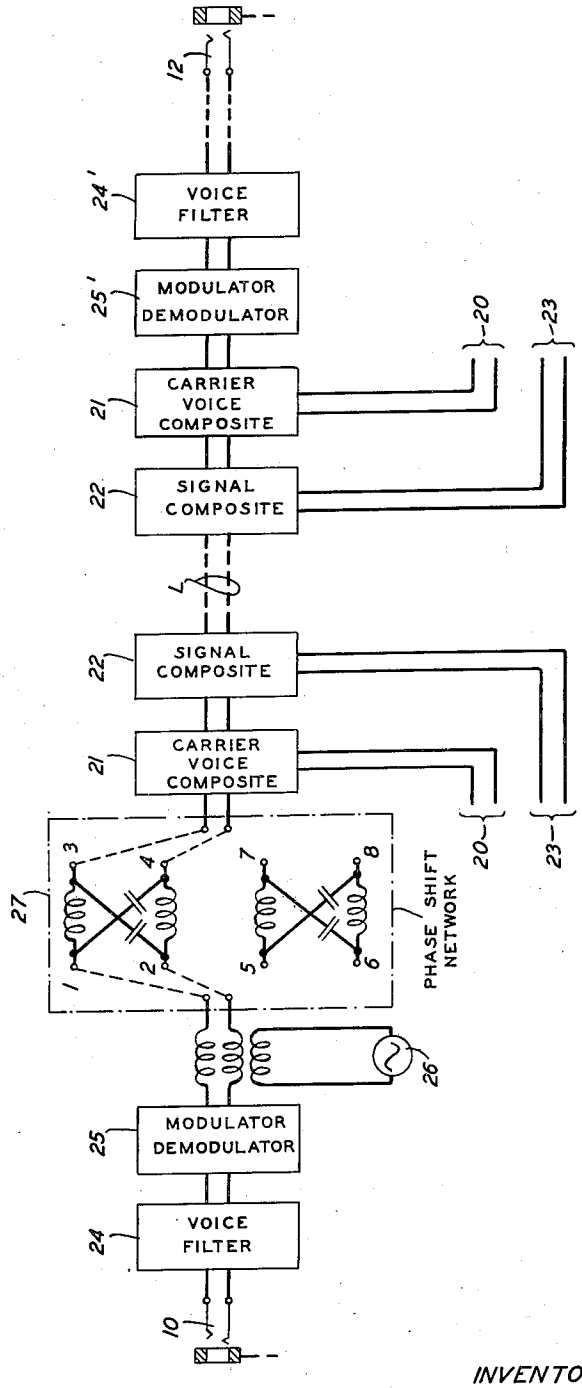
Dec. 11, 1934. R. W. CHESNUT 1,983,537

CARRIER CURRENT SIGNALING SYSTEM

Filed Dec. 7, 1933



INVENTOR
R.W. CHESNUT
BY H. A. Burgess
ATTORNEY

Patented Dec. 11, 1934 1,983,537

UNITED STATES PATENT OFFICE

1,983,537

CARRIER CURRENT SIGNALING SYSTEM

Roy W. Chesnut, Upper Montclair, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application December 7, 1933, Serial No. 701,267

3 Claims. (Cl. 179—43)

This invention relates to carrier line transmission of speech or other signals. It has particular reference to the two-way transmisison of signals over a high frequency carrier curent line.

The invention is in the nature of an improvement on the invention disclosed and claimed in H. S. Black application Serial No. 701,268, filed of even date. That application discloses and claims a carrier wave transmission system of simplified construction particularly adapted for use on relatively short lines where the economics of the problem require that the terminal apparatus represent comparatively low cost and low maintenance. An important item in low cost and low maintenance is a design of terminal apparatus to give such high transmission efficiency as to avoid the necessity of using amplifiers on relatively short lines.

The voice or signal output from a demodulator depends upon the phase relation between the incoming side-bands and the unmodulated carrier wave that is used to demodulate them. If the unmodulated carrier component supplied to the demodulator is in phase quadrature with the carrier component on which the side-bands are based, the output of demodulated signals or voice is theoretically zero. If these two components are in phase (or in phase opposition), the demodulated output is a maximum. For phase relations intermediate these two values the demodulated output has intermediate values between zero and the maximum.

Different lines met with in practice have different phase shift characteristics with the result that if the same carrier terminal apparatus were applied to different lines the demodulated voice or signal output would vary in magnitude dependent upon the phase shift of the line, other things being equal.

An object of the present invention is to so control the phase shift on the line as to obtain substantially maximum demodulated output of the voice or signals irrespective of the phase shift on the line.

One method of accomplishing this object in accordance with the invention is to include a phase shift network between the line and the terminal station at which the carrier source is located, to build out the line to a total phase shift of substantially one quarter wave length of the carrier wave or some integral multiple thereof. Since the carrier wave traverses the line twice, it going down to the modulator at the distant terminal and back again, if the line has a phase shift of the value indicated, the return carrier will be in phase or in phase opposition with the carrier originally sent out. Similarly, if the carrier is not actually returned, but is suppressed by the modulator at the distant terminal station, the phase which the incoming carrier component would have if it were present should be the same as that of the locally supplied carrier or in phase opposition.

The invention will be more clearly understood from the accompanying detailed description of a preferred embodiment thereof together with the attached drawing in which the single figure of the drawing shows in simplified schematic form so much of a complete carrier system as is necessary for an understanding of the present invention.

