Oct. 30, 1923. 1,472,035

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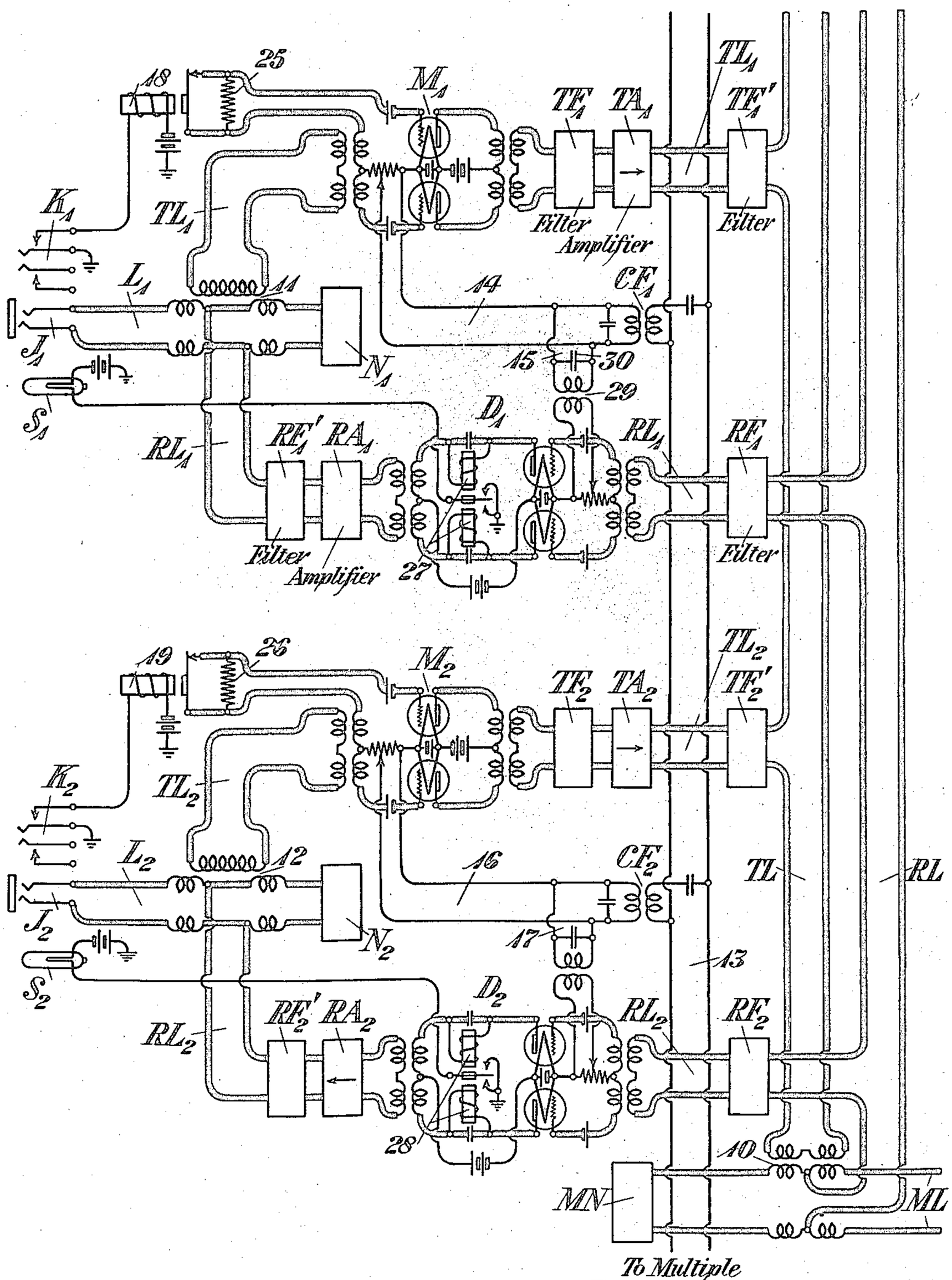
Filed July 29, 1919

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Patented Oct. 30, 1923. 1,472,035

# UNITED STATES PATENT OFFICE.

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## MEANS FOR SIGNALING OVER MULTIPLEX TRANSMISSION CHANNELS.

