super-regenerative receiver, the invention as claimed in claim 6, wherein there is an auxiliary anode in the other valve for cooperation with the cathode thereof to form a second diode rectifier, in combination with a signal frequency output circuit for both valves and working into said second diode rectifier, and means biasing the anode of the second diode rectifier negatively with respect to its cathode.

LESLIE HAROLD PADDLE.

CERTIFICATE OF CORRECTION.

Patent No. 2,212,182. August 20, 1940.

LESLIE HAROLD PADDLE.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, second column, line 54, claim 8, for the claim reference numeral "1" read --6--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 1st day of October, A. D. 1940.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)