

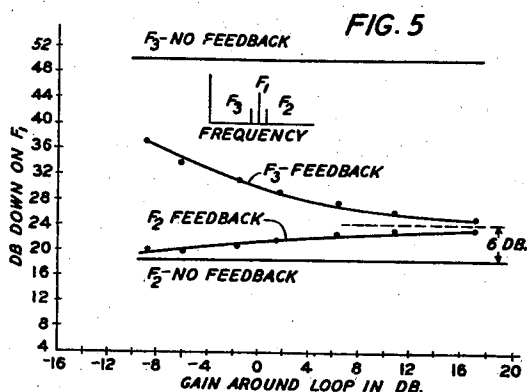
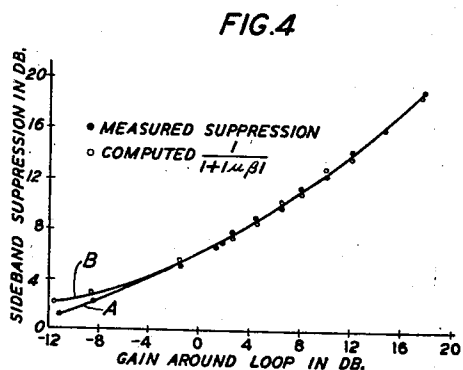
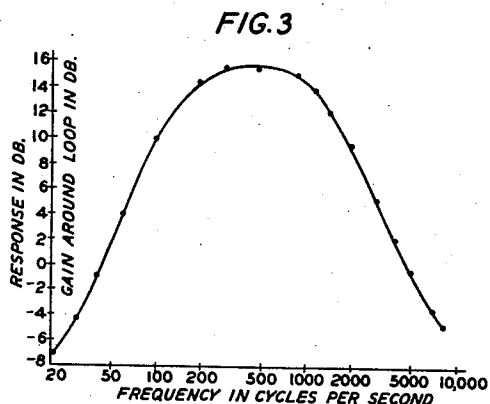
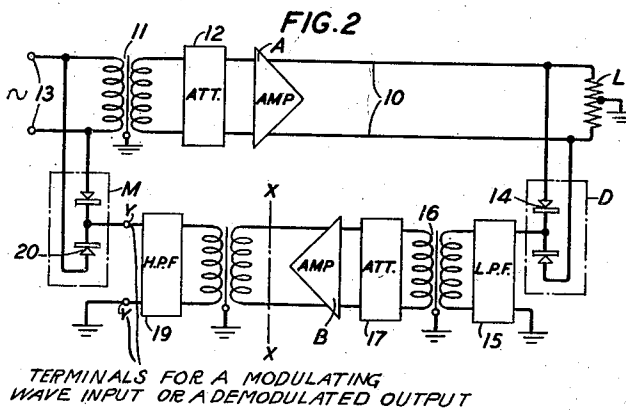
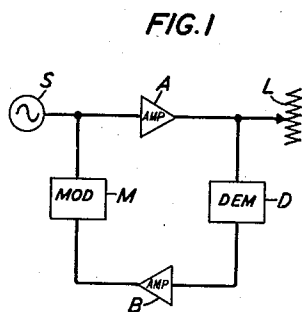
Dec. 10, 1940.

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2,224,580

MODULATION SYSTEM

Filed Nov. 16, 1938



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2,224,580

MODULATION SYSTEM

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Application November 16, 1938, Serial No. 240,639

3 Claims. (Cl. 179—171.5)

This invention relates to a method and means of reducing amplitude modulation of signal waves by any desired degree.

It is often desired to remove noise and other spurious side-bands on a carrier or other single tone supply, to remove amplitude modulation from signals in which only frequency modulation is wanted, to reduce the degree of modulation in a received radio signal, to remove modulation side-bands from a received signal so that its carrier may be used as a frequency reference, to reduce the effective noise in systems nominally carrying only a single frequency, or to reduce distortion in a modulator.

It is an object of this invention to provide a method and means for attaining such results in a simple and reliable manner.

A feature of the invention comprises the utilization of a negative feedback connection in which the undesired noise, distortion or side-bands are detected or demodulated, amplified, and remodulated on the transmission line but with a phase and magnitude to oppose or compensate for the original undesired component.

