March 15, 1932. H. H. BEVERAGE 1,849,608

SIGNALING

Filed Nov 19, 1928 2 Sheets-Sheet 1

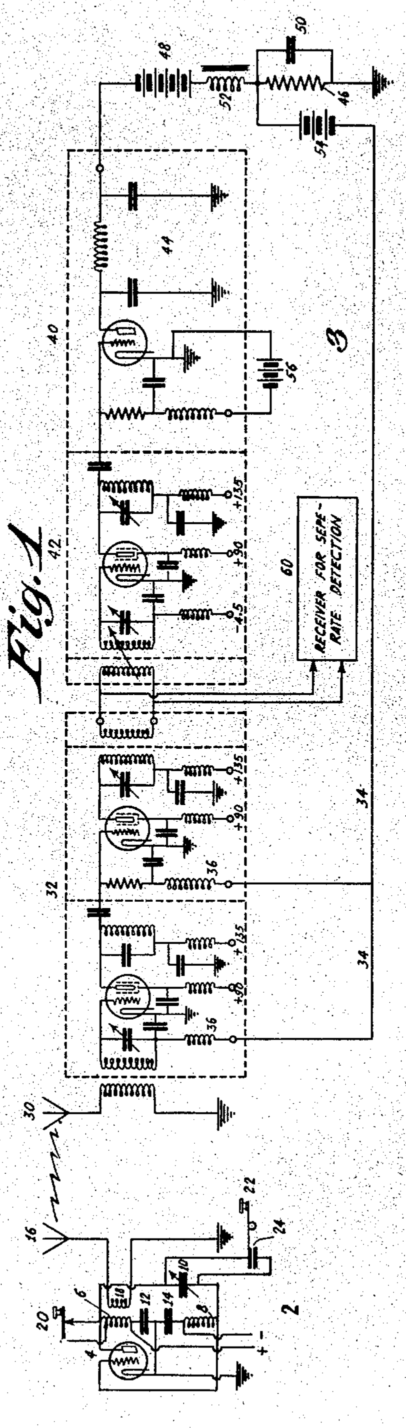


Fig. 1

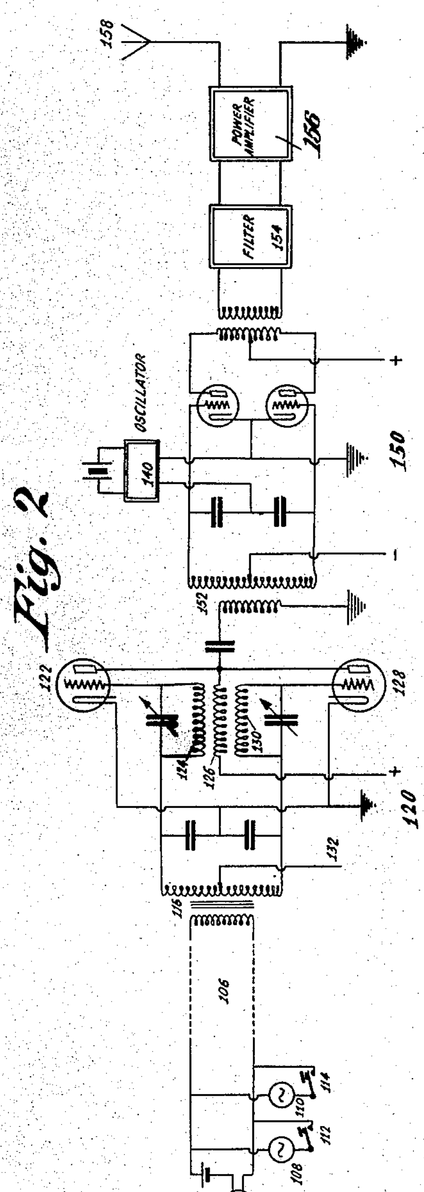


Fig. 2

Inventor
HAROLD H. BEVERAGE

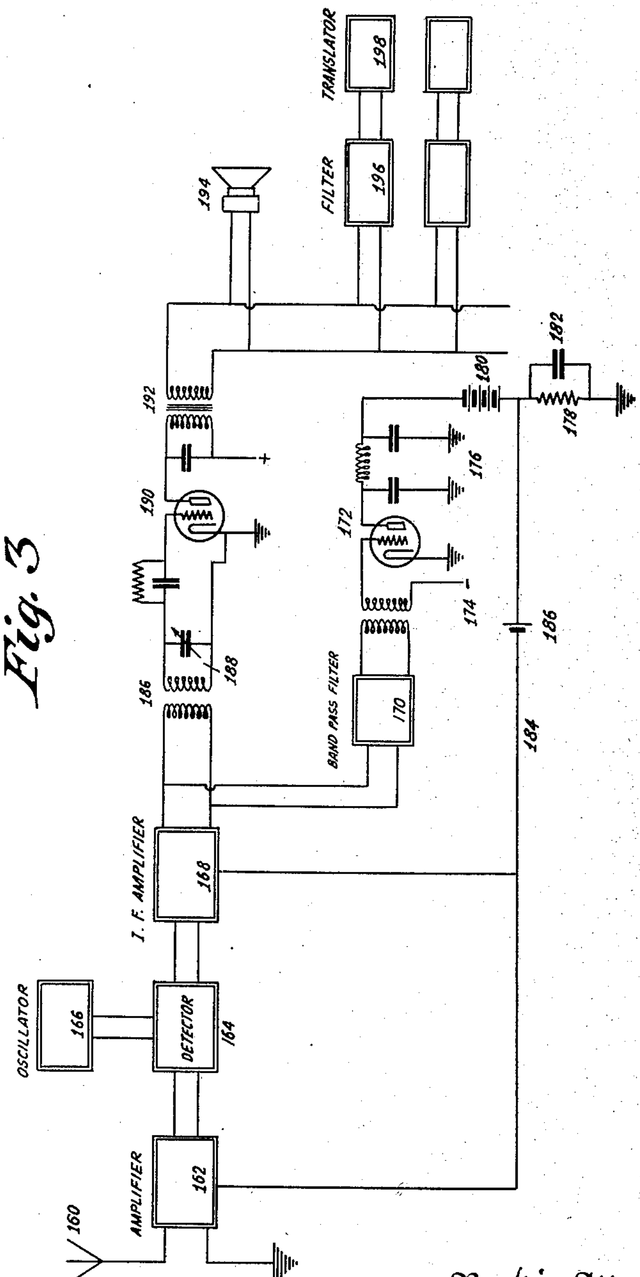
By his Attorney Ira J. Adams

March 15, 1932. H. H. BEVERAGE 1,849,608

SIGNALING

Filed Nov 19, 1928 2 Sheets-Sheet 2

Fig. 3



Inventor
HAROLD H. BEVERAGE

By his Attorney Ira J. Adams

Patented Mar. 15, 1932

1,849,608

UNITED STATES PATENT OFFICE

HAROLD H. BEVERAGE, OF RIVERHEAD, NEW YORK, ASSIGNOR TO RADIO CORPORATION OF AMERICA, A CORPORATION OF DELAWARE

SIGNALING

Application filed November 19, 1928. Serial No. 320,235.

This invention relates to signaling, and more particularly to the elimination of the effect of partial fading of signals by volume control at the receiver.

Signaling on high frequencies is often accompanied by fading which sometimes may be characterized by great rapidity, but which usually is partial rather than total. In attempting to overcome this fading by applying volume control at the receiver a difficulty arises in that a volume control of short time constant will tend to destroy the incoming signal modulation, while a volume control of long time constant will not respond to fading which is rapid. The primary object of my invention is to overcome this difficulty, for which purpose I frequency modulate the transmitted carrier in accordance with the signal, and then at the receiver, after amplifying the received energy, I control the gain in the amplifier by a volume control which is so broadly tuned as to be equally responsive to all of the frequencies in the working frequency range. In this manner, for the purpose of volume control the operation is almost exactly as though a perfectly unmodulated continuous wave were being transmitted, which is the condition most ideal for volume control. The volume-controlled output from the amplifier is then employed in a receiver which is unequally responsive to the frequencies employed, so that the frequency modulation may be changed into amplitude modulation preparatory to translation.

