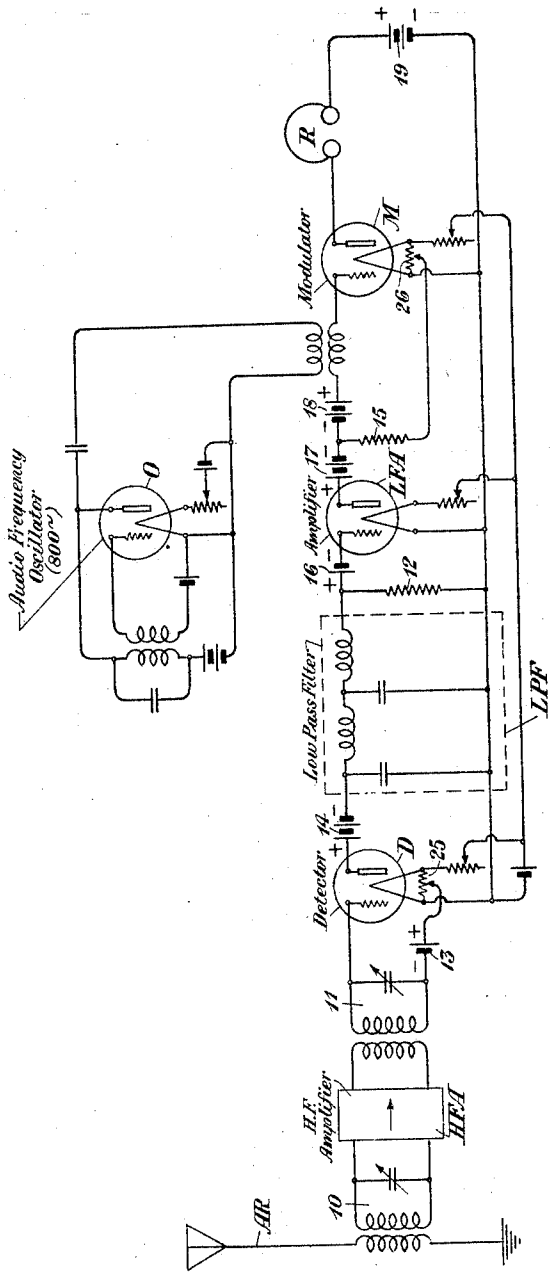
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RADIO RECEIVING SET

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INVENTORS
A. Weaver and
BY F. Harold Chase
ATTORNEY

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ALLAN WEAVER AND FAY HAROLD CHASE, OF BROOKLYN, NEW YORK, ASSIGNORS TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

RADIO RECEIVING SET.

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This invention relates to radio receiving systems, and more particularly to receiving circuits to be used in connection with continuous wave radio telegraphy.

In radio telegraph systems employing continuous wave transmission it has been the practice to receive signals from such waves by the heterodyne method which involves beating the received frequency with a locally generated frequency differing therefrom by an amount such as to produce a beat note which is audible. With this method of receiving, however, it frequently happens that as many as five or six interfering stations can be heard simultaneously where the stations signal at a frequency sufficiently close to the desired frequency to produce an audible beat note in the detector.

One of the objects of the present invention is to provide a receiving circuit for continuous waves which will produce audible tones in the receiver without depending upon the heterodyne principle and which will be highly discriminative against interfering stations. Another object of the invention is to provide a receiving set which is much more sensitive to strong signals than to weak signals. Still another object of the invention is to provide a receiving set so designed that the audible signal tone heard in the receiver may be maintained at a constant frequency even when receiving at very short wave lengths.

The invention will now be more fully understood from the following description when read in connection with the accompanying drawing, the figure of which shows a circuit arrangement embodying the principles of the invention.

Referring to the drawing, the receiving set consists primarily of a detector D, a low-pass filter LPF, a direct current or low frequency amplifier LFA, a source of audio frequency current O, and an audio frequency modulator M. The usual receiving antenna AR is provided, and the detector D may be connected to the antenna through a high frequency amplifier HFA, if necessary. The high frequency amplifier will, of course, be of any type well known in the art. As shown, the high frequency amplifier HFA is coupled to the antenna through a tuned circuit 10, said circuit being tuned to the continuous wave frequency which carries the signal. The output circuit of the amplifier may be coupled to the detector D through a similar tuned circuit 11.

