

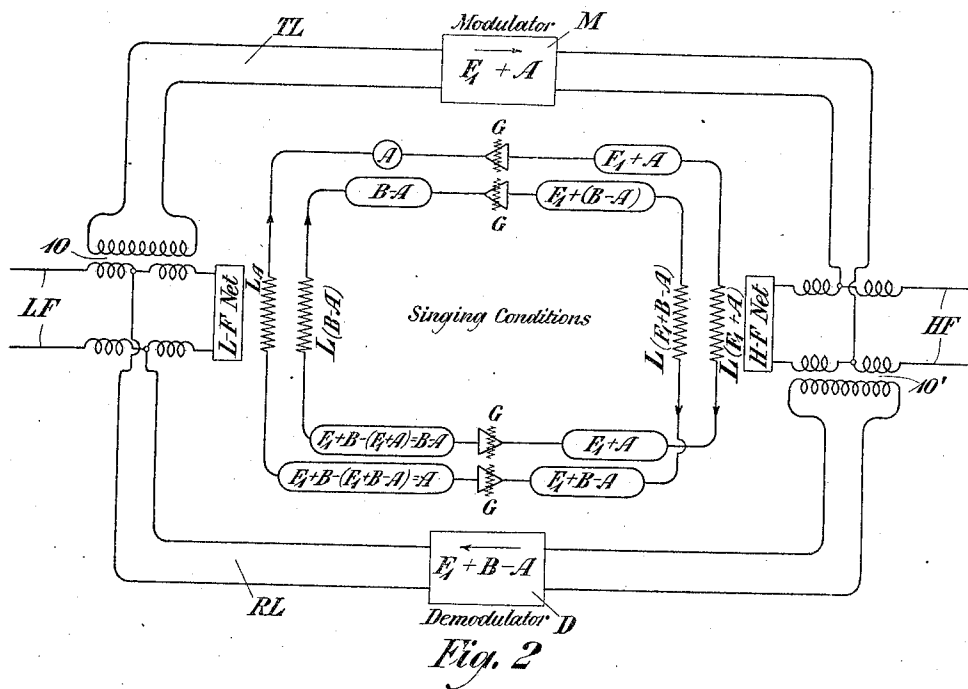
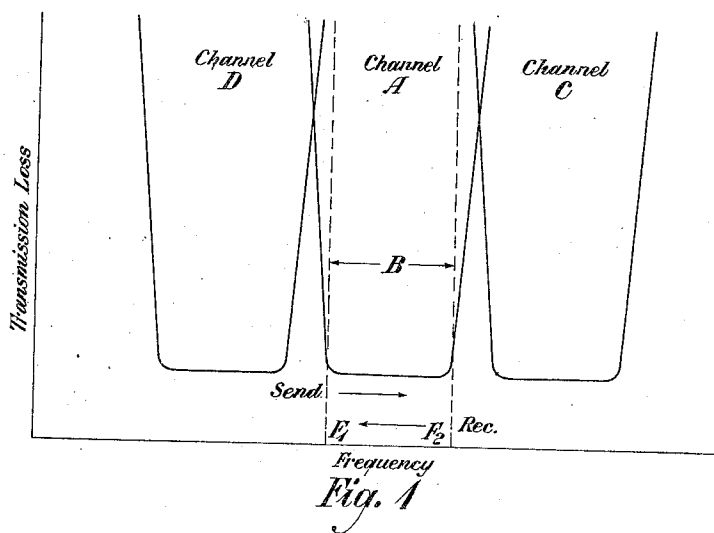
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MULTIPLEX TRANSMISSION CHANNEL

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UNITED STATES PATENT OFFICE.

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MULTIPLEX TRANSMISSION CHANNEL.

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To all whom it may concern:

Be it known that I, HERMAN A. AFFEL, residing at Brooklyn, in the county of Kings and State of New York, have invented certain Improvements in Multiplex Transmission Channels, of which the following is a specification.

This invention relates to the transmission of signals, and more particularly to the transmission of signals by means of so-called carrier currents.

In a two-way transmission system employing carrier currents for the transmission of signals, it is possible to use the same frequency for transmission in both directions where the lines are of such character that they may be balanced with a fair degree of accuracy at repeater points or terminal points where it is necessary to separate the oppositely directed transmissions. In many cases, however, the conditions with respect to balance are very unfavorable, so that it is difficult to obtain any appreciable gain without causing singing.

It has been proposed to overcome this difficulty by using different carrier frequencies for transmission in opposite directions. It has also been proposed to use the same carrier frequency for transmitting in both directions, the upper modulated side band being transmitted in one direction, and the lower modulated side band being transmitted in the reverse direction, thus necessitating two band filter ranges. Both of these methods are obviously undesirable in that they require an additional frequency range over and above the range required for transmission in both directions in the same band and at the same carrier frequency.

