July 29, 1924. 1,502,812

L. ESPENSCHIED

HIGH FREQUENCY MULTIPLEX SIGNALING SYSTEM

Original Filed Sept. 30, 1919

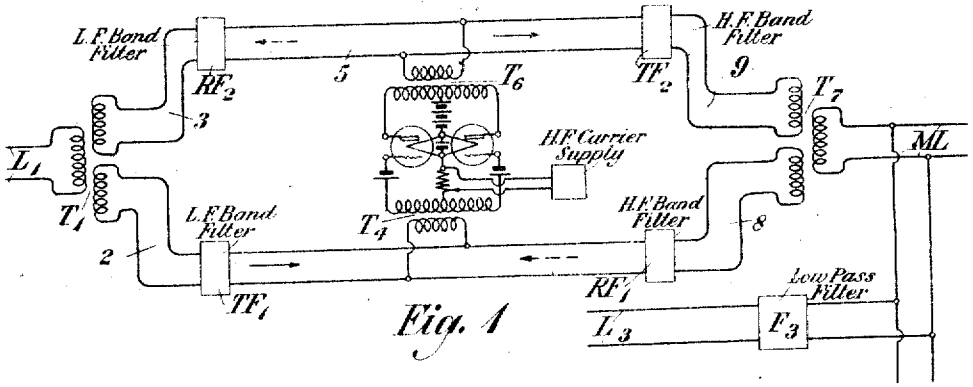


Fig. 1

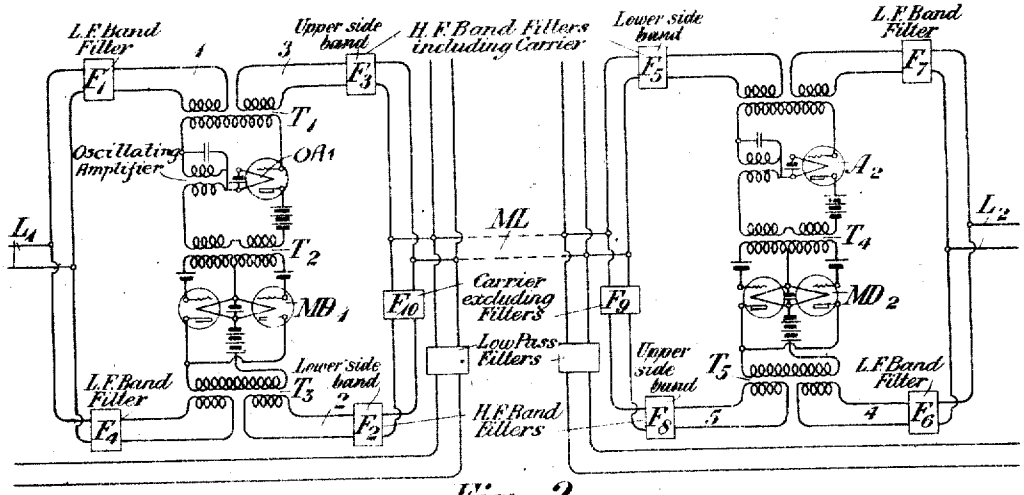


Fig. 2

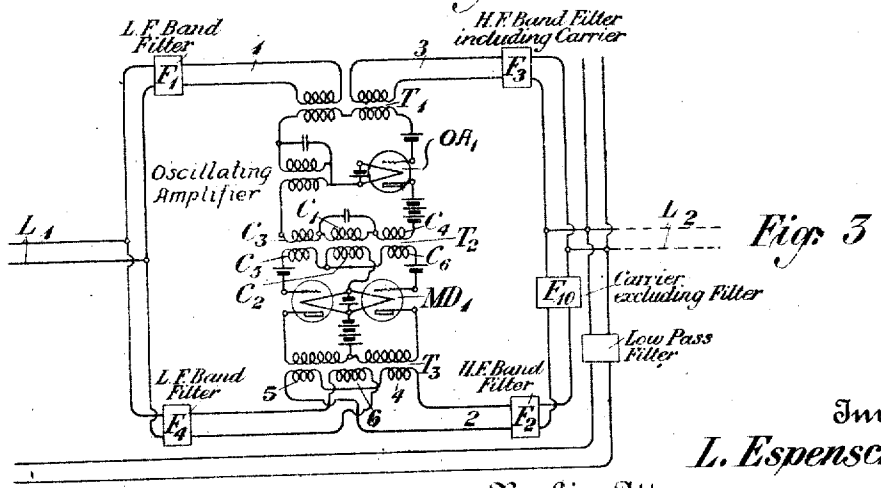


Fig. 3

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By his Attorney J E York

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UNITED STATES PATENT OFFICE.