The output circuit of the detector D is coupled to the direct current amplifier LFA through a low-pass filter LPF by means of a high resistance 12. The usual C battery 13 is provided in the grid circuit of the detector to make the potential of the grid sufficiently negative with respect to the filament so that during the spacing interval (when continuous waves are not being received) no current will flow in the plate circuit, and hence no current will flow through the resistance 12 due to the voltage of the B battery 14. During the marking interval, however, the high frequency oscillations impressed upon the grid will cause a low frequency current to flow from the battery 14 through the resistance 12, the impulse thus flowing corresponding to a marking current.

The output circuit of the amplifier LFA is coupled through a second resistance 15 to the input circuit of the modulating tube M. A C battery 16 is connected in the grid circuit of the amplifier LFA. During the spacing interval no current is flowing through the resistance 12 from the battery 14 so that there is no voltage drop across the terminals of resistance 12. Hence the potential of the battery 16 should be such as to make the grid sufficiently negative with respect to the filament during this interval that a maximum current will flow from the B battery 17 through the resistance 15. A C battery 18 is also connected in the grid circuit of the modulator tube M, and the voltage and polarity of the battery 18 are such that when the voltage is algebraically added to the drop through resistance 15, the grid of the modulator tube M will be so negative with respect to its filament during the spacing interval, that no current can flow in its output circuit even when the alternating voltage from the oscillator O is also superposed on the grid. A telephone receiver R is connected in the plate circuit in series with the B battery 19, and during the marking interval the voltage upon the grid of the modula-

tor tube will be made less negative in a manner to be hereinafter described, so that a pulsating wave of the frequency of the oscillator O will be produced in the receiver R. The audio frequency source O may be of any type well known in the art but is illustrated as a simple tube oscillator circuit generating an audible frequency of, say, 800 cycles per second.

The operation is as follows: Interrupted continuous frequency waves are received upon the antenna AR and are amplified by the high frequency amplifier HFA and then impressed upon the grid circuit of the detector D. During the spacing intervals no high frequency oscillations are received. During this interval the grid is rendered sufficiently negative due to the voltage of the battery 13, so that no electrons can pass from the filament to the plate. Consequently no current flows from the B battery 14 through the coupling resistance 12. Therefore the IR drop across the terminals of the resistance 12 is zero, and hence the difference in potential between the grid of the amplifier LFA and the filament of said amplifier is that due to the C battery 16. This battery is so proportioned as to make the grid just sufficiently negative with respect to the filament so that a desired maximum current will flow in the plate circuit during the spacing interval. The large current thus flowing from the battery 17 through the resistance 15 causes a considerable IR drop through said resistance, and this drop, when algebraically added to the potential of the battery 18 will render the grid of the modulator tube M so negative with respect to its filament that no current can flow in the outward circuit. In other words, the grid is so negative that the tube is operating well along the flat zero part of its characteristic curve, and the variation in potential of the grid due to the oscillations from the oscillator O are insufficient to bring the potential substantially up to the curved part of the characteristic. During the spacing interval, therefore, the 800 cycle frequency will not be heard in the receiver R. It will be understood that proper adjustment of the potential difference between the grids and filaments D and M may be made by potentiometers 25 and 26, respectively.

During the marking interval, on the other hand, the high frequency oscillations superposed upon the normal potential of the grid of the detector tube D cause a current wave to flow through the output circuit of the tube, this wave corresponding to the original marking signal wave at the transmitter. This current wave flows through the resistance 12 so that a material IR drop is present across the terminals of said resistance. This IR drop is in such a direction that it is series aiding with respect to the potential of the C battery 16, and therefore the grid of the amplifier tube LFA becomes much more negative with respect to its filament than during the spacing interval. The current flowing in the output circuit due to the battery 17 is therefore reduced. The reduction in the current flowing through the resistance 15 makes the IR drop across the terminals of this resistance small. As shown in the diagram, the C battery 18 is so poled as to tend to make the grid positive if the potential of the grid depended entirely upon this battery. The IR drop through the resistance 15, on the other hand, is in such a direction as to make the grid of the modulator tube M negative, and the algebraic sum of the two potentials is such that during the spacing interval the grid will be substantially negative as already stated. When the IR drop through the resistance 15 is reduced, however, the grid becomes less negative so that the tube M now operates upon the curved part of its characteristic and current can flow in its output circuit. Consequently the audible frequency from the oscillator O impressed upon the grid will produce a corresponding frequency wave through the receiver R so that an audible tone of, say, 800 cycles is heard during the marking interval.

