

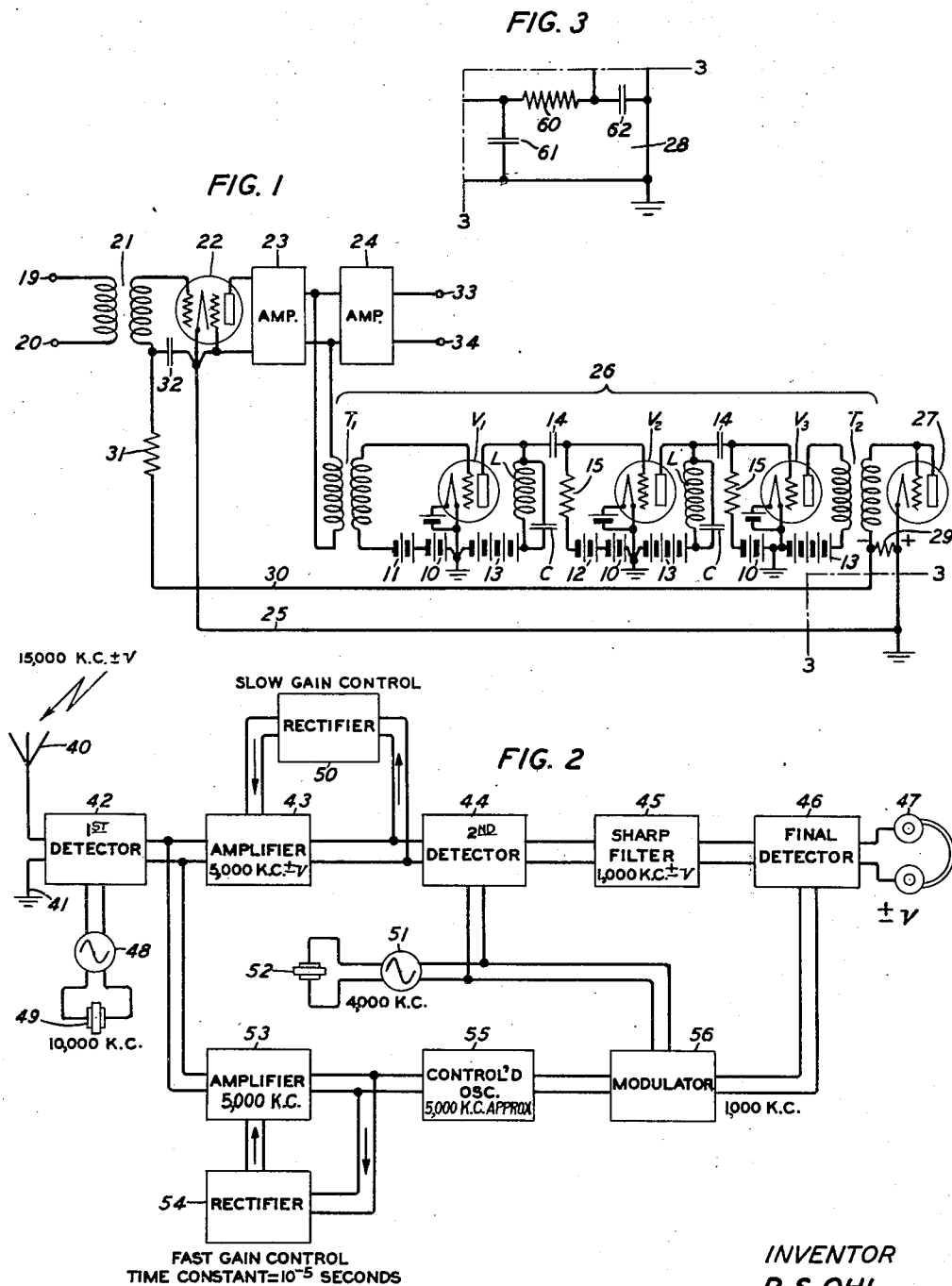
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METHOD OF AND MEANS FOR REMOVING MODULATION FROM A MODULATED WAVE

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METHOD OF AND MEANS FOR REMOVING
MODULATION FROM A MODULATED
WAVE

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6 Claims. (Cl. 178—44)

This invention relates to methods of and means for removing modulation from a modulated wave, or, as viewed from a slightly different angle, producing a carrier current of substantially constant amplitude from a single modulated current comprising carrier and side-band components.

