Oct. 8, 1929. J. F. FARRINGTON ET AL 1,730,605

SIGNAL RECEIVER

Filed July 27, 1923

Fig. 1.

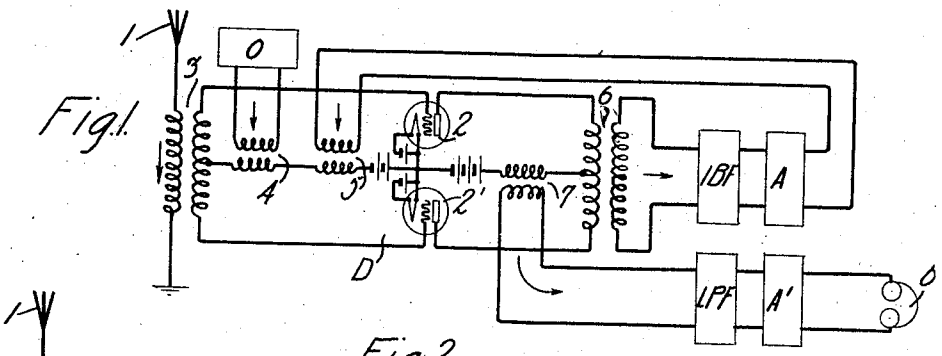


Fig. 2.

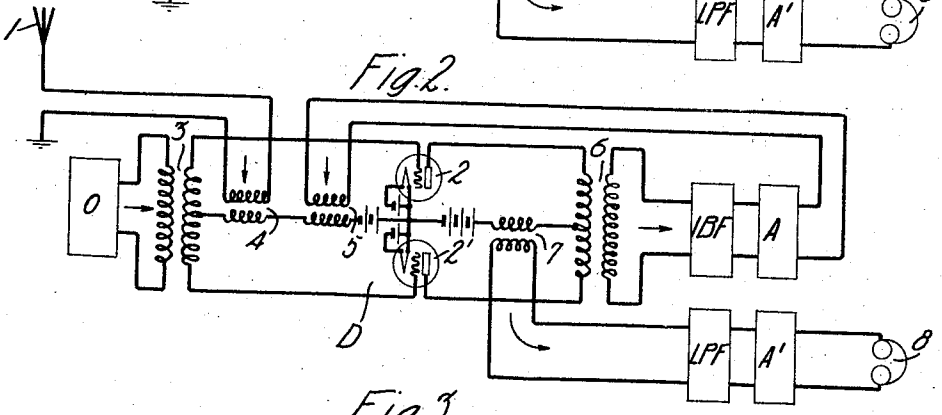


Fig. 3.

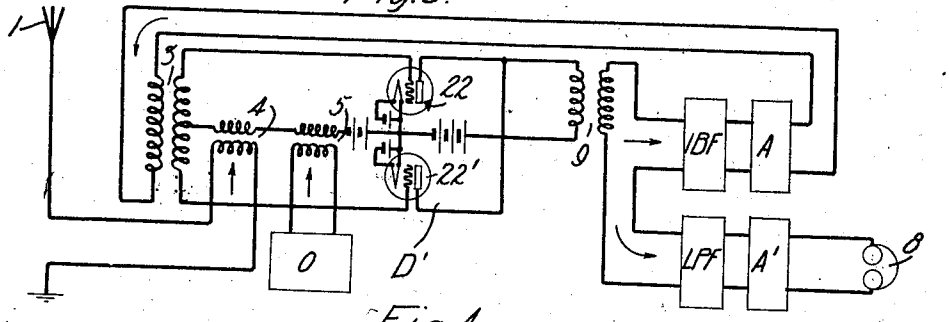
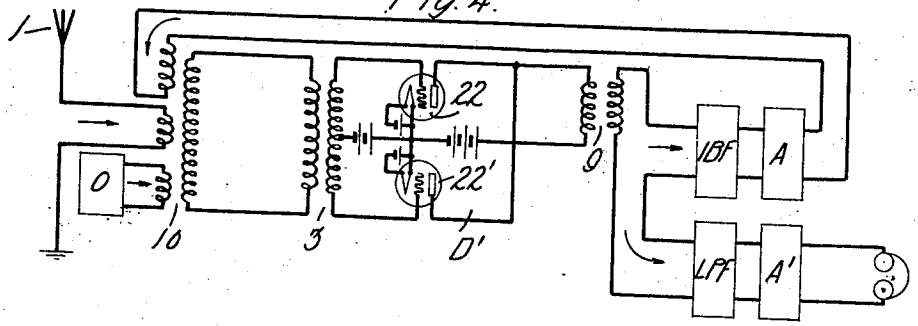


Fig. 4.



