Jan. 6, 1942. D. E. FOSTER 2,268,813

HUM REDUCTION CARRIER SYSTEM

Filed June 28, 1941

Fig. 1

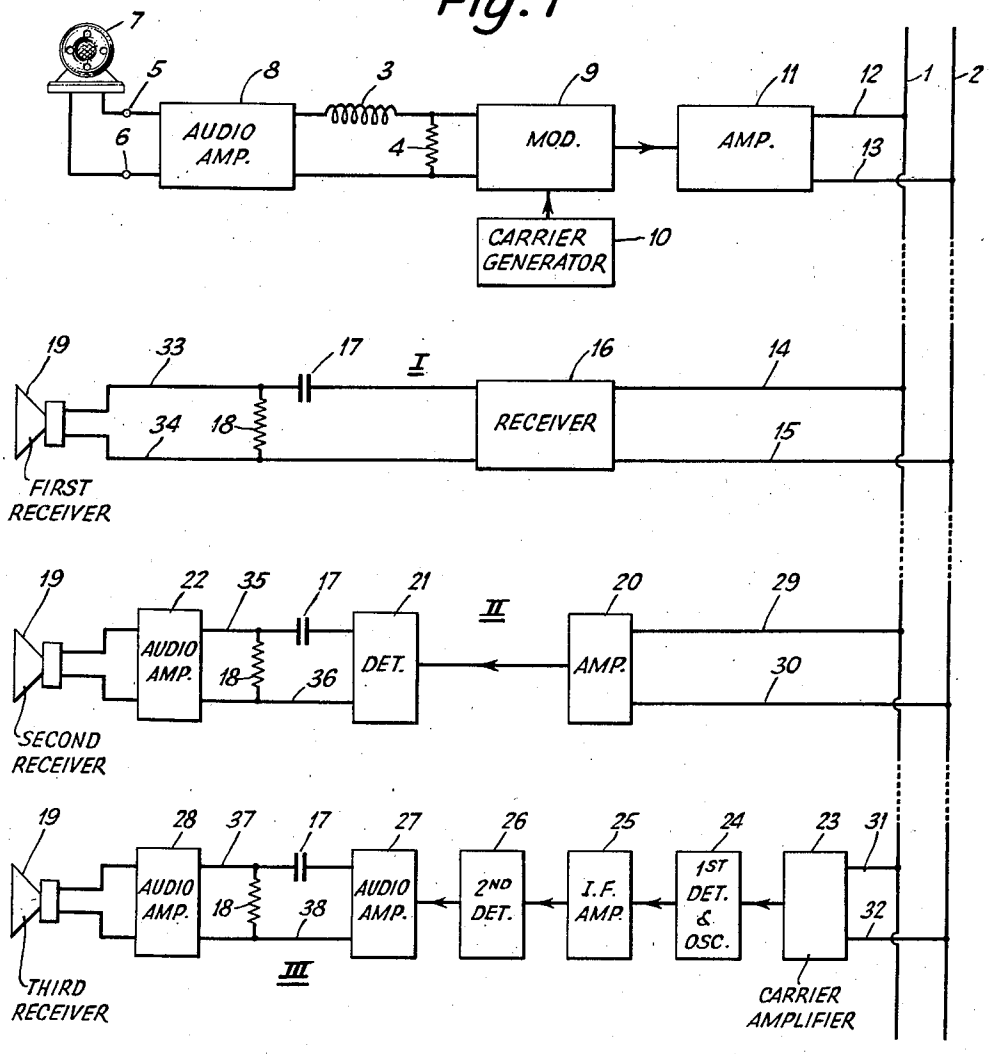
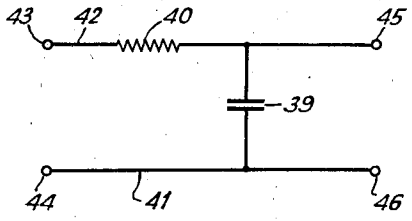