A carrier current which is derived from a signal modulated current, but which has been by some means freed from signal modulations, is of use at a radio receiving station, for example, as a means for controlling the frequency of a local generator. The generator may be kept in synchronism with the received carrier current, while at the same time the generator supplies a local carrier current which is free from the effects of fading. Not only may fading produce amplitude fluctuations in the received carrier current, but the frequency of the received carrier current may also be changed over a considerable range. This change of frequency may be due either to instability of the radio transmitter causing the frequency to vary as it is generated, or a Doppler effect may be present due to rapid changes in the length of the path traveled by the carrier wave in transmission between the transmitting and receiving stations. In the latter case the frequency variation may be regarded as a fading effect.

A highly resonant electrical or piezoelectric system or the like, tuned to the carrier frequency, if effective to separate the carrier from the sidebands provided the carrier frequency is sufficiently constant to maintain resonance. If, however, either the carrier frequency or the resonant frequency of the selective system is unstable, the resonance between the two will be impaired and fluctuations in the amplitude of the selected carrier current will result. In accordance with the invention the necessity of maintaining resonance is eliminated, a carrier current of substantially constant amplitude being produced by the use of an automatic gain or amplification control arrangement which is so quick in its action that it can follow and compensate the signal modulations of the received carrier. The effect of the arrangement is to wipe out the modulations, leaving only a carrier wave of unvarying amplitude.

A quick acting system of a type found suitable for use in connection with the invention comprises one or more space discharge devices or vacuum tubes employed in cascade arrangement and coupled by resonant circuits tuned to a suitably high frequency. Each of the space discharge devices is polarized by a potential at least sufficient to block its own space discharge. The blocking renders the system insensitive to waves of

weak intensity but this condition may be overcome by initial amplification whereby waves of a preassigned strength are amplified to the point at which the blocking is overcome. Each of the space discharge devices when suitably excited is capable of providing sufficient output to overcome the biasing potential of the next tube in the series. The last space discharge device in the series is adapted to produce sufficient power to actuate a relay or other means which may form a part of a control or switching system.

The invention is hereinafter described in detail with reference to the drawing in which:

Fig. 1 shows the modulation removing device of the present invention in schematic form;

Fig. 2 is a schematic diagram of a radio receiving system embodying the invention; and

Fig. 3 shows a modification of a portion of the system of Fig. 1 to convert it into a slow acting gain control arrangement.

Fig. 1 illustrates a system adapted to receive a modulated wave at a pair of input terminals 19 and 20 and deliver a substantially unmodulated carrier wave at a pair of output terminals 33 and 34. A transformer 21 is arranged to feed the modulated wave into a controlled amplifier 22 connected in cascade with further stages of amplification 23 and 24. For control purposes a connection is provided for supplying a portion of the energy from the output of amplifier 23 to a detecting circuit 26.

The circuit 26 comprises a series of vacuum tubes V_1 , V_2 and V_3 associated in cascade arrangement by means of coupling circuits each including an inductance coil L and a condenser C . The resonance frequency of each coupling circuit should be high relatively to the frequency of the impressed signals. Each of the coupling circuits may be tuned to the same frequency or the frequencies may be different in which case the second tuned circuit should preferably have the higher resonance frequency. The energization of the coupling circuits at frequencies remote from the frequency of the impressed wave is accomplished by impulse excitation as is explained more fully hereinafter in connection with the operation of the system. Each of the tubes is provided with a grid biasing potential by means of a battery 10, sufficient to entirely block the space discharge through the tube in the absence of any alternating current input. Tube V_1 is provided with additional negative biasing battery 11 connected in the same polarity as battery 10. The tube V_2 also has an additional polarizing battery 12 of the same polarity as the battery 10 and pref-

erably of somewhat lower voltage than battery 11. Space current sources 13 are connected to the anode of each tube. The anode of tube V₁ is coupled to the grid of the tube V₂ by a coupling condenser 14 and a grid leak is provided through a resistance 15. The plate circuit of the tube V₂ is coupled to the grid circuit of the tube V₃ by a similar condenser 14 and grid leak 15. The transformers T₁ and T₂ are input and output devices respectively for the cascade arrangement of tubes V₁, V₂, V₃.