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1,730,605

UNITED STATES PATENT OFFICE

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SIGNAL RECEIVER

Application filed July 27, 1923. Serial No. 654,104.

This invention relates to a signal receiver.

More particularly, the invention relates to a double detection signal receiver wherein a signal modulated high frequency wave is detected to yield a signal modulated intermediate frequency wave, which is then detected to yield the signal.

An object of this invention is to improve and simplify double-detection receiver circuits.

In such systems of the prior art, the signal modulated high frequency wave is impressed upon a frequency converter which steps down the incoming wave to an intermediate frequency wave modulated in accordance with the signal. The signal modulated intermediate frequency wave is then impressed upon a second frequency converter or detector which yields the signal.

In accordance with one feature of this invention the same frequency converter or detector circuit is employed both for combining the received signal modulated waves with waves from a local source and for detecting the resulting combination products to yield the signal.

In accordance with another feature of the invention the single frequency converting or detecting circuit is of the balanced or push-pull type, the intermediate frequency circuit being connected between the input and output circuits thereof, the connections being made symmetrically with respect to one circuit and differentially with respect to the other in order to eliminate any singing effects.

According to an auxiliary feature of the invention, the intermediate frequency wave modulated in accordance with the signal is selectively amplified before being impressed upon the detector.

While the invention is illustrated as applied to a radio receiver it will be understood that it may find application in other signal receivers such, for example, as are employed in carrier wave systems having conductive circuits between stations.

In the drawings:

Fig. 1 shows diagrammatically a radio signal receiver wherein the signal modulated radio waves are impressed upon the individual branches of the input circuits of a balanced detector, and waves from a local source and the detected intermediate frequency waves are impressed upon the common branch of the input circuits.

Fig. 2 shows diagrammatically a radio signal receiver wherein the waves from the local source are impressed upon the individual branches of the input circuits of a balanced detector and the incoming signal modulated radio waves and the intermediate frequency waves are impressed upon the common branch of the input circuits.

Fig. 3 shows diagrammatically a radio signal receiver wherein the incoming signal modulated radio waves and the waves from the local source are impressed upon the common branch of the input circuits of a balanced detector and the detected intermediate frequency waves are impressed upon the individual branches of the input circuits.

Fig. 4 shows diagrammatically a radio signal receiver wherein the incoming signal modulated radio waves, the waves from the local source and the detected intermediate frequency waves are impressed upon the individual branches of the input circuits of a balanced detector.

The radio receiver of Fig. 1 comprises an antenna 1, a balanced detector D, a band filter IBF, a low pass filter LPF, and amplifiers A and A′.

The balanced detector may be of any well known type, such, for example, as that disclosed in United States patent to Carson No. 1,343,308, June 15, 1920.

This balanced detector has two three-electrode valves 2 and 2′. The auxiliary electrodes or grids of these valves are connected to the terminals of the secondary winding of an input transformer 3, whose primary winding is included in circuit with the antenna 1. The mid-point of the secondary winding of transformer 3 is connected through the secondary windings of transformers 4 and 5, to the cathodes of the two valves. The anodes of the two valves are connected to the terminals of the primary winding of an output transformer 6. The mid-point of this primary winding is connected through the pri-

mary winding of a transformer 7 to the cathodes of the two valves. The secondary winding of the output transformer is connected through the band filter IBF to the input of amplifier A.

The band filter IBF is of the type disclosed in United States patent to Campbell No. 1,227,113, May 22, 1917. This filter is designed to pass currents of a frequency intermediate the incoming radio frequency and the signal frequencies and currents within either the upper or lower side band of that intermediate frequency, and to suppress currents of all other frequencies.

The low pass filter LPF is of the type disclosed in the Campbell patent, supra. It is designed to pass currents of the signal frequencies and to suppress currents of higher frequencies.

The amplifiers A and A′ may be of any well known type such, for example, as the three-electrode-electronic valve shown in Fig. 23 of the article entitled "Carrier current telephony and telegraphy" by Colpitts and Blackwell, published in the Transactions of American Institute of Electrical Engineers, Vol. 40, 1921.