In the case of communication by code signals I may key a tone signal, or, for multiplex, separately key a number of tone signals of different frequencies, and employ the single or combined tone signals for frequency modulating the carrier. However, in the special case of simplex code communication it is simpler, and in my opinion preferable, to arrange the transmitter to transmit one frequency during marking periods and a back wave of slightly different frequency during spacing periods. At the receiver the amplifier and the volume control are tuned to be equally responsive to both frequencies, while the receiver discriminates between the frequencies in order to translate the desired code signal.

The invention is described more in detail in the following specification which is accompanied by drawings in which, Figure 1 is a wiring diagram of a system arranged for code communication; Figure 2 is a transmitter arranged for modulation by speech-simulating signals; and Figure 3 is a receiver for cooperation with the transmitter shown in Figure 2.

Referring to Fig. 1 of the drawings, there is a code signal transmitter 2, which is in communication with a receiver 3. The transmitter has been indicated in simplest possible form, comprising a vacuum tube 4, with regeneratively coupled anode and control electrode inductances 6 and 8, tuned by a tuning condenser 10. The direct anode and control electrode potentials are applied to either side of the blocking condensers 12 and 14, while the output from the resonant circuit is fed to an antenna 16 by means of a coupling coil 18.

The transmitter is keyed with a back wave, that is, the key serves to detune the transmitter so that the spacing wave has a frequency which is slightly different from that of the marking wave. This has been indicated by either the key 20, which serves to short circuit a small portion of the inductance of the resonant circuit, or by the key 22, movement of which varies the spacing, and consequently the capacitance, of a small condenser 24, connected in parallel with the tuning condenser 10.

The transmitted energy is collected on a receiving antenna 30, and thence fed to a radio frequency amplifier 32. This, in the specific arrangement shown, consists of two stages of amplification preferably employing shield grid tubes, and fully shielded externally, as has been indicated by the dotted lines surrounding the amplifier stages. The amplifier tubes are biased externally by way of the conductors 34, in series with which chokes 36 may be provided to block the radio frequency from the bias circuit. Similar chokes are preferably provided in series with all of the direct current leads.

A volume control detector is indicated at 40, and this may be preceded, if desired, by a stage of radio frequency amplification 42. In the anode circuit of the detector tube a low pass filter stage 44 may be provided, as shown, to insure the separation of the radio frequency and direct current components. The direct current component is sent to ground through a resistance 46, which is connected to the negative terminal of the anode battery 48, in order that the resistance may be at low rather than at high potential. In parallel with the resistance a condenser 50 is connected, which serves to establish the time constant of the volume control. A series choke 52 may be employed, if desired, to stabilize the action. The bias control lead 34 is connected to the upper end of the resistance 46, so that potential fluctuations across the resistance due to changes in the anode current of the volume control 40 serve to vary the bias of the radio frequency amplifier 32. In series with the lead 34 a battery 54 is connected, which establishes the normal bias of the amplifier.

The tuning of the amplifier stages so far considered is either sufficiently broad so that the marking and spacing waves pass therethrough with equal facility, or is to a frequency lying midway between the marking and spacing frequencies. The detector 40 preferably is so biased by a battery 56 that in the absence of a signal no anode current flows through the detector, in which case the battery 54 is adjusted for maximum gain in the amplifier tubes. When signals are received there is a flow of anode current through the volume control detector 40, and the resulting potential drop across the resistance 46 serves to more negatively bias the control electrodes of the amplifier, thereby tending to reduce the volume. The amplification is a maximum only when the signal is very weak.

Between the amplifier 32 and the amplifier 42 a receiver 60 is connected to respond to a portion of the received energy. This receiver is adjusted to discriminate between the marking and spacing waves, either by the simple expedient of being sharply tuned to one of the waves, or more elaborately, by having tuned circuits which are tuned to each of the waves, and which move a recording pen in opposite directions.

