

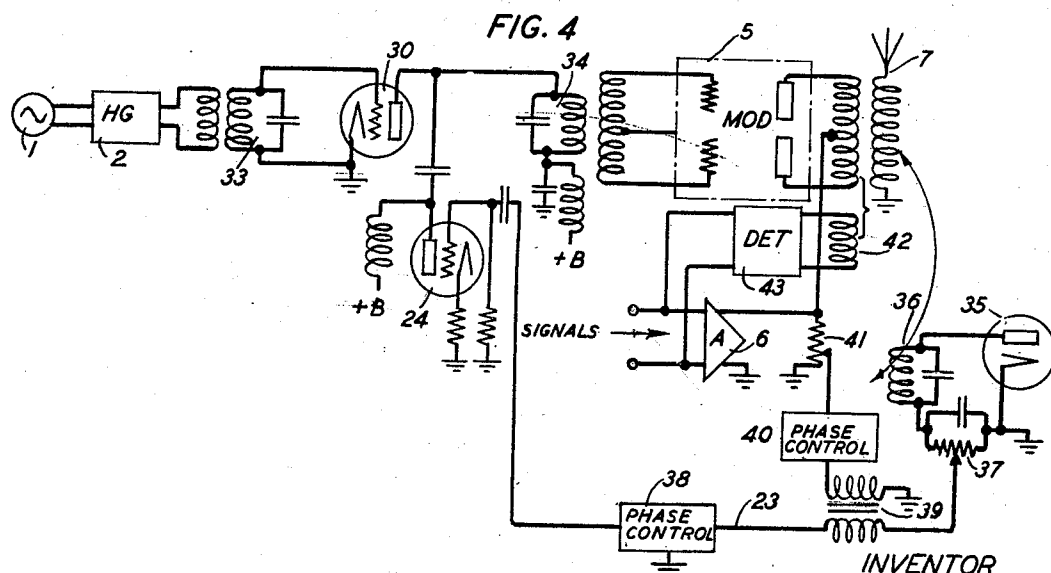
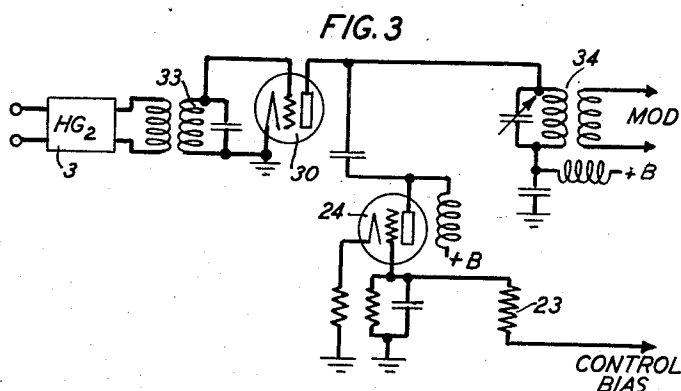
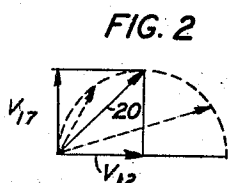
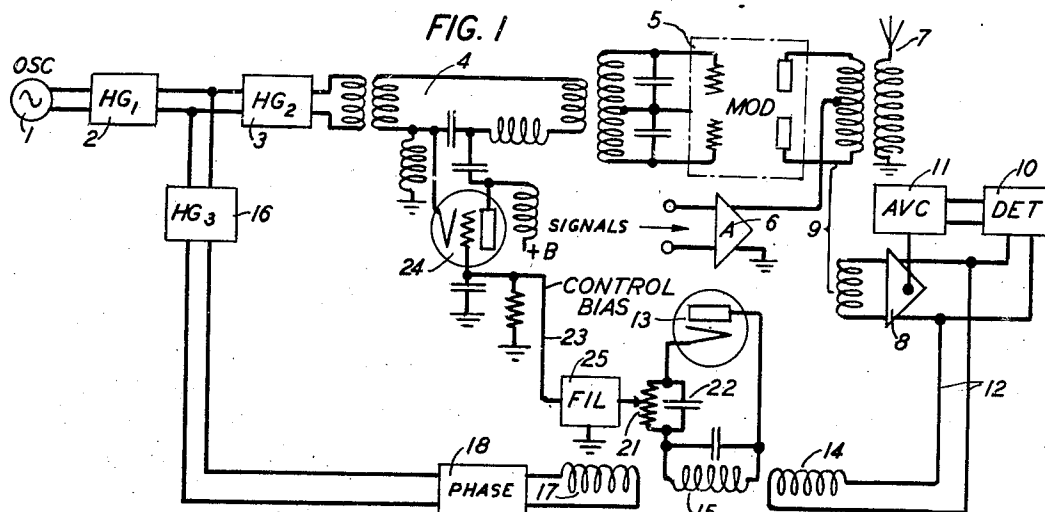
Oct. 13, 1942.