The final stage employing the tube V₃ is an output stage and is biased only sufficiently to prevent a discharge when no alternating current is applied to the input circuit of the tube. The output current of the tube V₃ is delivered through transformer T₂ to a rectifier 27. The circuit of the rectifier 27 extends from the anode, through the secondary winding of transformer T₂ and a resistance 29 to the cathode and ground. The negative or left hand terminal of resistance 29 is connected through a lead 30, a resistance 31 and the secondary of the transformer 21 to the control grid of the amplifier 22. The cathode of the amplifier 22 is grounded through a lead 25, with the result that the potential across the resistance 29 is applied between the control grid and cathode of the amplifier 22 as a biasing potential. A by-pass condenser 32 is connected between the cathode and the lower end of the secondary of transformer 21.

In the operation of the system shown in Fig. 1 a modulated wave is impressed upon the terminals 19 and 20 from any suitable source. The device 26 will not be affected until and unless the induced electromotive force in the secondary winding of the transformer T₁ is greater than the combined voltage of the biasing batteries 10 and 11. When the impressed current is sufficient to overcome the biasing potential, the positive tips of the wave of induced electromotive force are effective to cause space discharges in the tube V₁. These discharges will be in the form of impulses or trains of impulses. The effect in the output circuit of the tube V₁ is to excite high frequency oscillations in the circuit LC by impulse excitation. Between the successive impulses, the tube V₁ is blocked and therefore cannot then extract energy from the oscillating circuit LC. The tuned circuit itself is, as usual, only slightly damped and the oscillations tend to be sustained during the period between impulses. Extended peak voltages generated in the tuned circuit LC will cause the grid of the tube V₂ to become positive at times, particularly during or immediately following each exciting impulse. The grid filament impedance of the tube V₂ is greatly reduced while the grid of that tube is positive, thereby intermittently introducing a large damping effect. This intermittent damping reduces the excessive peaks of the oscillations, further tending to sustain the oscillations at a relatively constant amplitude as long as the impulses continue to be applied. When the end of a train of impulses is reached, the oscillations of the circuit LC are quickly damped out in the usual manner.

The tube V₂ is blocked by the polarizing batteries 10 and 12 and will not respond to an impressed wave unless the voltage generated by the wave impressed across the resistance 15 is greater than the combined voltage of the batteries 10 and 12. The response of the tube V₂ to a wave which is of sufficient intensity to overcome the biasing potentials will be in the form of a train of impulses having the frequency for which the circuit

LC is resonant. The second tuned circuit LC, in the output of the tube V₂, will be excited by the train of impulses and, due to an intermittent damping introduced by the input circuit of the tube V₃, a train of oscillations of more or less sustained amplitude will be generated.

When the alternating voltage applied to the input circuit of the tube V₂ is sufficiently great to drive the grid potential positive and cause a flow of grid current in the tube, any further increase in the applied voltage is accompanied by an increase in the grid current and an increased fall of potential in the grid leak 15. This fall of potential is in the requisite direction to establish a negative biasing potential upon the grid. This tends to prevent any further increase in the alternating voltage applied to the grid and limit the output of the tube V₂. The volume limiting effect is a further factor in maintaining a substantially constant amplitude of oscillation throughout the duration of the application of impulses to the tube V₁. The sustained form of the train of oscillations applied to the tube V₃ and thence to rectifier 27 is adapted to give a maximum rectified current. The advantage of the sustained form of wave will readily be evident when it is considered that each cycle of the wave contributes to the rectified current and that the cycles occur in rapid succession when the circuits LC are turned to a high frequency. The original impulses which cause the discharge in the tube V₁ are of relatively small amplitude and low frequency and are unsuited to the production of large rectified currents. Regenerative effect, if present in the system, will not be detrimental provided it is not sufficient to cause self-sustained oscillations and may be used in certain cases with beneficial results.

