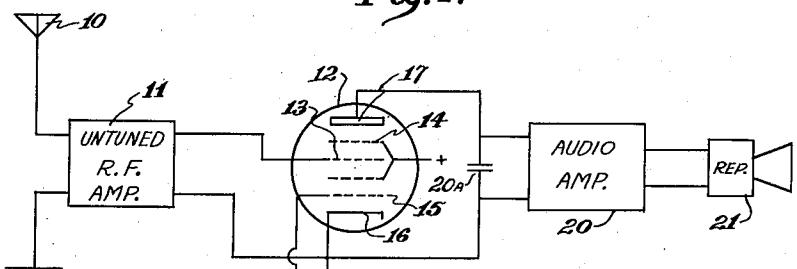
Sept. 20, 1949. R. T. KILLMAN ET AL 2,482,549

METHOD OF AND APPARATUS FOR RECEIVING RADIO SIGNALS

Filed Dec. 3, 1943

Fig. 1.



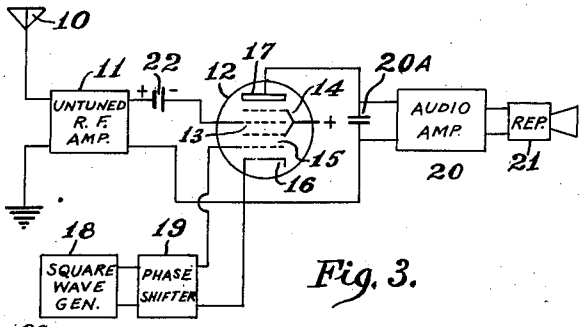


Fig. 3.

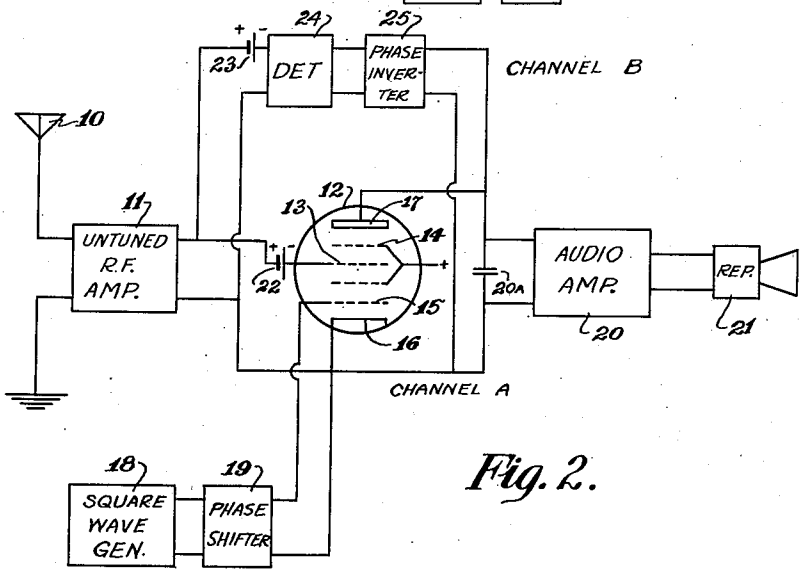


Fig. 2.

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METHOD OF AND APPARATUS FOR RECEIVING RADIO SIGNALS

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2 Claims. (Cl. 250—20)

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This invention relates to improvements in methods and apparatus for selecting and detecting radio waves.

In all previous methods of selecting a desired signal from the many present in the ether the signals, including the one desired, are usually picked up by an antenna and passed through one or more resonant circuits, composed of suitable inductance and capacity, which are tuned to the frequency of the desired signal. These resonant circuits are usually parallel resonant, and serve to increase the voltage appearing across them at the frequency of the desired signal while the voltage at all other frequencies is not increased, or at least not increased to such extent as is the voltage at the resonant frequency. These resonant circuits are usually coupled by electronic tube amplifiers, and due to the selective and amplifying action of such a system the desired signal may be picked out of the many signals impinging on the antenna and amplified to the exclusion of the unwanted signals.

Various modifications have been made in the above described basic system, such as for example, the use of the super-heterodyne principle wherein the frequency of the desired signal is changed to some arbitrary fixed intermediate frequency and then is passed through resonant circuits and amplifiers as described above.

However all previously known methods of selecting the desired signal from the welter of signals present in the ether rely on the resonant circuit.

This type of signal selecting system has several disadvantages. As is well known by those skilled in the art, in order to increase the selectivity of a resonant circuit it is necessary to decrease the resistance of the circuit, or in other words, to increase the Q. This has the effect of decreasing the decrement of the circuit and if carried sufficiently far the decrement of the circuit becomes so small that so called "tails" are formed on the ends of the dots and dashes of code signals and the higher modulation frequencies of a modulated signal are distorted and attenuated since the decrement of the signal is less than that of the resonant circuit and therefore the currents in the resonant circuit cannot vary in amplitude as rapidly as the signal.

A further disadvantage of resonant circuits as signal selectors lies in the fact that they are capable of being shock excited. A stray impulse of such short duration that it could not be heard may shock the resonant circuit so that it generates a damped wave train of sufficient duration to cause an audible impulse.