Application filed July 29, 1919. Serial No. 314,070.

*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 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 ordinary telephone currents.

The invention involves the provision of means whereby ringing and other signals may be transmitted for each carrier channel. It also comprises 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. It further consists in means whereby a direct current signal may be translated into high frequency oscillations for transmission over a carrier channel to a distant station. The invention furthermore provides means whereby high frequency oscillations representing a direct current signal may be translated into such direct current signal. Other and further features of the invention will be apparent as the description thereof proceeds.

The manner in which these features of the invention are realized, may now be understood from the following description of the arrangements of the invention when read in connection with the accompanying drawing, which is a circuit diagram of one embodiment of the 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 patent to B. W. Kendall, No. 1,459,709, June 19, 1923, or in the patent to John R. Carson, No. 1,343,307, 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, June 15, 1920. The detecting or modulating arrangement of the said application 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 application of B. W. Kendal, Serial No. 130,350, filed November 9, 1916. 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 the 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 lines are arranged to terminate in the jacks $J_1$ and $J_2$, respectively.

In order that a ringing signal may be transmitted from the line terminals $L_1$, a key $K_1$ is associated therewith, said key controlling a relay 18, whereby a resistance 25 may be included in the grid circuit of one of the tubes of the duplex modulator $M_1$, thereby unbalancing the modulator to transmit carrier oscillations of constant amplitude. In a similar manner a key $K_2$ is associated with the line terminals $L_2$ and controls a relay 19 so as to include a resistance 26 in the grid circuit of one of the tubes of the duplex modulator $M_2$, thereby unbalancing the modulator to transmit oscilla-

tions of constant amplitude having the frequency assigned to the channels associated with the line terminals $L_2$.

In order that carrier oscillations of constant amplitude transmitted from a distant station may be translated into direct current signals, the demodulators $D_1$ and $D_2$ are provided with differential relays 27 and 28 in their output circuits, these relays being so arranged as to control direct current signals, such as the lamps $S_1$ and $S_2$. In order to prevent telephone currents detected by the demodulators $D_1$ and $D_2$ from actuating the differential relays the windings of said relays are shunted by condensers.

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 lines, 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 circuits TL and RL.

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

Telephone currents incoming from the line terminals $L_1$ will be transmitted through the transformer 11 to the input circuit of a modulator $M_1$. High frequency oscillations are supplied from the circuit 14 to the common branch of the input circuit of the modulator, but as the modulator is normally balanced, high frequency oscillations will not be transmitted to the filter $TF_1$. When telephone variations are applied to the input circuit of the modulator $M_1$, however, the circuit is unbalanced so that carrier currents are transmitted from the output circuit of the modulator having an amplitude proportional to the amplitude of the telephone currents. These modulated high frequency currents are transmitted through the filter $TF_1$, amplified by the amplifier $TA_1$ and transmitted through the filter $TF_1'$ to the common transmitting circuit TL. At the same time modulated carrier currents from other transmitting channels, such as $TL_2$, are impressed upon the common transmitting circuit TL and the several modulated carrier oscillations are then transmitted through the transformer 10 and over the main line ML to the distant station.

Modulated carrier currents of the various frequencies corresponding to the several channels and transmitted from the distant station over the line ML pass into the common receiving circuit RL and are selected through the filters $RF_1$, $RF_2$, etc., into the receiving channels $RL_1$, $RL_2$, etc. The modulated high frequency oscillations transmitted into the channel $RL_1$ are impressed upon the input circuit of the demodulator $D_1$ where they react with unmodulated carrier oscillations from the branch circuit 15, with the result that low frequency telephone currents, corresponding to the telephone currents in accordance with which the carrier 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 passed through the filter $RF_1'$ to the mid points of the windings of the transformer 11 where the current divides, part flowing to the artificial line $N_1$ and part flowing over the line terminals $L_1$.