In the operation of the system of Fig. 1 as a whole, a small change in the alternating current output of amplifier 23 actuates the system 26 to produce a large change in the rectified current delivered by rectifier 27 through resistance 29. A correspondingly large change is produced in the potential across the resistance 29 and consequently a large change is effected in the biasing potential on the grid of the amplifier 22. This change in the biasing potential is found to be proportional to the change in the output of amplifier 23 over an extended operating range. The connections are such that the bias becomes more negative when the output increases and less negative when the output decreases and thus there is exerted a powerful control upon the gain of the amplifier 22 in the proper direction to restore the output of amplifier 23 to its former value. The rapidity of response of the gain control is regulated by adjusting the time constant of the circuit comprising resistance 31 and condenser 32. This constant is made extremely low, for example of the order of 1/100,000 of a second, so that the rectifier 27 exerts a very rapidly responsive control, capable of smoothing out all fluctuations of amplitude of the carrier current passing through amplifier 22. The action of the gain control is made sufficiently rapid so that the modulation is removed from the modulated carrier wave, and the output at terminals 33 and 34 is substantially an unmodulated carrier current.

In Fig. 2 is shown a schematic representation of a radio receiving station employing triple detection. The system includes an antenna 40 and ground connection 41 connected to a cas-

cade arrangement comprising first detector 42, high frequency amplifier 43, second detector 44, filter 45, final detector 46, receiver 47, with associated control apparatus. The first detector 42 receives local oscillations from an oscillator 43 which is controlled as to frequency by a piezoelectric crystal 49. The amplifier 43 has an associated rectifier 50 which operates as a slow gain control. The second detector 44 receives local oscillations from an oscillator 51 controlled by a piezoelectric crystal 52. A portion of the modulated carrier current of intermediate frequency is diverted from the output of detector 42 to an amplifier 53 and associated rectifier 54 for removal of the modulation in accordance with the invention. The smoothed out carrier current from amplifier 53 is used to control an oscillator 55. Oscillators 51 and 55 are connected to a modulator 56, the output of which is connected to the final detector 46 to supply the carrier current for the final stage of detection.

The amplifier 53 and rectifier 54 constitute a system similar to that disclosed in Fig. 1, the amplifier 53 representing the amplifying stages 22 and 23 of Fig. 1, and the rectifier 54 representing the combination of the detecting circuit 26, rectifier 27 and resistance 29.

The combination of amplifier 43 and rectifier 50 is a modification of the system of Fig. 1 adapted to provide a slow acting gain control to compensate for amplitude effects due to fading. The modification relates to the portion of Fig. 1 below and to the right of the section line 3—3. The circuit of Fig. 3 is substituted for this portion of the system of Fig. 1 and comprises a filter or time constant circuit 28 in which a resistance 60 is inserted in series with lead 30, a condenser 61 is bridged across between leads 30 and 25, and a condenser 62 is connected in parallel with resistance 29. The filter is proportioned to have a time constant relatively large compared to that of the resistance-condenser combination 31, 32. The control of the gain may be slowed down to any desired extent by this means. A slow gain control of this type is disclosed and claimed in my copending application Serial No. 563,265 filed September 17, 1931.

In the operation of the system of Fig. 2 as a whole, an incoming high frequency carrier wave comprising one or both side-bands and accompanied by at least a small proportion of unmodulated carrier frequency is impressed upon antenna 40. For purposes of illustration the carrier frequency is taken to be 15,000 kilocycles, modulated by a signal frequency designated by V. In detector 42 the incoming wave is combined with a 10,000 kilocycle wave from oscillator 48, thereby producing a modulated carrier wave having a carrier frequency of 5,000 kilocycles. This modulated wave is impressed upon the two amplifiers 43 and 53. The gain of amplifier 43 is controlled by rectifier 50 in a slow manner so that the output of amplifier 43 is a modulated wave of nearly constant volume but having all the characteristics of the original signals contained in the incoming 15,000 kilocycle wave. The amplifier 53, however, is controlled in a very rapid manner by rectifier 54 so that the output of amplifier 53 consists of a substantially unmodulated carrier current of approximately 5,000 kilocycle frequency. This unmodulated carrier current controls the frequency produced by the controlled oscillator 55 so that the output of oscillator 55 is maintained at approxi-