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2,298,930

PHASE DISTORTION CORRECTION

Filed Jan. 14, 1941



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2,298,930

PHASE DISTORTION CORRECTION

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Application January 14, 1941, Serial No. 374,337

3 Claims. (CL 179—171.5)

The present invention relates to wave transmission for signaling or other purposes, using modulated waves. More specifically, the invention relates to the reduction of effects due to unwanted phase modulation in an amplitude modulated system.

Undesired phase modulation may be introduced in an amplitude modulated wave in a variety of ways among which are: improper neutralization of a bridge-neutralized modulator stage, improper tuning of the output circuits and, at ultra-high frequencies, the effects of variations in electron transit time from the fact that the plate voltage is changing through the modulation cycle.

The phase modulation produced at the transmitter shows up as distortion in the receiver output when the receiver gain or phase characteristic versus frequency is unsymmetrical about the mid-band frequency or the band width is narrow. This is likely to be the case where the total band width is limited to the minimum amount for passing the multiplex channels by means of filters with sharp cut-off at the edges of the transmission band. In such instances the phase modulation is detected by the amplitude detector and appears as added distortion in the desired signal in the form of cross-talk or cross-modulation in a multiplex system due to the products that fall into the other channels. It is highly desirable, therefore, to suppress the phase modulation as well as to improve the over-all transmission characteristic.

It is common in radio transmitters to employ "over-all" or envelope negative feedback to reduce the total distortion occurring anywhere in the transmitter. This is done by detecting some of the output wave to recover the speech together with distortion and feeding the detected components into the speech input circuit in reverse phase. Phase modulation is not reduced by this procedure since the phase modulation is not fed back, at least in any way that is capable of producing compensation for the phase modulation.

In accordance with the present invention, phase modulation is detected at the transmitter and a feedback action is produced which results in reducing the phase modulation. The action is similar in principle to negative feedback in reducing amplitude distortion but the manner in which the negative feedback is applied to reduce the phase modulation is believed to be novel.

Phase modulation of the carrier may be caused by the speech or signal or by noise such as 60-

cycle power used to heat the cathodes or by both. The invention is effective, in its different forms of embodiment to be described, to reduce one or the other type or both of these types of modulation.

The nature and objects of the invention will be more fully understood from the following detailed description in connection with the attached drawing in which:

Fig. 1 is a schematic circuit diagram of one form in which phase modulation of the carrier is suppressed;

Fig. 2 is a vector diagram to be referred to in connection with Fig. 1;

Fig. 3 shows a modification in the phase compensating circuit of Fig. 1; and

Fig. 4 shows another form of the invention for reducing the effects of phase modulation of the carrier.

Referring to Fig. 1, the oscillator 1 may be of any suitable type such as a crystal controlled oscillator designed to produce a wave at a convenient frequency level, the frequency of which may be stepped up by one or more stages of harmonic generation, two being represented at 2 and 3. The carrier wave is then passed through a phase controlling circuit 4, to be described, to the input of the modulating circuit 5 which may be of any suitable type such as push-pull. It may comprise more than one stage and may include amplifiers as needed. The speech or other signal is introduced into the plate circuit of the modulator through speech amplifier 6. The output wave consisting preferably of both side-bands and the unmodulated carrier component is radiated from antenna 7. It will be understood that in the case of multiplex transmission other signals may be sent simultaneously from the same station and the common practice of using certain of the equipment in common including the antenna, carrier source, etc., may be assumed in this case, although not specifically indicated on the drawing. While negative feedback for amplitude distortion reduction is not shown it may be used in known manner.