In accordance with the present invention it is proposed to use different carriers for transmitting in opposite directions, the two carriers used in connection with the single two-way transmission channel being spaced apart by an amount at least equal to the voice range or other signaling range employed. As in the second case above described, one side band will be eliminated in each case, but in this instance the lower side band will be transmitted with the upper of the two carrier frequencies, the upper side band being suppressed, and the upper side band will be transmitted with the lower of the two carrier frequencies, the lower side band being suppressed in this instance. The

two transmitted bands will thus overlap to a greater or less extent, depending upon the degree of separation of the two carriers. If the two carriers are separated by an amount just equal to the voice range, the two transmitted bands will exactly coincide, but as the two carriers are further separated, a progressively decreasing portion of the two bands overlaps.

It will, of course, be apparent that a band corresponding to a channel on one line would tend to produce cross-talk in a corresponding receiving channel associated with a neighboring line. A certain amount of cross-talk will affect a receiver at the distant end of the neighboring line from the transmitter, but a greater effect is produced in the neighboring receiver at the same end as the transmitter. The present arrangement has, however, the distinct advantage that the disturbing cross-talk of the latter type will be unintelligible, owing to the reversed arrangement of the signaling bands with respect to each other. Owing to the unintelligible character of the cross-talk between the sending and receiving circuits, the allowable amount of cross-talk may be increased and the number of transpositions correspondingly reduced.

It has also been proposed heretofore to generate locally at each terminal the same carrier frequency for transmission from the modulator at one end to the demodulator at the other end or to limit the locally generated carrier to use in both the modulator and demodulator at the same end of the transmission path. Both of these methods are disadvantageous in requiring relatively close adjustment between the two carrier frequencies as well as good balance of the vacuum tubes or network circuits in order to prevent the two carrier frequencies which are not synchronous from combining in the demodulator circuit and producing low frequency beats or thumps.

A definite separation of the two frequencies in opposite directions as proposed in accordance with the present invention allows the possibility of suitable discrimination between the carriers transmitted in opposite directions, and even where the two different carrier frequencies might interfere, the resultant frequency difference could readily be made above the normal telephone range by a slight increase in the separation

of the carriers without material sacrifice in frequency range. The resulting beat frequency would be capable of being suppressed by a low pass filter.

5 The invention may now be more fully understood from the following detailed description when read in connection with the accompanying drawing, Figure 1 of which is a diagram showing the relative arrange-
10 ment of the carrier frequencies and transmission bands of a plurality of channels, while Figure 2 is a schematic diagram of the so-called "22" type of balanced circuit employed at terminal points for separating
15 oppositely directed transmission. Associated with the diagram of Fig. 2 is a schematic representation of the frequency relations involved for a terminal singing condition in a circuit of this character.

20 Referring to Fig. 1, attenuation curves or curves representing the transmission losses at different frequencies for the channel selecting circuits are shown for three channels, A, D, and C. In this diagram B represents the width of the signaling band. As
25 is well known, when a carrier is modulated by a signaling band, upper and lower side bands are produced, only one of which is necessary for the transmission of the signal, so that it is customary, in order to conserve
30 the frequency range, to eliminate one of the bands. As shown by the curves in Fig. 1, a frequency F_1 at one edge of the signal band B may be employed as the carrier for the sending condition, the transmitted high
35 frequency band in this case extending from the carrier frequency F_1 to the upper limiting frequency of the band F_2 . The frequency F_2 , on the other hand, may coincide
40 with that of the carrier used in receiving, the side band in this instance extending from the carrier F_2 to lower limit represented by the frequency F_1 . A similar arrangement of the frequencies will be provided
45 in connection with the channels C and D, although not shown on the diagram.

Referring now to Fig. 2, a low frequency line LF is associated with the transmitting channel TL and a receiving channel RL
50 through a balanced transformer arrangement 10, the line LF being balanced by a low frequency network in order that circuits TL and RL may be rendered approximately conjugate, depending upon the degree of simulation between the line LF and
55 the balancing network. The transmitting and receiving circuits RL and TL are similarly associated with the high frequency or carrier line HF through a transformer 10', the line HF being in turn balanced by a
60 high frequency network. A modulator M of any well-known character is schematically indicated as being included in the circuit TL for the purpose of translating the low
65 frequency signaling currents into high fre-

quency carrier currents modulated in accordance with the signal. Similarly, a demodulator D is schematically indicated in the receiving circuit RL for translating the
70 demodulated carrier frequencies for transmission to the line LF. The modulator and detector may include suitable amplifying apparatus for introducing a gain in transmission if desired. The modulator will also
75 include suitable filtering apparatus for selecting the upper side band to the exclusion of the lower side band. Likewise the demodulator will include filtering apparatus to select the lower side band corresponding
80 to the voice or other signaling currents to the exclusion of other frequencies.

