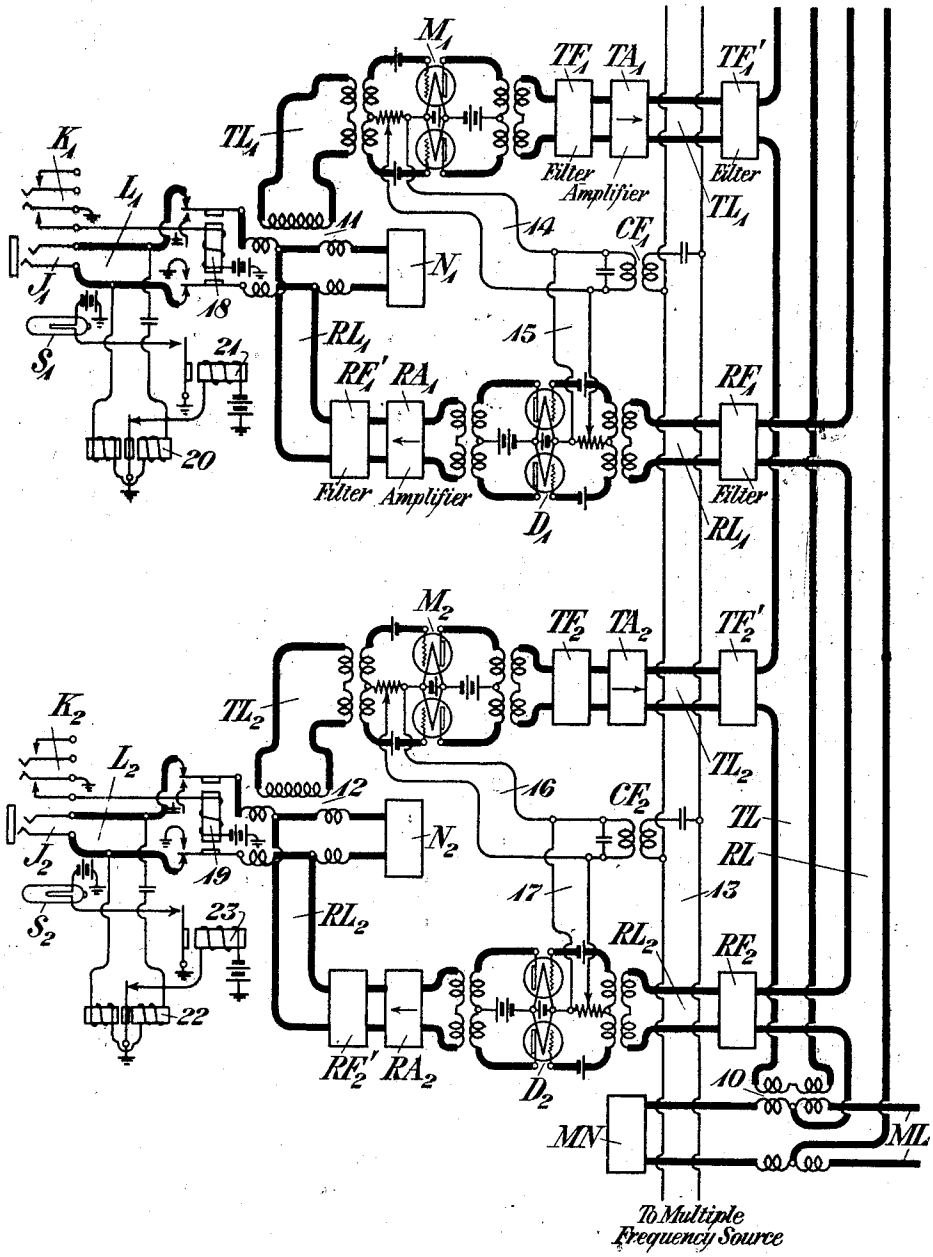
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MEANS FOR SIGNALING OVER MULTIPLEX TRANSMISSION CHANNELS.

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MEANS FOR SIGNALING OVER MULTIPLEX TRANSMISSION CHANNELS.

Application filed July 29, 1919. Serial No. 313,993.