mately 5,000 kilocycles and differs by a fixed amount (10,000 kilocycles determined by oscillator 48) from the frequency of the wave impressed upon the antenna. The wave from oscillator 55 is combined with a 4,000 kilocycle wave from oscillator 51 in modulator 56 to produce an output current of approximately 1,000 kilocycles which differs in frequency by 14,000 kilocycles from the frequency of the wave impressed upon antenna 40. The modulated output current from amplifier 43 is combined in detector 44 with the 4,000 kilocycle carrier wave from oscillator 51 to produce a modulated wave having a carrier frequency of approximately 1,000 kilocycles. This carrier frequency also differs from the carrier frequency of the carrier wave impressed upon antenna 40 by 14,000 kilocycles. This modulated wave is passed through filter 45 which is designed to pass only one side-band. The side-band is combined with the output from modulator 56 in the final detector 46 to produce signals in receiver 47. The frequency of the output current from modulator 56 will be exactly the correct frequency for detecting the modulated wave passed by filter 45 due to the control exerted upon oscillator 55 by the carrier wave produced in amplifier 53.

It is necessary that the transmission band of the filter 45 be of sufficient width to accommodate a single side-band in case of a slight variation in the frequency of the incoming wave. The use of the crystals 49 and 52 to control the frequency of oscillators 48 and 51, respectively, is designed to reduce the frequency instability to a minimum so that the frequency impressed upon the filter 45 will not vary materially except due to variations of the frequency impressed upon the antenna 40.

What is claimed is:

1. The method of producing a carrier current of substantially constant amplitude from a signal-modulated current having carrier and side-band components, which comprises deriving from said signal-modulated current an auxiliary current having intensity variations at least as rapid as the intensity variations of said signal-modulated current and variably amplifying said signal-modulated current in inverse correspondence with the intensity variations of said auxiliary current to substantially annul the intensity variations of said signal-modulated current due to side-band components.

2. The method of producing a carrier current of substantially constant amplitude from a signal-modulated current having carrier and side-band components which comprises detecting a portion of the signal-modulated carrier current to recover the signal and substantially simultaneously using the signal current so detected to modulate another portion of the signal-modulated carrier current in opposite phase and to a degree sufficient to substantially annul the original signal modulation, thereby substantially removing the variations in carrier amplitude impressed by the original signal modulation.

3. In a system for removing modulation from a modulated wave, the combination of an amplifier controllable as to gain by means of auxiliary currents, means for detecting in normal amplitude relation the signals carried by the modulated waves, and means for impressing all of the signal currents so produced upon the amplifier as gain control currents in sufficient amplitude and proper phase to substantially elimi-

nate all signal modulation from the carrier waves in the output of the amplifier.

4. In combination, a source of signal modulated carrier waves subject to fading, an amplifier controllable as to gain by means of auxiliary currents, a rectifier adapted to resolve a portion of the modulated wave into signal currents and into components of variation due to fading, and means for impressing all the signal currents and currents due to fading upon the amplifier as gain control currents in sufficient amplitude and proper phase to substantially eliminate all signal modulation and all fading from the carrier waves in the output of the amplifier.

5. In a system for removing modulation from a modulated wave, the combination of an amplifier with provision for automatic gain control, means controlled by the modulated carrier waves for generating a wave corresponding to the envelope of the carrier, and means for impressing

the envelope wave upon the amplifier to control the gain thereof in phase opposition to the envelope of the modulated carrier, whereby the modulation of the carrier wave as transmitted through said amplifier is substantially neutralized.

6. In a system for removing modulation from a modulated wave, the combination of an amplifier provided with automatic gain control, a rectifier for deriving from the modulated waves a wave corresponding to the envelope of the modulated carrier, a filter for suppressing the carrier in the envelope wave and transmitting all lower frequencies, and means for impressing the filtered envelope wave upon the amplifier to control the gain thereof in such amplitude and phase relative to the modulated wave as to substantially neutralize all the modulation of the carrier wave without materially reducing the average amplitude of the carrier.

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25	100
30	105
35	110
40	115
45	120
50	125
55	130
60	135
65	140
70	145
75	150