The system shown in the drawing extends between two jacks 10 and 12 which are located at toll offices at opopsite ends of the toll line L. As disclosed more fully in the Black application the line L may serve its usual purpose as a voice frequency toll line by making connection to the physical circuit shown extending at 20, 20 from the carrier composite sets 21, 21 at the respective stations; and at the same time it may serve to transmit carrier waves representing another or other conversations. The signal composite sets 22, 22 enable calling, dialing or supervisory functions to be carried out over signal wire-to-ground circuits 23, 23 as disclosed in the Black application.

In the carrier channel, the left terminal comprises voice filter 24, modulator-demodulator unit 25, carrier wave source 26 which may be a space discharge device oscillator or other suitable type, and phase shift network 27, besides the composite set 21 already referred to.

The right hand carrier terminal comprises a modulator-demodulator unit 25' and a voice filter 24' which may be identical with unit 25 and filter 24, respectively, of the left terminal. No carrier wave source or phase shift network is present at the right hand terminal.

The modulator-demodulator unit 25 is preferably a bi-lateral circuit as disclosed by Black, using copper-oxide rectifiers in bridge circuit configuration, with the voice circuit connected across one diagonal and the carrier and side-band circuit connected across the other diagonal. In this type of circuit the carrier waves are modulated by the speech currents impressed on the circuit to produce side-bands for transmission and, conversely, incoming side-bands are demodulated by the impressed carrier waves to reproduce in the voice circuit the speech being received.

The same carrier source 26 supplies carrier current to both units 25 and 25' for both modulating and demodulating purposes.

If the length of line is exactly one-quarter wave length of the carrier wave, it will be seen that the carrier wave from source 26 in once traversing the line to the distant modulator 25' and again traversing the line back to the demodulator 25 arrives at the latter point in opposite phase to the carrier supplied by the source 26 to demodulator 25. If the line is half a wavelength long, the carrier returns exactly in phase. For either of these conditions (in phase or in phase opposition) the phase relation between the side-bands and the carrier that is used to demodulate them is such as to produce maximum amplitude of the demodulated speech. This phase relation is realized if the effective length of the line from modulating unit 25 to unit 25' is a quarter wavelength or any integral multiple thereof.

It is not necessary to assume that any unmodulated carrier component actually comes back from modulator 25' to demodulator 25. The same reasoning applies if the unmodulated carrier component is suppressed at 25' and only the side-bands are transmitted.

It is the purpose of the phase-shift network 27, in accordance with this invention, to build out the line to a total effective length equal to a quarter wavelength of the carrier wave or a multiple of a quarter wavelength, or to approach such a condition in order to increase the output of demodulated speech at the left hand terminal.

In one case the phase shifting network comprised two sections as illustrated, which could be used separately or in series. The section between terminals 1, 2 and 3, 4 gave a phase shift of 22½ degrees while the alternate section, between terminals 5, 6 and 7, 8 gave a phase shift of 45 degrees. Connecting the two sections in series gives them a phase retardation of 67½ degrees. In this case the inductances between terminals 1, 2 and 3, 4 were each of 3.94 millihenries and the capacities in this section were each of 0.0048 microfarad. In the alternate section the inductances were each of 8.19 millihenries and the capacities 0.010 microfarad. The characteristic impedance in each case was 640 ohms. The carrier frequency was 10.3 kilocycles.

The loss in amplitude of received speech due to unfavorable phase relations may be very great. It has already been stated that if the phase shift for once traversing a given line is 45 degrees the received speech, in the type of system shown, is theoretically zero. If the phase shift departs from zero or from 90 degrees or from a multiple of 90 degrees by 11¼° for once traversing the line, the loss in received amplitude due to such departure is of the order of 0.5 decibels. It will be advantageous in any case to determine whether the loss in received speech amplitude is great enough to justify the cost of including the phase shift network. This may be done by trial. The values of network phase shift illustrated are such as always to permit of operation at no greater than 11¼ degrees departure from zero or 90 degrees shift for once traversing the line.

The invention is not dependent upon the use of the particular types of carrier apparatus that have been illustrated and described. Its scope is indicated by the appended claims.

What is claimed is:

1. In a carrier wave transmission system a line connecting separated stations, a demodulator at one station, a modulator at the other station, a source of carrier waves at said one station supplying carrier waves to both said demodulator and said modulator, and a phase shift network in the line for building out the line to a total phase shift substantially equal to one-quarter wavelength of the carrier wave or an integral multiple thereof.

2. In a carrier wave transmission system a line connecting separated stations, a demodulator at one station, a modulator at the other station, a source of carrier waves at the first station, supplying carrier waves to both said demodulator and said modulator, said line producing undesired phase shift in the transmitted frequencies, and a phasing network connected to the line between said source and the other station for improving the phase relation between the carrier applied from said source to said demodulator and that of the side-band components received from the other station.

3. In a carrier wave transmission system a line connecting separated stations, means at each station for modulating carrier waves in accordance with signals to be sent over said line and demodulating modulated waves received over said line, a source of carrier waves at a point in said line, said source supplying the carrier waves to the modulating and demodulating means at each station, said line producing undesired phase shift in the transmitted waves, and a phasing network in the line for improving the phase relation between the carrier wave applied to the demodulating means at a given station and the side-band components received from the modulating means at a distant station.

ROY W. CHESNUT.