To all whom it may concern:

Be it known that we, LLOYD ESPENSCHIED and HERMAN A. AFFEL, residing at Hollis and Brooklyn, in the counties of Queens and Kings, respectively, and State of New York, have invented certain Improvements in Means for Signaling Over Multiplex Transmission Channels, of which the following is a specification.

This invention relates to transmission systems and more particularly to multiplex transmission systems employing carrier currents.

Where multiplex transmission is attained by the use of carrier currents a plurality of carrier frequencies are transmitted over a common transmission line, the carrier frequencies being separated sufficiently to prevent interference and each frequency being assigned for use as a separate channel of communication so that signals, such, for instance, as telephonic variations may be transmitted by impressing them upon the carrier frequencies. Several channels may thus be superposed upon a common transmission line and each channel performs the functions of an ordinary telephone transmission line.

In ordinary telephone transmission it is customary to transmit over the line, in addition to the telephone currents, ringing currents or other signaling currents for the purpose of signaling between operators in establishing connections. In order to obtain practical telephone service over each carrier communication channel it is desirable that the channel be utilized for the transmission of such ringing or other signaling currents, as well as for the transmission of the ordinary telephone currents.

One feature of this invention is the provision of means, whereby ringing and other signals may be transmitted for each carrier channel. Another is the provision of means, whereby each carrier channel itself may be utilized for the transmission of the ringing or other signaling currents necessary in the establishment of communication over the channel. The invention further provides means, whereby the ringing or other signaling currents to be transmitted over a telephone carrier channel may be used to modulate the carrier frequency assigned to that channel in a manner similar to that employed in carrier telephone transmission. The invention also comprises certain other features that will become manifest as the description thereof proceeds. These several features of the invention and their manner of operation may now be understood from the following description, when read in connection with the accompanying drawing, which constitutes a circuit diagram of one embodiment of the said invention.

Referring to the drawing, ML designates a transmission line employed for the transmission of a plurality of carrier frequencies, said transmission line being associated through a balanced transformer arrangement 10, with a common transmitting circuit TL, upon which the carrier frequencies from the several transmitting channels are impressed, and a common receiving circuit RL from which the several received carrier frequencies are distributed to corresponding receiving channels. In order that the common circuits TL and RL may be conjugate with respect to each other, that is, may be so arranged that electrical variations arising in one circuit shall not affect the other, an artificial line or network MN is provided for balancing the main line ML. The common circuit TL is associated for transmitting purposes with each of a plurality of low frequency transmission lines through carrier transmitting channels, such as TL_1 and TL_2 associated with line terminals L_1 and L_2. In a similar manner the receiving circuit RL is associated with said low frequency lines through receiving carrier channels such as RL_1 and RL_2.

In order to translate the low frequency currents, such as telephone currents transmitted over the line terminals L_1 and L_2 into high frequency carrier currents for transmission over the line ML, the transmitting channels TL_1, TL_2, etc., are provided with modulating arrangements, such as M_1 and M_2. These modulating arrangements may be of any desired character, but are preferably duplex vacuum tube modulators of the character illustrated in the application of B. W. Kendall, Serial No. 125,349, filed October 13, 1916, or in the patent to John R. Carson, No. 1,343,307, dated June 15, 1920. As set forth in said

applications these modulators are so arranged that normally the carrier oscillations are suppressed, but when low frequency signaling currents, such as telephone currents are impressed thereon, carrier oscillations are transmitted, having an amplitude directly proportional to the modulating current.

In addition to the modulating arrangement the transmitting channel TL_1 includes a band filter TF_1, an amplifier TA_1 and a band filter TF_1'. The band filters TF_1 and TF_1' are of the general type disclosed in U. S. Patents to George A. Campbell, Nos. 1,227,113 and 1,227,114, dated May 22, 1917. These filters are preferably so designed as to transmit a band of frequencies extending either above or below the carrier frequency assigned to the channel by an amount equal to the range of frequencies employed in ordinary telephonic transmission. The amplifier TA_1 may be of any well-known character, but is preferably an amplifier of the well known vacuum tube type. In a similar manner the transmitting channel TL_2 is provided with a filter TF_2, an amplifier TA_2 and a filter TF_2'. These filters likewise are of the type disclosed in the Campbell patents above referred to and are designed to transmit a similar range of frequencies with respect to the carrier frequency assigned to this channel. This carrier frequency should be sufficiently separated from that of the channel TL_1 in the broad frequency scale so that interference is substantially prevented.