Owing to the translating operation taking place in the modulator and demodulator, it is apparent that the frequencies in the portion of the circuit at the right hand side of
85 the drawing will always be high frequencies, while the frequencies in the portion of the circuit at the left hand side of the drawing will always be low frequencies. Consequently the networks employed for balancing the
90 lines LF and HF respectively may be designed for approximate balance at the particular range of frequencies involved, in the one case a range of low frequencies, and in the other a range of high frequencies.
95

As is well known, in any circuit of the so-called "22" type, as, for example, in a
100 22 repeater circuit, the singing condition requires that the total loop circuit gain introduced by the amplifiers must be greater than the corresponding loop loss at the two balancing points for at least a single frequency. The same condition applies to the
105 ordinary 22 carrier circuit employing the same carrier frequency for transmission in opposite directions. In this case, however, the frequencies of unbalance at the two balance points are different. In both types of
110 circuit there is a favorable element of chance that the greatest degree of unbalance will not exist at both balancing points for the two corresponding frequencies. Where the
115 carriers are separated by an amount B, as proposed by the present invention, the condition is even more favorable with regard to freedom from singing, as will be clear
120 from a consideration of the singing condition schematically indicated in Fig. 2. In the schematic representation in the interior of the figure, the letters in the enclosed
125 areas (A, B—A, etc.) show the frequencies involved in various portions of the circuit and the letters G, $L_{(F_1+A)}$, etc. show the respective gains due to the modulator or demodulator, and the losses due to balance for the different frequencies.

Assuming that a frequency A originates in the circuit RL and is transmitted from the circuit RL through the transformer 10
130 to the circuit TL, it will be apparent that

a transmission loss L_A will take place at the balancing point, this loss depending upon the degree of balance, the loss being greater as the degree of balance increases.

involved are all equal and each is equal to G , the condition of singing requires that

$$4G > L_A + L_{(B-A)} + L_{(F_1+A)} + L_{(F_1+B-A)}$$

As previously stated, the condition of singing necessitates the current to traverse the circuit twice in order to be sustained. The resultant singing note in the low frequency circuit is composed of two frequencies, A and $B-A$, where B is the frequency spacing between the carriers employed for transmission in opposite directions. A practical advantage arising from this resides in the increase of the alluded chance that the worse degree of balance will not obtain for several frequencies simultaneously. As in this case two balancing points and four frequencies are involved, this advantage is considerable.

For the practical case where the low frequency line terminates a relatively short distance from the low frequency balancing coil, this advantage will be quite large, since the degree of unbalance under these circumstances is usually approximately a reverse function of the frequency. In other words, at low frequency, where the attenuation is less, the terminating reflection at the balancing point is greater and there is an inherent tendency to sing at this point. This tendency to sing at low frequencies is, however, counterbalanced in the proposed complementary carrier arrangement by the fact that in the second looping an appreciable unbalance at a relatively high frequency would have to exist. The net result is that the channel tendency to sing in the total range of frequencies tends to average up, and the balance conditions are correspondingly improved over a case of simple balancing.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. The method of two-way carrier transmission which consists in transmitting in opposite directions two carriers separated in frequency by an amount approximating the width of the signaling band involved in low frequency transmission, modulating said frequencies by low frequency signaling bands so that the upper side band corresponding to one carrier frequency overlaps the lower side band corresponding to the other carrier frequency.

2. The method of two-way carrier transmission which consists in transmitting in opposite directions two carriers separated in frequency by an amount approximating the width of the signaling band involved in low frequency transmission, modulating said frequencies by low frequency signaling

The frequency A , in passing through the modulator M which is supplied with the carrier frequency F_1 , is translated to a frequency F_1+A (it being assumed that the modulator is provided with means for suppressing the lower side band) and is at the same time subjected to a gain in transmission which is schematically represented at G . The translated frequency F_1+A then passes through the balanced transformer arrangement $10'$ and is subjected to a loss represented by $L_{(F_1+A)}$, this loss in turn depending upon the loss due to balance at the high frequency here involved. The frequency F_1+A , in passing through the demodulator D , is in turn stepped down by subtracting it from the carrier frequency F_2 supplied to the demodulator D , this frequency corresponding to the frequency of the carrier used in transmission from a distant point to the receiving channel RL . Since the frequency F_2 is equal to a frequency F_1+B , the stepped down frequency is obtained by subtracting the input frequency F_1+A from the carrier frequency F_1+B , so that the frequency is translated from F_1+A to $B-A$ in passing through the demodulator. A gain in transmission represented at G is also introduced by the demodulator.