For one example of a transmitter of frequency modulated speech-simulating signals reference is made to Fig. 2 of the drawings. For speech signals a microphone 102 is connected in series with a battery 104, and to a land line 106. If code signaling, rather than or in addition to speech telephony, is to be employed, there are a plurality of sources of relatively low frequency energy 108 and 110, each keyed by keying means 112 and 114. The resulting speech-simulating wave is transferred over the land line 106 to the input transformer 116 of a frequency modulation generator 120. This comprises an upper and a lower oscillator, the former consisting of the electron emission tube 122, the resonant circuit 124, and a regenerative anode circuit coil 126, while the latter comprises an electron emission tube 128, the resonant circuit 130, and the common anode circuit coil 126. Because of the common coil 126 both oscillators are forced to oscillate at a common frequency. However, the circuit 124 is tuned to one extreme frequency of the desired frequency range, while the circuit 130 is tuned to the other extreme frequency of the desired frequency range, so that the common oscillation frequency is a compromise frequency lying between the two resonant frequencies. The magnitude of this common frequency depends upon the relative strength of oscillation in the two oscillators, which in turn depends upon the relative potential applied to the control electrodes of the oscillator tubes. The mean value of this control electrode potential is determined by a biasing source connected to the lead 132, while the relative value is varied by the secondary of the input transformer 116, which is connected in series with the control electrodes, so that the frequency of the energy generated in the unit 120 is varied in accordance with the speech-simulating wave applied to the transformer 116.

This frequency modulated energy may be radiated directly, but in order to keep the mean frequency of the radiated energy constant I prefer to use the circuit 120 to generate a frequency modulated wave of intermediate frequency, and to modulate energy of high frequency from a constant frequency source by means of the intermediate frequency energy. For this purpose carrier energy is supplied from a crystal controlled high frequency oscillator 140, which is coupled to feed the tubes of the carrier suppression modulator 150 in parallel, while the energy of intermediate frequency is supplied through a transformer 152 to the control electrodes of the modulator tubes in series. Of the two resulting side bands one is selected and the other rejected by the filter 154, and the resulting frequency modulated energy of high frequency may be amplified in a power amplifier 156, and radiated from a suitable antenna 158. For a more detailed description of this transmitter reference may be made to a copending application of C. W. Hansell, Serial Number 264,101, filed March 23, 1928.

A receiver is indicated in Figure 3, in which there is an antenna 160, the energy collected by which is fed to an amplifier 162, the output from which is heterodyned in a detector 164, with energy from a local oscillator 166, in order to obtain frequency modulated energy of intermediate frequency. The output from the detector 164 is amplified in an intermediate frequency amplifier 168. One portion of the amplified energy is fed to a band pass filter 170, adjusted to pass the entire band of working frequency, and then to a volume control detector 172. This is biased from a potential source connected to the lead 174 to give it a detector action. Across the output circuit of the detector a filter 176 is connected, in order to by-pass the radio frequency component of the rectified energy. The steady component is fed through a volume control impedance 178, which preferably is connected between the anode current source 180 and ground, as shown, in order to keep it at a low potential. A condenser 182 is connected in parallel with the impedance 178 to determine the time constant of the volume control action, and with my invention this period may be shortened as much as desired. A lead 184 is taken from one terminal of the volume control impedance and connected to the control electrodes of the tubes in the amplifiers 162 and 168. A source of constant potential 186 may be connected in series with the lead 184 to fix the normal bias on the amplifier tubes.

The volume-controlled energy is fed by transformer 186 to a resonant circuit 188, which is tuned to one extreme of the working frequency range, so as to respond unequally to the frequencies applied thereto, and thereby act as an analyzing circuit for transforming the frequency modulation into amplitude modulation. The amplitude modulated energy is detected in a detector tube 190 and the signal output is fed through a transformer 192 to any suitable translating means. For speech this may be exemplifier by the speaker 194. For multiplex code signals a plurality of filters 196 are provided, which separate the detected wave into its constituent signal energies, each of which is then translated in a translating means 198.

In this receiver it should be understood that the bias control may be applied to either the high frequency or the intermediate frequency amplifier alone, as well as to both, as shown. Also, the volume control detector may be coupled immediately after the high frequency amplifier, instead of after the intermediate frequency amplifier. The use of a heterodyne receiver is not essential, though it is very desirable to heterodyne the received energy before applying it to the analyzing circuit, in order to increase the percentage frequency modulation to facilitate analysis.