In order to translate received carrier frequencies into low frequency signaling currents for transmission to the line terminals L_1 and L_2, the carrier receiving channels RL_1 and RL_2 are provided with demodulating or detecting arrangements, such as D_1 and D_2. These demodulator or detecting arrangements may be of any well known type, but are preferably of the duplex vacuum tube type illustrated and described in the patent to John R. Carson, No. 1,343,308, dated June 15, 1920. The detecting or modulating arrangement of the said patent of John R. Carson employs the so-called homodyne method of detecting, thereby necessitating that oscillations of the same frequency as the carrier oscillations supplied to the corresponding modulator be also supplied to the demodulator.

In addition to the demodulating arrangement the receiving channel RL_1 includes a filter RF_1, an amplifier RA_1 and a filter RF_1'. The filter RF_1 may be similar to the filters TF_1 and TF_1' of the corresponding transmitting channel. The filter RF_1' is also of the general type disclosed in the patents to Campbell above referred to, but is so designed as to transmit low frequency currents extending over the range employed in ordinary telephone transmission. The amplifier RA_1 may be of any well-known character, but is preferably of the well known vacuum tube type and is so arranged as to efficiently amplify low frequency currents. In a similar manner the receiving channel RL_2 is provided with a filter RF_2, an amplifier RA_2 and a filter RF_2'. The filter RF_2 is similar to the filters TF_2 and TF_2' of the corresponding transmitting channel, while the filter RF_2' is similar to the filter RF_1' already described. The amplifier RA_2 is likewise similar to the amplifier RA_1.

In order to supply carrier oscillations to the modulators and demodulators a circuit 13 is provided upon which is impressed the several carrier frequencies. These frequencies may be generated in any well-known manner, but are preferably supplied by generating a fundamental frequency and then producing harmonics thereof in accordance with the frequency control system disclosed in the British Patent No. 131,426, November 13, 1919. The carrier frequency assigned to the transmitting and receiving channels of the line terminals L_1 may be selectively transmitted from the circuit 13, through a filtering arrangement CF_1, which may be a simple tuned circuit as illustrated. The desired frequency is then supplied to the modulator M_1 and the demodulator D_1 through branch circuits 14 and 15, respectively. Similarly, the carrier frequency assigned to the transmitting and receiving channels of the line terminals L_2 may be transmitted through a tuned circuit CF_2 from which it is supplied to the modulator M_2 and demodulator D_2 through branch circuits 16 and 17.

The transmitting and receiving channels TL_1 and RL_1 are associated with the low frequency line terminals L_1, through a balanced transformer arrangement 11 and are rendered conjugate with respect to each other by balancing the line associated with terminals L_1 by an artificial line or network N_1. In a similar manner the transmitting and receiving channels TL_2 and RL_2 are associated with low frequency line terminals L_2 through a balanced transformer 12 and are rendered conjugate with respect to each other by balancing the line associated with terminals L_2 by an artificial line or network N_2. In order to associate the line terminals L_1 and L_2 with various terminal circuits, said means are arranged to terminate in jacks J_1 and J_2, respectively.

In order that a ringing signal may be transmitted from the line terminal L_1 a key K_1 is associated therewith, said key controlling a relay 18, whereby ringing current may be supplied through the transformer 11 to the modulator M_1. In a similar manner a key K_2 is associated with the line terminals L_2 and controls a relay 19, whereby ringing

current may be supplied through the transformer 12 to the modulator M_2. In order that ringing currents incoming from the receiving channel RL_1 may be utilized to actuate a signal associated with the line terminals L_1, a ringing responsive relay 20 is bridged across said line terminals, the bridge including this relay being so tuned as to be responsive to currents of ringing frequency but to afford a high impedance to voice currents. The relay 20 is arranged to control through a relay 21 a lamp or other signal S_1 associated with the line terminals L_1. Similarly, a ringing responsive relay 22 is bridged across the line terminals L_2 and controls a lamp or other signal S_2 through a relay 23.