In accordance with this invention, a transmission line or system is provided with a source of signal at one end and any suitable load or termination at its other end, an amplifier being included in the line. A feedback connection from the output to the input circuits of said amplifier comprises a detector or demodulator, an audio frequency amplifier and a modulator, in the order named, the feedback being of such amplitude and phase that the desired reduction or elimination occurs without singing tendency around the feedback path.

A more complete understanding of the invention will be obtained from the detailed description which follows, taken in conjunction with the appended drawing, wherein:

Fig. 1 is a schematic of a circuit arrangement or system embodying the invention;

Fig. 2 shows in greater detail the means utilized in practicing the invention; and

Figs. 3, 4 and 5 show curves illustrating characteristics of a circuit embodying the invention.

Fig. 1 shows schematically a transmission system comprising a transmission path or line 10 having a source S at one end and a suitable load L at its other end. The source S may be, for example, a source of carrier waves or other single tone supply including undesired noise or other spurious side-bands, or a source of frequency modulated carrier waves including unwanted amplitude modulation components, or a source of received radio signals whose modulation exceeds a desired degree, or a source of received signals having modulation side-bands which must be removed if its carrier is to be used as a frequency reference. The amplifier A is a high frequency

amplifier in the transmission path intermediate its ends. A feedback connection comprising a balanced detector or demodulator D, a low or audio frequency amplifier B, and a balanced modulator M, in the order named, extends between the output and the input sides of the high frequency amplifier.

The waves from the source S pass through the amplifier A and into the load or termination L. The amplifier output is impressed on the demodulator which produces the demodulated side-bands in the mid-branch, conjugate to the load. These side-band frequencies are amplified by the amplifier B, and are then impressed on the modulator M. The side-band frequencies are remodulated on the original input waves, but preferably are 180 degrees out of phase with the original side-bands and of such magnitude as to effectively oppose or compensate for the original side-bands. The remaining side-bands again pass through the amplifier A, and the process is repeated indefinitely, producing a result which in its broad aspect is identical with that found in negative feedback amplifiers of the type disclosed in H. S. Black Patent 2,102,671, issued December 21, 1937. It can be readily shown that to the first approximation, at least, the side-bands are reduced by the factor

$$\frac{1}{1 + \mu\beta}$$

where $\mu\beta$ has the magnitude and phase found by breaking the feedback path and measuring the transmission around the loop as taught in the Black patent.

The method of design of the loop characteristic is the same as that used for the Black type negative feedback amplifiers. Difficulty, if any, will be encountered in the low frequency path, for the necessary transmission band may be several octaves whereas in the amplifier A the transmission band may be relatively narrow. In some applications, it may be feasible to eliminate amplifier B and make all the amplifier useful in the forward path. In such a case, if amplifier A has a gain of N decibels, the demodulator should be designed to operate with a carrier N decibels greater than the proper carrier for the modulator. Both the modulator and the demodulator function as linear devices, that is, their output is directly proportional to the input.

The circuit arrangement shown in Fig. 2 is representative of an actual embodiment of the invention and comprises the transmission line 10, including a transformer 11 coupling the high frequency amplifier A and an attenuator 12 to the input terminals 13 of the line. The feedback connection comprises the demodulator D, for example, of oppositely poled asymmetric conducting units 14, such as copper-cuprous oxide recti-

fler units, a low-pass filter 15, an input transformer 16, another attenuator 17, the low frequency amplifier B, an output transformer 18, a high-pass filter 19, and the modulator M, for example, of oppositely poled asymmetric conducting units 20, such as copper-cuprous oxide rectifier units. The low frequency amplifier in the particular case had a sharp cut-off at the low and high frequencies, and the low and high-pass filters were used to reduce the gain at those frequencies to prevent singing, and enabled as much as twenty decibels gain around the feedback loop without tendency to singing. Although amplifiers of any conventional design may be used, it was found that, if the amplifiers A and B had degenerative or negative feedback within themselves, the phase shift around the feedback loop was reduced. A gain-frequency characteristic around the feedback loop is shown in Fig. 3, the feedback connection having been broken and the measurements made at X—X.