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Accordingly it is an object of this invention to disclose a method of selecting a desired signal from a number of undesired signals of different frequencies and to amplify and demodulate the desired signal, and to partially or totally exclude the undesired signals without making use of tuned or resonant circuits or their equivalent.

A further object of this invention is to provide means whereby a desired signal may be selected and differentiated from an undesired signal or signals of the same frequency provided the desired and undesired signals are not in phase, the results being most satisfactory when the two signals are of opposite phase.

A further object of this invention is to provide means whereby the effect of atmospheric or local strays or static upon the desired signal may be materially reduced.

A further object of this invention is to provide a radio receiving system which may be used as the receiving component of a "secrecy" system wherein two radio frequency waves of the same frequency but of opposite phase are transmitted simultaneously, one of said waves being modulated by the desired intelligence while the other wave is modulated by an unintelligible "jamming" signal which when both waves are received by ordinary receivers so garbles or "jams" the desired intelligence modulation that it is unreadable, but which when received by the receiving system of this invention can be separated into its two components and the desired intelligence becomes readable.

The means by which these and other objects, as will presently appear, is accomplished may be more readily understood by reference to the accompanying drawings wherein Fig. 1 is a single channel system for receiving radio signals making use of the principles of this invention, Fig. 2 is a two channel system making use of neutralization to eliminate all but the desired signal, and Figure 3 is an alternate single channel system for receiving radio signals making use of the principles of this invention.

Referring now to Fig. 1 the numeral 10 denotes the usual receiving antenna, preferably aperiodic or untuned. The signals received by antenna 10 are passed through and amplified by the untuned radio-frequency amplifier 11.

The output of amplifier 11 is applied across the grid 13 and the cathode 16 of the electronic tube 12. An adjustable square wave generator 18 feeds its output through the adjustable phase

shifter 19 to the grid 15 and cathode 16 of tube 12. The square wave output of the generator 18 is of such voltage that when its positive peak is applied to grid 15 tube 12 operates as a class A amplifier but when the negative peak of the square wave voltage is applied to grid 15 tube 12 is completely blocked and is incapable of passing signals received upon grid 13.

A plate or anode 17 serves to receive the electron stream emanating from the cathode 16 and acted upon by the two grids 13 and 15 and also feeds the output of the tube 12 through an audio amplifier 20 to a sound reproducer 21.

The operation of the system just described is as follows: The desired radio frequency wave emanating from a transmitter (not shown) together with the many undesired waves impinge upon the antenna 10 and are amplified by the amplifier 11 and passed on to grid 13. During the time interval that the desired radio frequency signal is passing from zero through its positive peak and back to zero on grid 13, the square wave generator 18, which is set to generate a square wave of a frequency identical to that of the desired signal, is adjusted to apply the positive peak of its square wave output to grid 15 so that, during this interval, the tube 12 acts as a class A amplifier and the plate current of the tube is a replica of the grid voltage on grid 13, and the signal is passed on to the audio amplifier 20 and reproducer 21. However during the time interval in which the desired radio-frequency wave passes from zero through its negative peak and back to zero, the negative peak of the square wave output of generator 18 is applied to grid 15 so that tube 12 is blocked and no signal is passed on to the audio amplifier 20 and reproducer 21.

Thus it will be seen that only the positive half cycles of the desired signal are passed on to the audio amplifier 20. The envelope of these positive half cycles constitutes the audio modulation and this audio wave or envelope is amplified by the audio amplifier 20 and reproduced into sound by the reproducer 21.

From the above it will be seen that the action is very similar to ordinary demodulation except that the only signal which is completely demodulated is the one of the frequency and phase of the square wave generator.

Any wave of a different frequency is not completely demodulated i. e. parts of both its negative and positive half cycles appear in the output and cancel each other.

It will be noted that, while in the above description it was said that the positive half cycles of the desired signal were passed but the negative half cycles were not, it might just as well be the other way round, i. e., the negative half cycles could be passed through and the positive half cycles blocked.

In order to make the system responsive only to positive half-cycles of the desired signal, a negative voltage may be introduced by the battery 22, as shown in Figure 3 of such magnitude as to just cause plate current cut-off. In this condition grid 13 will be responsive only to positive half-cycles, while the negative half-cycles applied thereto serve only to drive grid 13 further negative.

By adjusting the phase shifter 19 so that during the interval that positive half cycles of the signal are applied to grid 13 (the tube 12 being biased to cut-off by the voltage above referred to inserted in its grid circuit by battery 22, as shown in Figure 3) so that the negative peaks of

the square wave voltage are applied to grid 15, thus blocking the tube during this interval, the signal may be eliminated, while any other signal having positive half-cycles which appear between the positive half-cycles of the eliminated signal will appear in the output.

This phenomena allows a second circuit arrangement to be set up as shown in Fig. 2. In this figure the numeral 10 denotes the antenna, the untuned radio-frequency amplifier 11, tube 12, grid 13, grid 15, cathode 16, plate 17, square wave generator 18, phase shifter 19, audio amplifier 20 and reproducer 21 being the same as previously described in reference to Fig. 1. The circuit through tube 12 is called channel A.