If it is desired to transmit a ringing signal from the line terminals $L_1$, the key $K_1$ is actuated, thereby energizing the relay 18 which removes the short circuit from about the resistance 25, thereby unbalancing the modulator $M_1$ so that oscillations of carrier frequency and constant amplitude are transmitted from said modulator through the filter $TF_1$ to the amplifier $TA_1$. These oscillations after being amplified are passed through the filter $TF_1'$ and thence over the main line ML to the distant station as already described in connection with telephone currents. Carrier oscillations of corresponding frequency and constant amplitude generated at the distant station in a similar manner are transmitted over the line ML and flow into the common receiving circuit RL, from which they are selected through the filter $RF_1$ and impressed upon the input circuit of the demodulator $D_1$. At the same time oscillations of the same frequency and of constant amplitude are impressed upon the common branch of the input circuit of the demodulator $D_1$ from the circuit 15. The duplex output circuit of the demodulator is normally balanced so that direct current from the output circuit battery flows equally through the two windings of the differential relay 27, with the result that the relay is normally deenergized. When unmodulated carrier oscillations from the filter $RF_1$ are impressed upon the modulator simultaneously with oscillations of the circuit 15, the demodulator circuit is unbalanced so that the current flowing in the two windings of the differential relay 27 is no longer the same and said relay is actuated to complete a direct current circuit through the lamp or other signal means $S_1$, thereby indicating that a ringing signal has come in from the line $L_1$.

In order that the action of the demodulator $D_1$, just described, shall be secured, it is desirable that the phase relation between the carrier supply current from the circuit 15 and the unmodulated carrier current

which represents the D. C. signal be properly adjusted. If, for instance, the carrier current entering the demodulator from the line and representing the D. C. signal, happens to be in a 90° phase relation with respect to the carrier current from the circuit 15, no D. C. unbalance current flow would result in the output circuit of the demodulater and the relay 27 would not be actuated. Accordingly, a phase changing element comprising a transformer 29 and a capacity 30 is provided in the circuit 15 so that by adjusting the capacity 30, for instance, the proper phase relation between the two currents may be secured.

The operation of the channels associated with the line $L_2$ will be 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, an arrangement for modulating high frequency carrier oscillations in accordance with signals, said modulating arrangement being arranged to normally suppress the transmission of the carrier oscillations, means to impress telephone currents upon said modulating arrangement whereby oscillations modulated in accordance with said telephone currents will be transmitted, and means whereby in response to a ringing signal said modulating arrangement will permit the transmission of oscillations of constant amplitude.

2. In a signaling system, an arrangement for modulating high frequency carrier oscillations in accordance with signals, said modulating arrangement being arranged to normally suppress the transmission of the carrier oscillations, means to impress telephone currents upon said modulating arrangement whereby oscillations modulated in accordance with said telephone currents will be transmitted, means whereby in response to a ringing signal said modulating arrangement will permit the transmission of oscillations of constant amplitude, and a demodulator so arranged that in response to oscillations modulated in accordance with telephone currents it will reproduce the telephone currents in accordance with which the oscillations were modulated, and in response to a train of oscillations of constant amplitude will produce a direct current so long as said oscillations persist.

3. In a signaling system, means to transmit either high frequency oscillations modulated in accordance with telephone currents or sustained oscillations of constant amplitude, and a demodulator so arranged that in response to oscillations modulated in accordance with telephone currents it will reproduce the telephone currents in accordance with which the oscillations were modulated, and in response to a train of oscillations of constant amplitude will produce an effective direct current so long as said oscillations persist, means to receive the telephone currents reproduced by said demodulator and direct current responsive means unresponsive to telephone currents for producing a continuous indication so long as said effective direct current continues.