The carrier wave for a particular transmission system is frequently derived from a relatively low frequency carrier wave by means of a harmonic producer, the desired carrier wave being a harmonic of the lower frequency wave. If the latter contains, as is sometimes the case, troublesome power supply or other undesired side-bands, these side-bands become even more troublesome at the higher desired frequency because the ratio of the amplitude of the side-bands to that of the harmonic increases with the order of the harmonic. When high order, high frequency harmonics are used, the requirements for the removal of the low frequency side-bands become stringent.

A source of 72 kilocycles carrier with two noise side-bands resulting from the superposition of a 700 cycles per second wave on the carrier was impressed on the input terminals 13 of the line 10, and measurement of the carrier and the side-bands in the load circuit was made by means of a current analyzer. Curve A of Fig. 4 shows the suppression of the side-bands as a function of the gain around the feedback loop. The theoretical results to be expected from computations based on the measurement of gain around the loop is shown by curve B of Fig. 4. Close agreement between the theoretical and actual results is indicated, with only slight discrepancy at low values of gain. The circuit arrangement described will function for any purpose where it is desired to reduce the amplitude of double side-bands of a carrier, and it will reduce such side-bands to whatever degree of stable feedback the circuit is designed.

The circuit arrangement described may be used also in the case of a carrier and single side-band. From a theoretical standpoint and to a first order approximation, it would seem that the side-band should be reduced 6 decibels for very large amounts of feedback and another side-band added equal in magnitude but 180 degrees out of phase with it. The demodulated value of these two side-bands would be expected to decrease as the value of $1+\mu\beta$ increased. For many applications, therefore, the production of out of phase side-bands is equivalent to removing the original side-bands.

The results of a test made to determine if the circuit arrangement described would function in accordance with these considerations is shown in

Fig. 5. Two frequencies, F_1 , the carrier, and F_2 , the single side-band, were impressed on the input terminals 13. With the feedback connection open, F_2 was 18.5 decibels down on F_1 , and the other side-band F_3 , where $F_3=2F_1-F_2$ is produced spuriously in the modulator M, was 50 decibels below F_1 . With the feedback loop closed and the gain around the loop increased, F_2 was reduced by a value approaching 6 decibels and F_3 increased to a value approaching F_2 . Measurement of the demodulated difference frequency F_2-F_1 indicated that it decreased by the value of $1+\mu\beta$, showing the two side-bands to be out of phase. For large amounts of feedback, therefore, the demodulated noise is reduced by the amount of feedback or gain around the loop. It follows, therefore, that the circuit arrangement described will reduce the effects of noise or random frequencies in amplifiers made to pass a single frequency for, with rare exception, out of phase double side-band noise cannot manifest itself.

The circuit arrangement of Figs. 1 and 2 can be used to reduce distortion in modulators. Carrier only will be impressed on the terminals 13 of the transmission line 10, while the modulating signal is introduced in the feedback connection, for example, at the terminals Y—Y. The distortion side-bands are reduced by a process analogous to the reduction of distortion in the Black amplifier.

As a demodulator, the circuit arrangement also functions to reduce distortion. Here the signal and side-bands are applied at 13, and the demodulated side-bands or original signal taken out at Y—Y.

What is claimed is:

1. A wave transmission system comprising a transmission line containing an amplifier, a source at one end of said line of carrier frequency current containing an undesired side-band, a load at the other end of said line, and a negative feedback connection between the output and the input of said amplifier for limiting the amplitude of said side-band, said feedback connection including, in the order named, a demodulator, an audio frequency amplifier and a modulator, each of said amplifiers having degenerative feedback within itself whereby phase shift around the feedback loop is reduced.

2. In combination, a transmission line containing an amplifier, a source of carrier frequency current at one end and a load at the other end of said line, a feedback path from the output to the input of said amplifier, said path including a demodulator, an amplifier and a modulator in the order named, each of said amplifiers having degenerative feedback within itself whereby phase shift around the feedback loop is reduced.

3. The method of reducing the amplitude of an unwanted component in a carrier frequency wave to be modulated and transmitted over a transmission line, which comprises amplifying said wave, degeneratively feeding back a portion of the amplified wave, demodulating the amplified wave, amplifying the demodulated wave, degeneratively feeding back a portion of the demodulated amplified wave and modulating said amplified demodulated wave on the unamplified carrier frequency wave in such phase and of such amplitude as substantially to balance out said unwanted component.

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