My invention, employing frequency modulation, possesses all of the advantages concomitant to the use of this type of modulation, such as the possibility of reducing the necessary frequency band for each channel of communication, the inherent reduction of fading owing to the range of frequencies employed, and the use of the transmitter at its maximum output at all times, but no claim is made herein to frequency modulation per se. My invention, in so far as it employs volume control, is accompanied by important advantages such as the reduction of the effect of slow fading, but no claim is made herein to volume control per se. However, in combining frequency modulation with volume control there results not only the advantages of each, but new and very important advantages, in improving the action of the volume control and in making possible the application of volume control to overcome the effect of rapid fading, even when the fading frequency approaches or surpasses the order of magnitude of the modulation frequency, and therefore, what I claim is:

1. In communication on a high frequency carrier the method of eliminating the effect of partial fading which includes, at the transmitter, frequency modulating the carrier in accordance with the signal to be transmitted, and at the receiver, amplifying the received energy, equally utilizing the received energy over the entire working frequency range for so controlling the gain in the amplifier as will tend to keep the amplified energy constant, and utilizing the amplified energy for translation.

2. In communication on a high frequency carrier, the method of eliminating the effect of partial fading, which includes, at the transmitter, frequency modulating the carrier in accordance with the signal to be transmitted, and radiating the frequency modulated carrier, and at the receiver, collecting the radiated energy, amplifying the collected energy, equally utilizing the amplified energy over the entire working frequency range for so controlling the gain in the aforesaid step of amplification as will tend to keep the amplified energy constant, and discriminating between the energy of different frequencies in the working frequency range for translating the desired signal.

3. The method of eliminating partial fading of code signaling which includes transmitting a marking wave of one frequency and a spacing wave of a different frequency, and at the receiver, amplifying the received energy, purely electrically controlling the amplification gain in response to both the marking and spacing waves so as to obtain a constant volume output, and discriminating between the marking and spacing waves for translation.

4. The method of eliminating partial fading of code signaling which includes transmitting a marking wave of one frequency and a spacing wave of a slightly different frequency, and at the receiver, amplifying the received energy, purely electrically controlling the amplification gain in response to both the marking and spacing waves so as to

obtain a constant volume output, and discriminating between the marking and spacing waves for translation.

5. A communication system for overcoming very rapid fading comprising the combination of a frequency modulation transmitter and a volume controlled receiver.

6. A communication system for the elimination of the effect of partial fading, comprising a frequency modulation transmitter and a receiver including an amplifier, a volume control equally responsive to the entire range of working frequency for controlling the gain in the amplifier, and a receiver responsive to the amplified energy for obtaining the desired signal.

7. A communication system for the elimination of the effect of partial fading, comprising a transmitter including a source of carrier energy, means to frequency modulate the carrier in accordance with a desired signal, and means to radiate the frequency modulated energy, and a receiver including means to collect the radiated energy, an amplifier for amplifying the collected energy, a volume control equally responsive to energy of the entire range of working frequency for so controlling the gain in the amplifier as will tend to keep the amplified energy constant, a circuit tuned to be unequally responsive to the working range of frequency for changing the frequency modulation into amplitude modulation, and means to translate the amplitude modulated energy in order to obtain the desired signal.

8. An arrangement for eliminating the effect of partial fading of code signals comprising a transmitter arranged to transmit one frequency during marking periods and another frequency during spacing periods, a receiver comprising an amplifier for the marking and spacing waves, a volume control responsive to both the marking and spacing waves for controlling purely electrically the amplification gain obtained in the amplifier, and means to discriminate between the marking and spacing waves for translating the signal.

9. An arrangement for eliminating the effect of partial fading of code signals comprising a transmitter arranged to transmit one frequency during marking periods and a slightly different frequency during spacing periods, a receiver comprising an amplifier for the marking and spacing waves, a volume control equally responsive to both the marking and spacing waves for controlling purely through electrical action the amplification gain obtained in the amplifier, and means to discriminate between the marking and spacing waves for translating the signal.

10. A receiver for code signals transmitted on marking and spacing waves of different frequencies comprising an externally biased vacuum tube amplifier for amplifying both the marking and spacing waves, a volume control detector equally responsive to both the marking and spacing waves, an impedance in series with the anode circuit thereof, a control electrode biasing circuit for the amplifier connected to the impedance in order to so vary the amplifier gain as to tend to keep the amplifier output constant, and means coupled to the output circuit of the amplifier for discriminating between the marking and spacing waves in order to translate the desired signal.

HAROLD H. BEVERAGE.