A portion of the output wave is picked up in the input of radio frequency amplifier 8 through the coupling 9. This amplifier is shown provided with a detector 10 and automatic volume control 11 set for sufficiently fast action to counteract the speech variations in the carrier and to produce in the circuit 12 a substantially constant amplitude wave. In place of elements 10 and 11 a limiter could be used in the circuit 12 or gain control and limiter action could be used

together. If the modulation is substantially 100 per cent, the elimination of the speech side-bands will be incomplete. In some cases it may not be necessary to use either the automatic volume control or a limiter. In any case, circuit 12 will carry a wave having as a component the carrier frequency accompanied by any phase modulation that may have taken place in the transmitter. Circuit 12 is coupled to the detector 13 by inductively related coils 14 and 15.

Detector 13 is supplied also with unmodulated carrier waves obtained from harmonic generator 16 by way of coil 17 and (if needed) phase shifter 18. The unmodulated carrier components applied to the detector from 14 and 17 are adjusted to be equal in amplitude and to be normally in phase quadrature as indicated by the vectors V_{12} and V_{17} of Fig. 2. The two vectors produce a vector 20 the length of which represents the normal or zero adjustment when the two component vectors are in 90-degree relation. If the angle between the component vectors decreases, the resultant 20 increases in length and if the angle increases, the length of the resultant decreases, its arrow having a locus represented by the dotted semi-circle, assuming vector V_{12} as stationary. The output of the rectifier detector 13 represents, therefore, a current whose magnitude varies as the phase angle between the two carrier frequency voltages impressed on the detector varies. This resultant current flows through resistor 21 which is by-passed for the carrier by capacity 22. A bias control lead 23 is connected to a slider on resistor 21 for deriving a control voltage therefrom for application to the grid of reactance tube 24. A filter 25 may be included in the bias control lead to pass certain frequencies only if desired as will be described later on.

The change in rectified current obtained from detector 13 is used to vary the bias on the grid of control tube 24 whose plate circuit impedance is thereby adjusted so as to produce a change in its shunt reactance. This changing impedance is used to control the phase of the radio frequency driving voltage to the modulator 5 so as to compensate for the phase modulation occurring in the radio transmitter. In the embodiment shown in Fig. 1 the control tube 24 varies the reactance of the series resonant circuit 4.

The vector V_{17} of Fig. 2 is unaffected by amplitude modulation and may be assumed constant in length and phase. If the vector V_{12} is also of constant length notwithstanding the amplitude modulation of the carrier so that only the phase angle between the two vectors is effective in changing the length of vector 20, then the compensation of the phase modulation can be accomplished in high degree. If, however, the vector V_{12} varies in length as well as in its angular position with respect to vector V_{17} , these length variations representing amplitude modulation should not be allowed to be translated into phase variations in the carrier since they would produce spurious effects. If the amplitude modulation present in voltage V_{12} is confined to a particular frequency range, such range may be suppressed by filter 25 and the fluctuations of such range are prevented from affecting the control tube 24. For example, let it be supposed that phase modulation of the carrier at power frequencies below the speech range is objectionably large and that the coupling 14, 15 impresses on the detector 13 some speech amplitude modulation which if allowed to affect the control tube would produce objectionable phase modulation.

In such case the filter 25 serves to suppress the speech frequency fluctuations but the power frequency variations such as 60-cycle variations are allowed to pass on to control tube 24 and effect the necessary phase compensation.

Fig. 3 illustrates another manner of connecting the control tube 24 to the carrier supply path leading to the modulator 5. The carrier output of the harmonic generator 3 feeds into a carrier amplifier 30 through tuned coupling 33, the output of the amplifier including tuned coupling 34. Control tube 24 has its plate impedance shunted across the tuned coupling 34 so that variations in the plate impedance of tube 24 produce corresponding variations in the reactance in shunt of coupling 34 and consequent variations in the phase of the carrier transmitted to the modulator. Still other types of control tube coupling are possible.