It will be apparent from the above description of the operation that the low frequency amplifier LFA is necessary in order to make the change in the voltage drop across the resistance 15 of the modulator tube of the proper direction. If the output circuit of the detector D were connected through the low-pass filter LPF directly to the modulating tube through the coupling of the resistance 15, the effect of the marking signal would be to increase the drop through the resistance 15, and therefore make the grid of the modulator even more negative than during the spacing interval, with the result that no current would flow in the output circuit of the modulator either during the spacing interval or the marking interval. The interposition of the amplifier 16, however, reverses the situation so that the drop through the resistance 15 is decreased during the marking interval with respect to the drop during the spacing interval, and consequently the audible tone can be heard in the receiver during the marking interval.

The low-pass filter LPF in the detector circuit is so designed that it will pass all signals from zero up to the maximum telegraph speed which ordinarily is of the order of 100 cycles. The marking impulse which flows in the output circuit of the detector D in response to the high frequency marking oscillations will contain all of the frequency components of the original telegraph wave, and these components will pass through the filter so that the impulse which is amplified will correspond substantially to the original telegraph wave.

Interfering high frequency waves, whether due to static or to interfering stations, when impressed upon the input circuit of the detector modulate with the continuous wave which is being received from the desired station during the marking interval to produce difference frequencies in the output circuit. In the ordinary heterodyne operation these difference frequencies might range anywhere from zero to a frequency corresponding to the limit of audibility which may be in the neighborhood of 20,000 cycles. The low-pass filter LPF, however, cuts off all difference frequencies above 100 cycles, so that practically all components resulting from interference are entirely without effect. Even where interfering waves beat with each other to produce a frequency within the range of the filter, the beat note is of negligible effect unless it is of such magnitude as to cause an appreciable current wave to flow in the output circuit of the detector D, which would not ordinarily be the case for usually the interference is of smaller amplitude than the desired signal. However, a beat note resulting from the interaction of an interfering wave with the relatively much stronger signal wave might, if within the range of the filter, be of considerable magnitude.

In general, therefore, such interference as is heard in the receiver only occurs, if at all, during the marking interval, and not during the spacing interval. The effect of the interference upon the ear of the listener consequently does not detract from the intelligibility of the signal.

It is a well known fact that the efficiency of a detector or a modulator over a certain range is roughly proportional to the square of the input voltage, because the effective detected component arises from the second power term of the Fourier series in accordance with which the output wave may be expressed. As there are two tubes in the circuit (the detector D and the modulator M) having non-linear characteristics, the ratio of final signaling current to interfering currents will be much greater than in the case of a heterodyne receiver. This will, of course, have the effect of accentuating the strong signals in comparison with weak signals. Consequently, as the desired signal is ordinarily much stronger than interfering signals the effect upon the receiver will be such that there is considerable discrimination against interference. In other words, the signal to interference ratio is much greater than in the ordinary heterodyne system where the signal is merely proportional to the square of the input voltage.

In practice, the circuit herein described has been found to be more satisfactory than the ordinary heterodyne method of reception. Ordinarily when signals are received by the heterodyne method as many as 5 or 6 interfering stations can be heard simultaneously, because the frequencies of the interfering stations beat with the heterodyne frequency to produce audible notes. On the other hand, with the circuit of the present invention, it has been demonstrated that not more than one station can be heard under the same circumstances. Furthermore, tests of the circuit of the present invention have shown that during the spacing interval (when the distant operator has his key open) there is no static or other interference which is audible.

It has also been found that in practice no difficulty is encountered in maintaining constant the frequency of the tone to be heard in the receiver, for this tone is produced by a low frequency oscillator. Hence a considerable percentage of frequency variation would only change the tone a few cycles per second. When a heterodyne system is employed, however, particularly if the frequencies are very high, a small percentage variation in the heterodyne frequency may change the beat note from one that is audible to one that is inaudible. The circuit of the present invention obviously eliminates this difficulty and can therefore be employed as well for short wave length reception as for long wave lengths.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. The method of radio detection which comprises detecting from the received radio wave low frequency current pulses corresponding to telegraph signals, suppressing from said pulses frequency components higher than those essential to ordinary telegraph transmission, continuously generating an audible wave of substantially constant amplitude for transmission to a receiver, and controlling the transmission of the audible wave in accordance with said detected and selected current impulses.

2. In a radio receiving system, a detector for detecting from the received radio wave current impulses corresponding to the original signal, means to continuously generate waves of audible frequency and substantially constant amplitude, a receiver, a modulator for controlling the transmission of said audible waves to said receiver, means to prevent the transmission of said audible waves through said modulator in the absence of detected signal impulses, and means to impress said detected waves upon said modulator to thereby control the transmission of the audible wave to the receiver in accordance with the signal.