The output circuit of amplifier A is connected to the primary winding of transformer 5.

A local source O of oscillations is connected to the primary winding of transformer 4. The secondary winding of transformer 7 is connected to the low pass filter LPF, and the output circuit of amplifier A′ is connected to a signal receiving device such as a telephone receiver 8.

The incoming radio waves may have a frequency of 700,000 cycles and the local source O may supply waves of 650,000 cycles.

The operation of the radio receiver shown in Fig. 1 is as follows—

The desired incoming radio waves modulated in accordance with signals which may be speech are intercepted by the antenna 1 and selected by the antenna circuit which, according to customary practice, may be tuned for that purpose. The selected signal modulated radio waves are impressed through transformer 3 upon the input circuits of the balanced detector D. The signal modulated radio waves interact with the waves from local source O in the detector D which produces in the secondary winding of output transformer 6 a current having components with frequencies equal to the sum and difference of the radio and locally impressed frequencies, each modulated by the signal frequencies.

The signal modulated radio waves are reproduced in the secondary winding of output transformer 6. The band filter IBF prevents the passage of such waves to the amplifier A.

The waves from local source O impressed upon the common branch of the detector input circuits are balanced out in the primary winding of the output transformer and consequently do not appear in the secondary winding thereof. While the waves from local source O are reproduced in the secondary winding of transformer 7, the low pass filter LPF prevents the passage of such waves to the amplifier A′.

Currents of an intermediate frequency modulated by signals are selected by the band filter IBF and are impressed upon the amplifier A. This intermediate frequency is the difference between the incoming radio frequency and the frequency supplied from the local source O.

The intermediate frequency currents modulated by speech are amplified by amplifier A and are impressed through transformer 5 upon the common branch of the input circuits of the detector D. Frequency components of the detected signal modulated intermediate frequency currents are produced in the output circuits of the detector. Among these components a band of frequencies within the signal or speech range which appears in the common branch of the output circuits and is impressed through transformer 7, upon the circuit including the low pass filter. This low pass filter LPF passes this band of frequencies and suppresses currents of higher frequencies. The band of frequencies passed by the low pass filter and amplified by amplifier A′ are impressed upon the receiver 8.

The radio receiver of Fig. 2 is similar to that of Fig. 1 differing therefrom merely in the manner of connecting the antenna and the local source of oscillations to the input circuits of the balanced detector. The antenna 1 is coupled to the common branch of the input circuits of the detector D by means of transformer 4, while the local source of oscillations O is connected to the individual branches of the input circuits by means of transformer 3.

The operation of this radio receiver is similar to that of Fig. 1.

Currents having frequency components equal to the sum and difference of the radio frequency and the frequency from local source O, each modulated by the signal are produced in the secondary winding of the output transformer 6. One of these components, such, for example, as the signal modulated difference frequency, is selected by band filter IBF and impressed upon the amplifier A. The signal modulated radio frequency, impressed on the common branch of the input circuits is balanced out in the primary winding of output transformer 6, and therefore is not reproduced in the secondary winding. The local source frequency impressed upon the individual branches of the input circuits is reproduced in the secondary winding of the output transformer, but is suppressed by the

band filter IBF. During the process of detecting the signal modulated radio frequency to yield the signal modulated intermediate frequency, the signal frequency currents of small amplitude are obtained direct from the incoming waves and are impressed through transformer 7 and low pass filter LPF onto the amplifier A'. The amplified signal modulated intermediate frequency currents are impressed upon the common branch of the detector input circuits so as to yield the amplified signal frequency currents in the same way as in the receiver of Fig. 1.

The radio receiver of Fig. 3 employs a balanced detector D' of the type disclosed in United States patent to Hartley No. 1,419,562, June 13, 1922.

The incoming signal modulated radio waves and the oscillations from the local source are impressed upon the common branch of the detector input circuits through transformers 4 and 5 respectively. The amplified signal modulated intermediate frequency is impressed upon the individual branches of the detector input circuits through transformer 3. The anodes of the detector electronic valves 22 and 22' are connected to one terminal of the primary winding of output transformer 9, the other terminal of which is connected to the cathodes of the two valves. The secondary winding of the output transformer 9 has connected thereto the band filter IBF and the low pass filter LPF, whose input circuits may be connected in series as shown.