Fig. 2



INVENTOR
DUDLEY E. FOSTER
BY H. S. Grover
ATTORNEY

Patented Jan. 6, 1942 2,268,813

UNITED STATES PATENT OFFICE

2,268,813

HUM REDUCTION CARRIER SYSTEM

Dudley E. Foster, South Orange, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application June 28, 1941, Serial No. 400,204

7 Claims. (Cl. 179—2.5)

The present invention relates generally to signal modulated carrier current transmission over power supply lines and more particularly to an arrangement for reducing the hum superimposed upon the carrier in such systems by the power line frequency or alternating current power. In most power supply networks, the frequency of the current is either twenty-five or sixty cycles. When a carrier is transmitted over such power lines, the power line frequency becomes superimposed as a modulation on the carrier and is made evident as a disturbing hum in the receiver. In such arrangements it is not feasible to filter the hum because it is present as a modulation on the carrier and it is therefore not susceptible to filtering. The hum is present as a modulation on the carrier because practically all power lines have within themselves or in the equipment connected thereto at least one contact which acts as a rectifier although an imperfect rectifier. Despite the fact that such rectifiers are relatively inefficient, it has been general experience that with the high alternating current voltages present in such lines, a carrier transmitted along this line is modulated by the alternating current frequency.

In accordance with the present invention, the effect of such undesired modulation is minimized by increasing the low frequency signal modulations of the carrier with respect to the high frequency signal modulation at the transmitter and compensating for the accentuation of low frequencies at the receiver. In other words, the transmitter is provided with means for preemphasizing the low frequencies and the receiver is provided with means for de-emphasizing the low frequencies to thereby compensate for said preemphasis of the low frequencies.

Various other objects and advantages of the invention will appear from the following description when read in conjunction with the appended drawing.

In the drawing:

Figure 1 illustrates, in diagrammatic form, a carrier frequency transmission system operable over a power supply line and incorporates a preferred type of transmitting means and three possible receiving means; and,

Figure 2 illustrates a low frequency pre-emphasis network which may be used in place of the pre-emphasis network shown in Figure 1.

Referring now more particularly to Figure 1 of the drawing, the power supply line over which signal modulated carrier energy is to be transmitted is represented generally by two conductors, 1, 2 which may be the two conductors of an alternating current network. The carrier frequency signalling system may comprise a microphone 7, an audio frequency amplifier 8, a modulator 9, a network comprising series inductance 3 and shunt resistor 4, a carrier frequency generator 10, and a carrier frequency amplifier 11 the output of which is impressed across the power supply line 1, 2 by means of conductors 12 and 13. The electrical energy impressed across the input terminals 5 and 6 of amplifier 8 by the device 7 may represent speech, music, or, in general, any signals in the audio frequency range which it is desired to transmit. The amplified audio frequency energy is then utilized to modulate the carrier frequency energy generated by generator 10. For this purpose the modulation energy and the carrier energy are combined in the modulator 9 and the resulting signal modulated carrier after being amplified in amplifier 11 is impressed across the power supply line 1, 2. The network including series inductance 3 and shunt resistor 4 through which the audio frequency passes, constitutes a low frequency pre-emphasis network by virtue of the fact that the series inductance 3 has a reactance which increases directly with frequency, whereas the shunt resistor 4 has a resistance which is independent of frequency. The voltage across resistor 4 available for modulating the carrier when a constant voltage is applied across terminals 5 and 6 therefore, decreases with increasing frequency. This has the effect of raising the percentage of the low frequency components with respect to the modulation due to the higher frequency components thereby providing the required low frequency pre-emphasis.