The apparatus so far disclosed is characteristic of the terminal arrangements at one end of the main transmission line ML and it will be understood that similar arrangements may be provided at the distant terminal of the main line. Furthermore, while receiving and transmitting channels have only been illustrated for two line terminals such as L_1 and L_2, it will be understood that similar channels for other low frequency lines and having other characteristic carrier frequencies assigned thereto may be associated with the common transmitting and receiving circuit TL and RL.

Further details of the apparatus will now be clear from a description of the operation which is as follows:

Talking currents incoming from the line terminals L_1 are transmitted over the back contacts of relay 18 and through the transformer 11 to the input circuit of the modulator M_1. Normally, high frequency oscillations from the circuit 14 are impressed on the common branch of the input circuit of the modulator M_1, but due to the balanced arrangement of the modulator circuit, these oscillations are not transmitted to the filter TF_1. Talking currents impressed upon the input circuit of the modulator, however, unbalance the modulator circuit so that high frequency oscillations modulated in direct proportion to the talking currents are transmitted from the output circuit of the modulator M_1, through the filter TF_1 to the amplifier TA_1. Upon being amplified by said amplifier the modulated oscillations are transmitted through the filter TF_1' to the common transmitting circuit TL. These modulated high frequency oscillations, together with the modulated high frequency oscillations from other transmitting channels are impressed through the transformer 10 upon the main transmission line ML, over which they are transmitted to similar carrier apparatus at a distant station.

Modulated oscillations of the several carrier frequencies incoming from the line ML are transmitted to the common receiving circuit RL, from which they are selectively transmitted through the filters such as RF_1 and RF_2 to the several receiving channels. The modulated high frequency oscillations transmitted through the filter RF_1 are impressed upon the input circuit of the demodulator D_1. These modulated oscillations react with unmodulated carrier oscillations from the circuit 15, with the result that currents simulating the low frequency telephone currents, in accordance with which the received oscillations were modulated, appear in the output circuit of the demodulator. The low frequency telephone currents are then amplified by the amplifier RA_1 and transmitted through the low frequency filter RF_1' to the midpoints of windings of transformer 11, from which point they are transmitted to the artificial line M_1 and over the back contacts of relay 18 to the line terminals L_1.

If it is desired to transmit a ringing signal from the line terminals L_1 to the distant station the key K_1 may be actuated, thereby energizing the relay 18 so that ringing current is transmitted over the front contacts of said relay and through the transformer 11 to the modulator M_1. The low frequency ringing currents modulate high frequency oscillations from the circuit 14 through the agency of the modulator M_1 in the same manner as in the case of telephone currents. The oscillations modulated in accordance with these ringing currents are then transmitted to the distant station in the same manner as that already described. High frequency oscillations modulated in accordance with ringing currents at a distant station and incoming from the line ML are transmitted over the circuit RL and through the filter RF_1 to the input circuit of the demodulator D_1. The demodulator detects the ringing currents in accordance with which the carrier oscillations were modulated and impresses them upon the amplifier RA_1. Upon being amplified they pass through the filter RF_1' to the midpoints of the windings of the transformer 11. From this point the ringing current passes in one direction to the artificial line N_1 and in the other direction over the back contacts of relay 18 to the ringing responsive relay 20, the bridge circuit in which this relay is included being tuned to the ringing frequency as already described; the relay 20 upon responding to the ringing current, opens the circuit to the relay 21, so that the circuit of the lamp signal S_1 is completed to indicate that the ringing signal has come in.

The operation with respect to the channels associated with other low frequency lines, is similar to that already described and need not be further considered.