4. In a signaling system, an arrangement for modulating high frequency carrier oscillations in accordance with signals, circuits for said modulating arrangement so arranged that in response to variable signaling currents said modulating arrangement supplies high frequency oscillations modulated in accordance with said variable currents, and in response to constant direct current signals said modulating arrangement supplies oscillations of constant amplitude, a demodulator, and circuits therefor so arranged that in response to high frequency oscillations modulated in accordance with variable signaling currents said demodulator will reproduce said variable signaling currents, and in response to a train of oscillations of constant amplitude said demodulator will produce an effective direct current so long as said oscillations persist, means to receive the variable currents reproduced by said demodulator and direct current responsive means unresponsive to said variable currents for producing a continuous indication so long as said effective direct current continues.

5. In a signaling system, means to transmit either high frequency oscillations modulated in accordance with variable signaling currents or sustained oscillations of constant amplitude, a demodulator, and circuits therefor so arranged that in response to high frequency oscillations modulated in accordance with variable signaling currents said demodulator will reproduce said variable signaling currents, and in response to a train of oscillations of constant amplitude said demodulator will produce an effective direct current so long as said oscillations persist, means to receive the variable currents reproduced by said demodulator and direct current responsive means unre-

sponsive to said variable currents for producing a continuous indication so long as said effective direct current continues.

6. In a signaling system, an arrangement for modulating high frequency oscillations in accordance with signals, said arrangement being so balanced that normally substantially no oscillations are transmitted, means whereby said modulating arrangement may be unbalanced in response to variable signaling currents to transmit oscillations modulated in accordance with said currents, and means whereby in response to a direct current signal said modulating arrangement may be unbalanced to transmit continuous oscillations of constant amplitude.

7. In a signaling system, an arrangement for modulating high frequency oscillations in accordance with signals, said arrangement being so balanced that normally substantially no oscillations are transmitted, means whereby said modulating arrangement may be unbalanced in response to variable signaling currents to transmit oscillations modulated in accordance with said currents, means whereby in response to a direct current signal said modulating arrangement may be unbalanced to transmit continuous oscillations of constant amplitude, a demodulator, and circuits therefor so arranged that in response to high frequency oscillations modulated in accordance with variable signaling currents said demodulator will reproduce said variable signaling currents, and in response to a train of oscillations of constant amplitude said demodulator will produce a direct current so long as said oscillations persist.

8. In a signaling system, a transmission line adapted to transmit high frequency oscillations, a plurality of signaling channels associated with each end of said line, means associated with each channel at one end of said line and responsive to variable signaling currents to transmit from each channel and over said line high frequency oscillations modulated in accordance with said currents, said means being responsive to direct current signals to transmit from each channel and over said line high frequency oscillations of constant amplitude, means associated with each channel at the other end of the line and responsive to high frequency oscillations modulated in accordance with variable signaling currents to reproduce the variable currents in accordance with which the high frequency oscillations were modulated, said means being responsive to high frequency oscillations of constant amplitude to produce effective direct currents of constant amplitude so long as said high frequency oscillations of constant amplitude persist, but producing no effective direct current when high frequency oscillations are not received, means associated with each element at said other end of the line to receive said reproduced variable currents, and direct current responsive means producing a continuous response so long as said effective direct current continues.

9. In a signaling system, a transmission line adapted to transmit high frequency oscillations, a plurality of signaling channels associated with each end of said line and means associated with each channel at the other end of the line and responsive to high frequency oscillations modulated in accordance with variable signaling currents to reproduce the variable currents in accordance with which the high frequency oscillations were modulated, said means being responsive to high frequency oscillations of constant amplitude to produce effective direct currents of constant amplitude so long as said high frequency oscillations of constant amplitude persist, but producing no effective direct current when high frequency oscillations are not received, means to receive the variable currents reproduced by said demodulator, and direct current responsive means producing a continuous response so long as said effective direct current continues.

In testimony whereof, I have signed my name to this specification this 23rd day of July, 1919.

HERMAN A. AFFEL.