Referring to Fig. 4, the oscillator 1, harmonic generator 2, amplifier 30 with its input coupling 33 and output coupling 34, modulator 5 and antenna 7 may all be as previously described, the harmonic generator 2 comprising, if desired, a plurality of stages of frequency multiplication to arrive at the desired carrier frequency.

It was stated above that phase modulation in the transmitted wave is particularly objectionable in multiplex systems in which the tuned receivers may have unsymmetrical phase characteristics giving rise to amplitude distortion in the detected wave. It is assumed in Fig. 4 that the detector 35 with its tuned selector circuit 36 has an unsymmetrical phase characteristic so as to detect the phase modulation for control purposes. As a result the detected current in resistor 37 will be composed of detected amplitude modulation (the signal and detected phase modulation (distortion) resulting from the unsymmetrical phase characteristic of the detector circuit. A voltage of proper value is picked off the resistor 37 by the slider and conveyed over bias control lead 23 to the grid of control tube 24. Inserted in lead 23 is the speech coupling 39 leading from the output of speech amplifier 6 and derived, for example, from potentiometer resistance 41. The purpose of the speech coupling 39 is to apply a cancelling speech voltage to lead 23 adjusted in magnitude and phase so as exactly to balance out that part of the detected voltage in lead 23 that is due to the amplitude modulation but to leave as a residue that part of the detected voltage that is due to the phase modulation. For this purpose a phase shifter 40 may be necessary between resistor 41 and the coupling 39. The adjustments should be such that only the distortion due to phase modulation is applied to the grid of control tube 24, and the magnitude and phase of this distortion so applied should be of the proper values to produce the appropriate compensating phase premodulation of the carrier passing from the driver stage 30 to modulator 5. Phase shift circuit 38 is provided for producing the necessary phase relation in the control voltage.

If desired, a negative feedback path may be provided from a suitable output point such as winding 42 coupled to the modulator output, through detector 43 to the speech input circuit on the input side of amplifier 6. This path provides negative envelope feedback for reducing amplitude distortion in the output wave, in known manner. It is, of course, desirable to keep the amplitude distortion as low as possible in the transmitted wave in the interest of high quality

transmission and, also, in connection with the invention, so that the residue of speech current in lead 23 remaining after comparison with some of the input speech in coupling 39 shall consist so far as possible of distortion due solely to phase modulation.

What is claimed is:

1. In a system for modulating the amplitude of carrier waves by an input signal with incidental phase modulation of said carrier waves, means to detect the amplitude modulation and the phase modulation, means comprising a differential circuit for combining a portion of the input signal with the output of said detecting means to separate the components resulting from phase modulation from the components resulting from amplitude modulation, and means to produce compensating phase modulation of the carrier in accordance with the former components.

2. In a transmitting system for signal amplitude modulated carrier waves possessing gain from input to output, a source of input signal wave, said system tending to produce incidental phase modulation in its output, means to detect the output amplitude modulation and the output phase modulation, means comprising a differential circuit for combining a portion of the input signal with the output of said detecting means to separate the components due to amplitude modulation

from the components due to phase modulation, and means to feed back the latter components in gain reducing sense to counteract the incidental phase modulation.

3. In a radio transmitter, a source of input signal wave, a source of high frequency waves, a radio transmitter including means to modulate the amplitude of said high frequency waves by said signal wave for transmission, said radio transmitter producing incidental modulation of the phase of said high frequency waves, means to detect some of the phase modulation of the transmitted waves, said last means also producing incidental detection of the amplitude modulation thereof, means to eliminate such incidental detected amplitude modulation comprising a differential coupling for combining a portion of the input signal wave with the output of said detecting means to cancel the signal component resulting from detection of the amplitude modulation, thereby leaving a residue of signal resulting substantially solely from detection of the phase modulation, and means to modulate the phase of the high frequency wave by said residue, in reverse sense, on the input side of said amplitude modulating means, to reduce the amount of said incidental phase modulation in the transmitted waves.

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