The operation of the radio receiver of Fig. 3 may be explained as follows:

The incoming signal modulated radio waves and the waves from local source O impressed upon the common branch of the detector input circuits interact to produce in the secondary winding of output transformer 9 currents having the following frequency components:

(1) Radio frequency.
(2) Local source frequency.
(3) Radio frequency modulated by the signal.
(4) Sum of radio and local source frequencies modulated by the signal.
(5) Difference between radio and local source frequencies modulated by the signal.
(6) Harmonics of (4) and (5).
(7) Signal frequencies (small amplitude).

Due to the action of band filter IBF, only currents of frequency component (4) or (5) pass therethrough and are impressed upon the amplifier A. Likewise, due to the action of low pass filter LPF, only the signal frequency currents pass therethrough and are impressed upon the amplifier A'.

The amplified signal modulated intermediate frequency currents from amplifier A are impressed through transformer 3 upon the individual branches of the detector input circuits. The resulting currents in the secondary winding of output transformer 9 have the following frequency components:

(A) Second harmonic of intermediate frequency.
(B Amplified signal frequencies.

The band filter IBF suppresses currents of all these frequency components and the low pass filter LPF suppresses all but the amplified signal frequency currents which pass therethrough and are impressed upon the amplifier A'.

The radio receiver of Fig. 4 is similar to that of Fig. 3, with this difference: The incoming signal modulated radio waves, the waves from the local source O and the signal modulated intermediate frequency waves are impressed upon the individual branches of the detector input circuits.

The antenna is coupled to the detector by means of a transformer 10 having three primary windings, one of which is in series with the antenna. The local source O is connected to a second primary winding of this transformer 10, while the output circuit of amplifier A is connected to the third primary winding. The secondary winding of transformer 10 is connected to the primary winding of transformer 3.

The radio receiver of Fig. 4 operates as follows:

The incoming signal modulated radio waves and the waves from the local source are impressed upon the individual branches of the detector input circuits. The currents produced in the secondary winding of output transformer 9 have the following frequency components:

Second harmonic of radio frequency.
Second harmonic of local source frequency.
Sum of radio and local source frequencies modulated by the signal.
Difference between radio and local source frequencies modulated by the signal.
Signal frequencies (small amplitude).

The band filter IBF passes either the signal modulated sum or difference frequency currents, preferably the latter, which are impressed upon the amplifier A and suppresses currents of all other frequencies.

The low pass filter LPF passes only the signal frequency currents which are then impressed upon amplifier A'.

The amplified signal modulated intermediate frequency currents are impressed upon the individual branches of the detector input circuits to yield the signal in the output circuit thereof in the same manner as in the radio receiver of Fig. 3.

The amplifier A is adjusted to give comparatively large gain in the signal modulated intermediate frequency waves, which is possible because such waves are prevented from re-entering the amplifier after being impressed upon the detector input circuits. Consequently singing is prevented.

Since the signal modulated intermediate frequency waves are greatly amplified by the amplifier A, a greatly amplified signal is obtained from detection of such amplified signal modulated intermediate frequency waves. Therefore the amplitude of the signal resulting from double detection is many times greater than that of the signal resulting from direct detection of the incoming signal modulated high frequency waves. Consequently the double detection receivers shown in the drawings are highly selective, since any low frequency currents resulting from direct detection of any incoming interfering high frequency waves are negligible compared to the desired amplified signal resulting from double detection.

The invention set forth herein is obviously susceptible of various other modifications and adaptations.

The invention claimed is:

1. A double detection signal receiver comprising a detector having input and output circuit, means for impressing an incoming signal modulated high frequency wave upon the input circuit, a local source of waves, means for impressing waves from the local source upon the input circuit, means in the output circuit to pass a signal modulated intermediate frequency wave and to suppress waves of all other frequencies, an amplifier having its input circuit coupled to the frequency discriminating means and its output circuit coupled to the detector input circuit, a signal responsive device, and a low pass filter between said device and the detector output circuit.

2. The method of operating a double detection signal receiver employing a single detector circuit, which comprises impressing an incoming signal modulated high frequency wave upon the detector and therein converting such incoming wave into a signal modulated wave of a lower frequency, and impressing such signal modulated lower frequency wave upon the detector and therein detecting the same to yield the signal.