However a second channel, marked channel B, between the amplifier 11 and the amplifier 20, comprises the detector 24 and the phase inverter 25. The detector 24 is biased to cut-off by the battery 23 and the tube 12 is likewise biased to cut-off by battery 22. The connections, polarities, and voltages are so adjusted that the output of amplifier 11 is divided, half going through channel A and half going through channel B.

The phase inverter 25 inverts the phase of the currents in channel B so that they oppose those in channel A and any signal which appears both in channels A and B will be completely neutralized and will not appear in the combined output of channels A and B and will not be passed on to audio amplifier 20 nor reproduced by the reproducer 21, while any signal appearing in only one channel will not be neutralized and therefore will be passed on to audio amplifier 20 and will be reproduced by reproducer 21.

In operation of the circuit shown in Fig. 2, the desired signal together with many undesired signals, strays, static, etc., impinge upon antenna 10 and are amplified by amplifier 11 and passed on to channels A and B in equal proportions.

Since the tubes in both channels are biased to cut-off only positive voltages are effective in either channnel. In channel A the desired signal is eliminated by means of the action of the square wave generator in blocking tube 12 during the intervals that the positive half cycles of the desired signal appear on grid 13, but at all times between these intervals the tube is responsive to any other positive voltages from other signals or static and the envelope of these signals will be passed on as an audio signal to the amplifier 20. However the envelope of the desired signal will not be passed since each positive half cycle of the desired signal was eliminated as above described and all negative half cycles have been eliminated due to the high bias voltage 22.

However the positive half cycles of the desired signal together with the positive components of all the undesired signals and static etc. are passed by channel B and the envelope of these positive impulses constitute an audio wave which is passed through the phase inverter 25 which causes its phase to be opposite to the audio signal coming through channel A. These two audio voltages are combined and as pointed out above all portions which are similar cancel out and only the desired signal which appears in only channel B is amplified by amplifier 20 and reproduced by reproducer 21.

It is of course understood that the devices shown in Figs. 1 and 2 include all the necessary and usual accessories for proper operation such as power and voltage supplies, shielding, filters, networks, etc. some of which, such as the shield grid 14 and the filter condenser 20*a*, are shown,

but others are not shown, these details and auxiliaries forming no part of the basic concept of this invention. It is also understood that this invention is not limited to the actual devices shown, but equivalents for any of the devices shown for the purpose used herein may be substituted therefor. For example, for the square wave generator 18 shown, there may be substituted a simple radio frequency oscillator together with a half wave rectifier which removes the positive half cycles of the oscillator output. The negative half cycles which remain, when applied to grid 15, if of sufficient amplitude, have the same effect thereon as did the square wave output of generator 18, since the tube 12 will be blocked very early during each of these negative half cycles and will remain so until very late in said negative half cycle and it will not matter that the negative half cycle has a much greater negative amplitude between these two points than is required to block the tube.

Also a properly wound neutralizing transformer or other means may be used to differentially couple channels A and B to amplifier 20 of Fig. 2 instead of making use of the phase inverter 25 to cause the signals in channel A to neutralize like signals in channel B.

While there has been described what are at present considered the preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention, and it is therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. In a radio receiving system, a signal wave collecting system which is non-differentiative as between desired and undesired signal waves, a two channel signal wave passing system, each of said channels being normally responsive only to signal wave half cycles of one polarity, one of said channels being capable of being intermittently blocked so that during the blocked interval said channel is not responsive to signal waves of either polarity, means for blocking said last named channel during the interval that the half cycles of the desired signal wave of the polarity to which said channel is normally responsive are applied thereto but allowing said channel to pass all signal waves of the polarity to which it is normally responsive which are applied thereto during the interval that half cycles of the desired signal of the opposite polarity to that to which the said channel is normally responsive are applied thereto, means for differentially combining the outputs of the two channels so that all signal waves appearing in both channels are cancelled out, while signal waves apearing in only one channel are not cancelled, and means for translating the uncancelled waves into sensible phenomena.

2. In a radio receiving system, a signal collecting antenna, an untuned radio-frequency amplifier coupled to the antenna, two signal passing channels A and B coupled to the amplifier, channel A comprising an electronic tube having at least an anode, a cathode and two grids, the first grid being connected to the amplifier, means for generating an oscillatory voltage of rectangular wave form, means for adjusting the frequency of said voltage, means for adjusting the phase of said voltage with respect to time, means for applying the voltage to the second grid of the tube in such manner that during the interval that the positive half-cycle of said voltage is applied thereto the tube will operate as a clas B amplifier and will be responsive only to the positive half-cycles of signals applied to the first grid, but during the interval that the negative half-cycle of the locally generated oscillatory voltage is applied to the second grid the tube will be completely blocked and not responsive to signals of either polarity applied to the first grid, channel B comprising a detector or rectifier system responsive to signal half cycles of only one polarity and means for differentially combining the outputs of channels A and B so that signals appearing in both channels will be cancelled while a signal appearing in only one channel will not be cancelled, an audio amplifier for amplifying the uncancelled signal, and an audio reproducer for translating said signal into sound.

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