Signals impressed upon the power line by a transmitter like that described above may be received anywhere along the power line 1, 2 by connecting a suitable receiving circuit to the power line. Three different types of receivers have been shown in Figure 1. Receiver I comprises an ordinary carrier frequency receiver which may be tuned to the frequency of the energy generated by carrier generator 10. The input of receiver I is connected by means of conductors 14 and 15 across the power line 1, 2 and its output is connected through conductors 33 and 34 to a suitable reproducing device such as a loudspeaker 19. Since, as pointed out above, the carrier impressed upon the power line 1, 2 by the transmitter is modulated by audio frequency energy, the low frequency portions of which are pre-emphasized, it is necessary for proper reproduction to de-emphasize the low frequencies. For this purpose there is incorporated a network con-

sisting of the series capacitor 17 and shunt resistor 18 which will decrease the response to low signal frequency with respect to the response to the higher signal frequencies. It will be evident from the above that along with the reduction of low frequency by network 17 and 18 the hum modulation introduced by the power line or apparatus connected thereto is likewise reduced. If the time constant of the pre-emphasizing network 3 and 4 at the transmitter is made equal to the time constant of the de-emphasizing network 17 and 18 at the receiver, the over-all transmission for signal frequencies impressed across terminals 5 and 6 to the speaker 19 will be uniform. Under these conditions the boost in low frequencies at the transmitting end is compensated for by the low frequency selective attenuator at the receiver. Since the hum frequencies in power line 1, 2 are not accentuated at the transmitter but are attenuated by network 17 and 18 at the receiver, there will be a net reduction of hum frequencies with respect to the signal.

The time constant of an inductance-resistance network is given by the expression L/R where L is the inductance and R is the resistance of the network. Similarly, the time constant of a resistance-capacity network is given by the expression R'C where R' is the resistance and C the capacitance of the network. It is seen therefore that for uniform over-all response, L/R at the transmitter should be made equal to R'C at the receiver.

In receiver II the de-emphasizing network 17, 18 is placed between the detector 21 and the audio frequency amplifier 22 of the receiver. In this receiver, the input of carrier frequency amplifier 20 is connected to power line 1, 2 through conductors 29 and 30, and the output of amplifier 20 is fed into detector 21. The detected energy is then fed through conductors 35, 36 and de-emphasizing network 17, 18 to audio amplifier 22 where it is amplified and impressed across reproducer 19.

Receiver III shown in Figure 1 is a superheterodyne receiver. In this case signal modulated carrier on the power line 1, 2 is impressed upon a carrier frequency amplifier 23 through conductors 31 and 32 and after amplification fed to a first detector oscillator circuit wherein the amplified carrier frequency energy is combined with locally generated oscillations in order to produce intermediate frequency energy. The intermediate frequency energy is amplified in intermediate frequency amplifier 25 and then detected in a second detector 26. The resulting audio frequency output of detector 26 is then amplified in an audio frequency amplifier 27 and fed to another audio frequency amplifier 26 through conductors 37 and 38 and de-emphasizing network 17 and 18.

Referring to Figure 2 which illustrates another suitable network for pre-emphasizing the low frequencies, the network 39 and 40 may be substituted for the network 4 and 3 shown in Figure 1. Element 40 comprises a resistor which is series connected in conductor 42 while element 39 comprises a shunt capacitor connected between conductors 41 and 42.

In the arrangement shown in Figure 2, assuming that a constant voltage is applied across the terminals 43 and 44, the low frequencies will be attenuated less than the higher frequencies since the series resistance 40 has a resistance which is independent of frequency and the shunt capacitance 39 has a reactance which varies inversely as the frequency. Thus, the energy available across the output terminals 45 and 46 has, in effect, its low frequencies pre-emphasized. If the pre-emphasizing network shown in Figure 2 is substituted for the pre-emphasizing network 3 and 4 shown in Figure 1 then the product of the resistance of resistor 40 and the capacitance of condenser 39 should be made equal to R'C for uniform frequency response of the system where R' and C are as stated heretofore.

While I have disclosed several preferred embodiments of my invention, it is to be understood that the invention is not limited to the details disclosed herein but may be varied within the scope of the following claims.