3. The method of operating a double detection signal receiver employing a single detector circuit, which comprises impressing an incoming signal modulated high frequency wave upon the detector and producing a wave having frequency components including a lower frequency modulated in accordance with the signal; selecting, amplifying and impressing the signal modulated lower frequency wave upon the detector and producing in said detector circuit a wave having frequency components including the signal frequencies, and selecting the signal frequencies.

4. A signal receiver comprising a frequency converting or detecting device having input and output circuits, means to impress an incoming signal modulated high frequency wave upon the input circuit and produce in the output circuit a lower frequency wave modulated in accordance with the signal, means to amplify the signal modulated lower frequency wave and impress such amplified wave upon said input circuit so as to produce in the output circuit a wave of the signal frequencies, a signal receiving device coupled to said output circuit, and frequency discriminating means in said output circuit to direct the signal modulated lower frequency wave to its amplifying means and to direct the signal frequency wave to the receiving device.

5. A signal receiver comprising a balanced detector having input and output circuits, a local source of waves, means to impress a wave from the local source and a signal modulated high frequency wave upon the input circuit so as to produce in the output circuit a signal modulated wave having a frequency which is the difference between the high frequency wave and the frequency of the wave from the local source, means coupled to the output circuit to select, amplify, and impress such signal modulated difference frequency wave upon the input circuit so as to produce in the output circuit the signal frequency wave, a signal receiving device, and means coupled to the output circuit to select and impress the signal frequency wave upon the signal receiving device.

6. In combination a pair of three-electrode electric discharge devices connected in push-pull relation between an input circuit and an output circuit so that waves supplied to one portion of said input circuit will not appear in one portion of said output circuit, means for supplying signal modulated waves to said input circuit, means for supplying to said input circuit a carrier or heterodyne wave which combines with said first wave to produce super-audible frequency combination products in said output circuit, amplifying means interconnecting said portions of said input and output circuits for feeding back said combination products to said input circuit whereby the signal wave is detected, and means responsive to the signal wave connected to said output circuit.

7. A double detection receiving system comprising a pair of three-electrode electric discharge detectors, a source of signal modulated waves, a local source of waves, means for impressing waves from said sources upon said detectors in push-pull relation for producing in the output thereof signal modulated combination products of said waves, means for selectively amplifying said signal modulated combination products to the exclusion of waves of other frequencies connected differentially to the outputs of said detectors, means for impressing said amplified combination products upon said detectors in parallel for detecting the signal wave, and means responsive to the detected signal wave

connected to the outputs of said detectors in parallel.

8. A double detection receiver comprising a pair of three-electrode electric discharge detectors connected in push-pull relation between an input circuit and an output circuit, a source of signal modulated waves, a local source of waves, means for impressing waves from said sources upon said input circuit to produce in said output circuit combination products thereof, an amplifier having a frequency selective characteristic for selectively amplifying said combination products, said amplifier having an input circuit connected to the detector output circuit and an output circuit connected to the detector input circuit whereby the amplified combination products are impressed upon said detector and detected to produce the signal, the connection of said amplifier to the detector input and output circuits being, with respect to said detectors, symmetrical in one of said circuits and differential in the other of said circuits, and a circuit selectively responsive to the signal waves connected to the output circuit.

9. A double detection receiver comprising a pair of three-electrode electric discharge devices, each having an anode, a cathode and a control electrode, said devices being connected in push-pull relation between an input and an output circuit, each of said circuits having a portion common to said cathodes, said input circuit having proportions individual to said control electrodes, and said output circuit having proportions individual to said anodes, a source of signal modulated waves, a local source of waves, means for impressing waves from said sources upon said input circuit to produce in the individual portions of the output circuit difference frequency combination products of said waves, a frequency selective amplifier having its input connected to receive waves from said individual portions of the output circuit for selectively amplifying said difference frequency combination products and having its output connected to supply the amplified combination products to the common input portion of the input circuit whereby the combination products are detected to yield the signal, and a circuit selectively responsive to the detected signal waves connected to the common portion of the output circuit.

In witness whereof, I hereunto subscribe my name this 13th day of July, A. D. 1923.

JOHN F. FARRINGTON.

In witness whereof, I hereunto subscribe my name this 23rd day of July, A. D. 1923.

EDWIN H. SMYTHE.