It will be seen that by means of the arrangements above described, ringing or other

signals may be transmitted over the carrier channels of a multiplex system without interference and without necessitating any substantial change in the high frequency apparatus of the carrier system. It will also be obvious that while the invention has been illustrated as embodied in a circuit arrangement, which is deemed quite desirable from the standpoints of efficiency and simplicity, 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. In a signaling system, a circuit for the transmission of high frequency carrier currents, a circuit for the transmission of low frequency currents such as telephone currents, a two-way connection between said circuits comprising two paths, one for transmission in one direction and the other for transmission in the opposite direction, a modulating repeater in one of said paths, a demodulating repeater in the other path, means to supply carrier current for said modulating and demodulating repeaters, means whereby telephone currents may be transmitted from said second mentioned circuit over one of said paths to said modulating repeater, means whereby ringing current may be transmitted over said path to said modulating repeater, said modulating repeater functioning to supply to said first mentioned circuit carrier currents modulated in accordance with said telephone or ringing currents, and means to transmit carrier currents modulated in accordance with telephone or ringing currents from said first mentioned circuit to said demodulating repeater, said repeater functioning in response thereto to supply to said second mentioned circuit the telephone or ringing currents in accordance with which said carrier currents were modulated.

2. In a signaling system, a circuit for the transmission of high frequency carrier currents, a circuit for the transmission of low frequency currents such as telephone currents, a two-way connection between said circuits comprising two paths, one for transmission in one direction and the other for transmission in the opposite direction, a modulating repeater in one of said paths, means to supply carrier current for said modulating repeater, means whereby telephone currents may be transmitted from said second mentioned circuit over said path including said modulating repeater to said repeater, and means whereby ringing current may be transmitted over said path to said repeater, whereby said modulating repeater functions to supply to said first mentioned circuit carrier currents modulated in accordance with said telephone or ringing currents.

3. In a signaling system, a circuit for the transmission of high frequency carrier currents, a circuit for the transmission of low frequency currents such as telephone currents, a two-way connection between said circuits comprising two paths, one for transmission in one direction and the other for transmission in the opposite direction, a demodulating repeater in one of said paths, means to transmit carrier currents modulated in accordance with telephone currents and carrier currents modulated in accordance with ringing currents from said first mentioned circuit to said demodulating repeater, whereby the latter supplies to the path in which it is included the telephone or ringing currents in accordance with which the carrier currents were modulated, and means to transmit said telephone or ringing currents over said path to said second mentioned circuit.

4. In a signaling system, a pair of intercommunicating stations, a signaling channel at one station, a corresponding signaling channel at the other station, a demodulator in said second mentioned channel, means including a modulator to which telephone currents are applied for supplying high frequency oscillations modulated in accordance with telephone currents for transmission to the distant station, means to apply ringing currents to said modulator whereby high frequency oscillations modulated in accordance with said ringing currents may be supplied by said modulator for transmission to the distant station, and means to impress the oscillations modulated in accordance with said telephone or ringing currents upon the demodulator in the corresponding channel at the distant station whereby said demodulator translates the modulated oscillations into the telephone or ringing currents in accordance with which said oscillations were modulated.

5. In a signaling system, a pair of intercommunicating stations, a signaling channel at one station, a corresponding signaling channel at the other station, means including a modulator in said first mentioned channel to which telephone currents are applied for supplying high frequency oscillations modulated in accordance with telephone currents for transmission to the corresponding channel at the distant station, and means to apply ringing currents to said modulator, whereby high frequency oscillations modulated in accordance with said ringing currents may be supplied by said modulator for transmission to the corresponding channel at said distant station.

6. In a signaling system, a pair of intercommunicating stations, a signaling channel at one station, a corresponding signaling chan-

nel at the other station, a demodulator in said second mentioned channel, and means whereby high frequency oscillations modulated in accordance with telephone currents and high frequency oscillations modulated in accordance with ringing currents may be transmitted from said first mentioned channel to the distant station and applied to said demodulator, said demodulator functioning to translate said high frequency oscillations into the telephone currents or ringing currents in accordance with which said oscillations were modulated.