What I claim is:

1. In a carrier current transmission system operable over an alternating current power supply line, a transmitter connected to said supply line, said transmitter including signal modulating means, a receiver for reproducing the signal modulations of said carrier connected to the power supply line, a network, interposed between the modulating source and the transmitter, arranged to increase the modulation of low frequencies with respect to the modulation of the higher frequencies and a compensating network interposed between the detector of the receiver and the reproducer thereof.

2. In a system of the kind described, a power supply line, a source of audio frequency signal energy, a carrier generator, a modulator for modulating the carrier energy by said audio frequency energy and coupling means for impressing the modulated carrier energy upon said power line, a receiver for said signal modulated carrier connected to said power supply line, said receiver including a reproducing device, means at the transmitter for pre-emphasizing the low frequencies of said audio frequencies and means at the receiver for compensating for said pre-emphasis.

3. In a system for transmitting signal modulated carrier current over an alternating current power supply line, a transmitter connected to said power line including a source of carrier current and modulating means, a receiver connected to said power line for reproducing the modulation of said carrier, said transmitter including a network for pre-emphasizing the modulation of low frequencies with respect to the modulation of the higher frequencies, said receiver including a compensating network for de-emphasizing the modulation of low frequencies with respect to the modulation of higher frequencies whereby the original relationship between the low and high frequencies of the modulation is substantially reestablished.

4. In a system for transmitting signal modulated carrier energy over an alternating current power supply line, the method of reducing the effect of cross-modulation between the alternating current of the power supply line and the signal modulated carrier energy which includes the steps of pre-emphasizing the low frequency end of the modulation at the transmitter, generating the carrier frequency, modulating the carrier frequency with the resulting modulation energy, impressing the modulated carrier frequency upon the power supply line, deriving the energy impressed upon the power supply line at a remote point, detecting the derived energy, de-emphasizing the low frequency end of the detected energy and translating the resulting energy.

5. In a system for signalling over an alternating current power supply line, translating means for producing audio frequency current representing the signals to be transmitted, a source of carrier frequency current, a modulator for modulating the carrier current by the audio current, said source of audio frequency current being connected to said modulator through a network having means for pre-emphasizing at least that portion of the lower frequencies of said audio frequency current which includes the frequency of the power supply line alternating current, an amplifier for amplifying the resulting modulated carrier current and coupling means for impressing the amplified current across the power supply line.

6. In a system for receiving signal modulated carrier current impressed upon an alternating current power supply line by an arrangement such as described in claim 5, a detector having an input circuit and an output circuit, a receiver for coupling the detector input circuit to said power supply line, said receiver being arranged to intercept the signal modulated carrier current impressed upon the power supply line and impress electrical energy representing said intercepted energy upon the input of said detector, an audio frequency utilizing device, and a network for connecting said utilizing device to said detector output, said network having means for de-emphasizing the frequencies pre-emphasized at the transmitter.

7. In a system for signalling over an alternating current power supply line, translating means for producing audio frequency current representing the signals desired to be transmitted, a source of carrier frequency current, a modulator connected with said translating means and said source of carrier current for modulating the carrier current by the audio frequency current, said source of audio frequency current being connected to said modulator through an inductance-resistance network including a series inductance and a shunt resistor, said network having a predetermined time constant and acting to pre-emphasize at least that portion of the lower frequencies of the audio frequency current which includes the frequency of the power supply line alternating current, coupling means for impressing the resulting modulated carrier current across the power line, a detector having an input circuit and an output circuit, a receiver for connecting the detector input circuit to a remote point of said power supply line, said receiver being arranged to intercept the signal modulated carrier current impressed upon the power line and impress electrical energy representing said intercepted energy upon said detector input, an audio frequency utilizing device and a resistance-capacity network including a series condenser and a shunt resistor and having a predetermined time constant for connecting said utilizing device to said detector output circuit, resistance-capacity network having a time constant which is substantially the same as said first named time constant, said last named network acting to de-emphasize said pre-emphasized frequencies.

DUDLEY E. FOSTER.