The translated frequency $B-A$ now passes from the channel RL to the channel TL through the balanced transformer 10 so that it is subjected to an additional loss represented by $L_{(B-A)}$. The frequency then passes through the modulator M , being translated to frequency $F_1+(B-A)$ and subjected to a gain in transmission G . The translated frequency $F_1+(B-A)$ in turn passes from the circuit TL to the circuit RL through the balanced transformer $10'$, thereby undergoing a loss represented by $L_{(F_1+B-A)}$. The translated frequency F_1+B-A now passes through the demodulator D , where it undergoes a gain in transmission represented by G and a step-down in frequency by beating with the received carrier frequency F_2 . As previously stated, this frequency corresponds to frequency F_1+B , and the resultant step-down frequency is $F_1+B-(F_1+B-A)$, which equals A , the frequency with which we originally started out.

It will thus be seen that the complete cycle of operation involves transmission twice around the loop circuit, so that four frequency translating operations take place, and the transmission is subjected to four conditions of gain and four conditions of loss. Assuming that the transmission gains

bands so that the upper side band corresponding to one carrier frequency overlaps the lower side band corresponding to the other carrier frequency, and suppressing the side bands which do not overlap.

3. The method of two-way carrier transmission which consists in transmitting in opposite directions two carriers separated in frequency by an amount at least as great as the width of the low frequency signaling band involved in low frequency transmission, modulating said frequencies by low frequency signaling bands so that the upper side band corresponding to one carrier frequency overlaps the lower side band corresponding to the other carrier frequency.

4. The method of two-way carrier transmission which consists in transmitting in opposite directions two carriers separated in frequency by an amount at least as great as the width of the low frequency signaling band involved in low frequency transmission, modulating said frequencies by low frequency signaling bands so that the upper side band corresponding to one carrier frequency overlaps the lower side band corresponding to the other carrier frequency, and suppressing the side bands which do not overlap.

5. The method of two-way carrier transmission which consists in transmitting two carriers of different frequencies in opposite directions for each channel of communication, modulating each carrier by a low frequency signaling band, and spacing the oppositely directed carriers so that the adjacent side bands due to modulation at least partly overlap, and discriminating between overlapping frequencies transmitted in opposite directions.

6. The method of two-way carrier transmission which consists in transmitting two carriers of different frequencies in opposite directions for each channel of communication, modulating each carrier by a low frequency signaling band, spacing the oppositely directed carriers so that the adjacent side bands due to modulation at least partly overlap, and suppressing the side bands which do not overlap.

7. The method of two-way carrier transmission which consists in transmitting two carriers of different frequencies in opposite directions for each channel of communication, modulating each carrier by a low frequency signaling band, and spacing the oppositely directed carriers so that the adjacent side bands resulting from modulation occupy substantially the same frequency range.

8. The method of two-way carrier transmission which consists in transmitting two

carriers of different frequencies in opposite directions for each channel of communication, modulating each carrier by a low frequency signaling band, spacing the oppositely directed carriers so that the adjacent side bands resulting from modulation occupy substantially the same frequency range, and suppressing the side bands which do not overlap.

9. In a system of two-way carrier transmission, means for generating carrier frequencies for transmission in opposite directions, separated by an amount such that the adjacent side bands resulting from modulation will at least partially overlap, means for modulating the carrier frequencies to produce such overlapping side bands, means to transmit the overlapping frequencies in opposite directions and means to discriminate between overlapping frequencies transmitted in opposite directions.

10. In a system of two-way carrier transmission, means for generating carrier frequencies for transmission in opposite directions, separated by an amount such that the adjacent side bands resulting from modulation will at least partially overlap, means for modulating the carrier frequencies to produce such overlapping side bands, means to transmit the overlapping frequencies in opposite directions, and means to suppress side bands which do not at least partially overlap.

11. In a system of two-way carrier transmission, means for generating carrier frequencies for transmission in opposite directions, separated by an amount such that the adjacent side bands resulting from modulation will occupy substantially the same frequency range, means for modulating the carrier frequencies to produce such overlapping side bands, and means to transmit the overlapping frequencies in opposite directions.

12. In a system of two-way carrier transmission, means for generating carrier frequencies for transmission in opposite directions, separated by an amount such that the adjacent side bands resulting from modulation will occupy substantially the same frequency range, means for modulating the carrier frequencies to produce such overlapping side bands, means to transmit the overlapping frequencies in opposite directions, and means for suppressing the non-adjacent side bands resulting from modulation of the carrier frequencies.

In testimony whereof, I have signed my name to this specification this 30th day of December, 1920.

HERMAN A. AFFEL.