7. In a signaling system, a circuit for the transmission of high frequency carrier currents, a plurality of circuits for the transmission of low frequency currents such as telephone currents, a two-way connection between each of said last mentioned circuits and said first mentioned circuit, each connection comprising two paths, one for transmisison in one direction and the other for transmission in the opposite direction, a modulating repeater in one path of each pair, a demodulating repeater in the other path of each pair, means to supply carrier current for said modulating and demodulating repeaters, means whereby telephone currents may be transmitted from each of said plurality of circuits over one path of each pair to the corresponding modulating repeater, means whereby ringing current may be transmitted over each of said paths to said modulating repeaters, said modulating repeaters functioning to supply to said first mentioned circuit carrier currents modulated in accordance with said telephone or ringing currents, and means to transmit a plurality of carrier currents modulated in accordance with telephone or ringing currents from said first mentioned circuit and over the other paths of each pair to said demodulating repeaters, said repeaters functioning in response thereto to supply to each of said plurality of circuits the telephone or ringing currents in accordance with which said carrier currents were modulated.

8. In a signaling system, a circuit for the transmission of high frequency carrier currents, a plurality of circuits for the transmission of low frequency currents such as telephone currents, a two-way connection between each of said plurality of circuits and said first mentioned circuit, each two-way connection comprising two paths, one for transmission in one direction and the other for transmission in the opposite direction, a modulating repeater in one path of each pair, means to supply carrier currents for said modulating repeaters, means whereby telephone currents may be transmitted from each of said plurality of circuits over said paths including modulating repeaters to each of said repeaters, and means whereby ringing current may be transmitted over each of said paths to said repeaters, whereby said modulating repeaters function to supply to said first mentioned circuit carrier currents modulated in accordance with said telephone or ringing currents.

9. In a signaling system, a circuit for the transmission of high frequency carrier currents, a plurality of circuits for the transmission of low frequency currents such as telephone currents, a two-way connection between each of said plurality of circuits and said first mentioned circuit, each two-way connection comprising two paths, one for transmission in one direction and the other for transmission in the opposite direction, a demodulating repeater in one path of each pair, means to transmit carrier currents modulated in accordance with telephone currents and carrier currents modulated in accordance with ringing currents from said first mentioned circuit over each of said paths to said demodulating repeaters, whereby said repeaters each supply to the path in which it is included the telephone or ringing currents in accordance with which the carrier currents were modulated, and means to transmit said telephone or ringing currents over said paths to said plurality of circuits.

10. In a signaling system, a pair of intercommunicating stations, a plurality of signaling channels at one station, a plurality of corresponding signaling channels at the other station, a demodulator in each of said second mentioned channels, means including a modulator in each of said first mentioned channels to which carrier currents are applied for supplying high frequency oscillations modulated in accordance with telephone currents for transmission to the distant station, means to apply ringing currents to said modulators whereby high frequency oscillations modulated in accordance with said ringing currents may be supplied by said modulators for transmission to the distant station, and means to impress the several oscillations modulated in accordance with said telephone or ringing currents upon the several demodulators in the corresponding channels at the distant station, whereby said demodulators translate the modulated oscillations into the telephone or ringing currents in accordance with which the oscillations were modulated.

11. In a signaling system a pair of intercommunicating stations, a plurality of signaling channels at one station, a plurality of corresponding signaling channels at the other station, means including a modulator in each of said first mentioned channels to which telephone currents are applied for supplying high frequency oscillations modulated in accordance with telephone currents for transmission to the corresponding channels at the distant stations, and means

to apply ringing currents to each of said modulators, whereby high frequency oscillations modulated in accordance with said ringing currents may be supplied by said modulator for transmission to the corresponding channels at said distant station.

12. In a signaling system, a pair of intercommunicating stations, a plurality of signaling channels at one station, a plurality of corresponding signaling channels at the other station, a demodulator in each of said second mentioned channels, and means whereby high frequency oscillations modulated in accordance with telephone currents and high frequency oscillations modulated in accordance with ringing currents may be transmitted from each of said first mentioned channels to the distant station and applied to the corresponding demodulators, said demodulators functioning to translate said high frequency oscillations into the telephone currents or ringing currents in accordance with which said oscillations were modulated.

In testimony whereof we have signed our names to this specification this 28th day of July, 1919.

LLOYD ESPENSCHIED.
HERMAN A. AFFEL.