3. In a radio receiving system, a detector

for detecting from the received radio wave currents of wave form and shape corresponding to the original signal, a modulator, means for continuously supplying audible oscillations of substantially constant amplitude to said modulator, means to prevent the transmission of said audlible oscillations through said modulator in the absence of detected signal impulses, means to supply said detected waves to said modulator to produce in the output thereof waves corresponding to said audible oscillations but modulated in accordance with said detected signal waves, and a receiving circuit associated with the output of said modulator to receive said modulated waves.

4. In a radio receiving system, a detector for detecting from the received radio waves current waves corresponding to the original signal waves, means to suppress from said detected waves all of the frequency components higher than those essential to the intelligible transmission of the original signal, a modulator, means to continuously impress audible oscillations of substantially constant amplitude upon said modulator, means to prevent the transmission of said audible oscillations through said modulator in the absence of detected signal impulses, means to supply said detected waves to said modulator to produce in the output thereof waves corresponding to said audible oscillations but modulated in accordance with said detected and selected signal waves, and a receiving circuit associated with the output of said modulator to receive said modulated waves.

5. In a radio telegraph receiving system, a detector for detecting from the received radio waves impulses of current separated by zero current intervals, a modulator, means to continuously impress audible oscillations of substantially constant amplitude upon said modulator, means to prevent the transmission of said audible waves through said modulator in the absence of detected signal impulses, a receiver connected with said modulator, and means to supply from said detector to said modulator detected current impulses separated by zero current intervals, to control the transmission of audible oscillations from the modulator to said receiver in accordance with the detected current pulses separated by zero current intervals.

6. In a radio receiving system, means for receiving radio oscillations controlled in groups to correspond to marking and spacing intervals, a detector upon which said oscillations may be impressed, means to bias the input of said detector so that during one of said intervals no current flows in its output and during the other of said intervals a pulse of current does flow, a modulator, means to continuously impress audible oscillations of substantially constant amplitude upon said modulator, means connected with said detector to impress detected current pulses separated by zero current intervals upon said modulator, and means to prevent the transmission of said audible oscillations through said modulator during no current intervals, whereby during a no current interval none of the oscillations impressed upon said modulator will be transmitted therethrough while during a current flow interval said oscillations will be transmitted in accordance with said pulse of current.

7. In a radio receiving system, a vacuum tube detector for detecting currents corresponding to the original signals, a low frequency vacuum tube amplifier, means to couple the output circuit of said detector to the input circuit of said amplifier comprising a resistance whose voltage drop determines the grid potential of the amplifier, a vacuum tube modulator, means to impress oscillations upon the circuit of said modulator, and means to couple the output circuit of said amplifier to the input circuit of said modulator comprising a resistance whose voltage drop determines the potential of the grid of said modulator.

8. In a radio receiving system, a vacuum tube detector for detecting currents corresponding to the original signals, a low frequency vacuum tube amplifier, means to couple the output circuit of said detector to the input circuit of said amplifier comprising a resistance whose drop determines the grid potential of the amplifier, a filter associated with said detector for suppressing from the detected currents components having a frequency higher than those essential to the transmission of the original signal, a vacuum tube modulator, means to impress oscillations upon the circuit of said modulator, and means to couple the output circuit of said amplifier to the input circuit of said modulator comprising a resistance whose drop determines the potential of the grid of said modulator.

9. In a transmission system, a plurality of vacuum tubes arranged in tandem and each having a grid-filament circuit and a plate-filament circuit, means to couple the plate-filament circuit of any preceding tube in the series to the grid-filament circuit of the succeeding tube in the series, said coupling means comprising a resistance whose drop due to current flowing in said plate-filament circuit determines the biasing potential of the grid of said succeeding tube, and means to apply a biasing potential to the grid of the succeeding tube independently of the biasing potential produced by said plate filament current.

10. In a transmission system, a plurality of vacuum tubes arranged in tandem and

each having a grid-filament circuit and a plate-filament circuit, a conductive plate to grid connection from the plate of any preceding tube of the series to the grid of the succeeding tube of the series, said connection including a plate current source, a filament to filament connection between the filaments of any two adjacent tubes, a resistance bridged between said plate to grid connection and said filament to filament connection, the drop through said resistance due to the flow of current in said plate-filament circuit determining the biasing potential of the grid of the succeeding tube, and means to apply a biasing potential to the grid of the succeeding tube independently of the biasing potential produced by said plate filament current.

In testimony whereof, I have signed my name to this specification this 21st day of February 1925.

ALLAN WEAVER.

In testimony whereof, I have signed my name to this specification this 9th day of February, 1925.

FAY HAROLD CHASE.