LLOYD ESPENSCHIED, OF QUEENS, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

HIGH-FREQUENCY MULTIPLEX SIGNALING SYSTEM.

Original application filed September 30, 1919, Serial No. 327,500. Divided and this application filed April 16, 1921. Serial No. 461,964.

To all whom it may concern:

Be it known that I, LLOYD ESPENSCHIED, residing at Queens, in the county of Queens and State of New York, have invented certain Improvements in High-Frequency Multiplex Signaling Systems, of which the following is a specification.

This invention relates to high frequency multiplex signaling systems and particularly to a terminal circuit arrangement embodying the use of a common translating circuit adapted both to modulate the transmitted current and to demodulate the high frequency received current.

This application is a division of my copending application Serial No. 327,500, filed September 30, 1919, entitled High frequency multiplex signaling systems.

In the multiplex signaling systems heretofore used which employ a plurality of carrier currents of various frequencies it has been customary to insert in the transmitting and the receiving branches of the terminal circuit a translating device individual to each of said branches. It is the object of the present invention to adapt the terminal circuit arrangement so that the processes of modulation and demodulation and amplification of the various currents in both the transmitting and receiving branches of the terminal circuit may be performed by a single translating device. Although the preferable form of translating device is a single thermionic vacuum tube or a plurality of such tubes in combination adapted to function as a single unit with respect to the two branches of the terminal circuit, yet any well known type of translating device such as the mechanical repeater may be used.

Another object of this invention is to provide a terminal circuit arrangement which does not require line balancing networks and in which the transmitted and received currents are guided through the terminal circuit by means of suitable selecting networks.

Other and further objects of this invention will become apparent from the following description when read in connection with the attached drawing of which Figure 1 shows a circuit arrangement having a balanced duplex modulating and demodulating device which prevents the transmission therethrough of the unmodulated carrier frequency; Figure 2 shows a terminal circuit having a translating circuit comprising both an amplifier and a modulating and demodulating device, the said amplifier being arranged in a feed-back circuit designed to oscillate at the carrier frequency; and Figure 3 has a translating circuit similar in general to Figure 2 but designed to suppress the low frequency component impressed upon the modulating and demodulating device.

Figure 1 shows a terminal circuit arrangement in which no artificial lines are employed to balance the low frequency or high frequency transmission lines. In the circuit arrangement shown in this figure, the low frequency voice currents of line L_1 are impressed upon the terminal circuit by means of the transformer T_1. These low frequency oscillations in circuit 2 pass through the low frequency filter TF_1 and are impressed upon the translating circuit by means of the transformer T_4. The translating circuit is preferably that shown in the patents to J. R. Carson 1343306 and 1343307 each dated June 15, 1920. The low frequency oscillations which are impressed upon the circuit modulate the high frequency carrier current and the modulated wave is impressed upon the circuit 5 by means of the transformer T_6. These high frequency modulated waves pass through the high frequency filter TF_2 and are impressed upon the main transmission line ML by means of the transformer T_7. In a similar manner the oscillations which are received over the main transmission line ML pass through circuit 8 and the high frequency receiving filter RF_1 and are impressed upon the translating circuit by means of the transformer T_4. These high frequency modulated waves are demodulated in the said circuit by means of the high frequency carrier oscillations, and the low frequency modulating current is impressed upon circuit 5 by means of the transformer T_6. These low frequency oscillations pass through the low frequency filter RF_2 and are impressed upon the low frequency circuit L_1 by means of the transformer T_1. It will be apparent that the low frequency voice currents transmitted over circuit L_1 may also be impressed upon circuit 3 by

means of the transformer T_1, and will pass through the filter RF_2 into the circuit 5. Since, however, the filter TF_2 is designed to pass only high frequency oscillations, none of the low frequency oscillations will pass to the main line ML and furthermore, since the low frequency oscillations will be impressed upon the plate side of the translating device, substantially no effect will be produced in the translating circuit. In a similar manner the received high frequency oscillations may pass into both circuits 8 and 9. Those which pass into circuit 9 may be transmitted through the filter TF_2 into the circuit 5, but cannot pass into the low frequency circuit L_1 on account of the presence of the low frequency filter RF_2, and likewise produce no substantial effect upon the translating circuit, since they are impressed upon the plate end of the translating circuit. If the same side bands are transmitted in both directions through the terminal circuit shown in Figure 1 the amplification produced by the modulating and demodulating device must be limited to the loss in the terminal circuit itself, that is to say the loss through the transmitting and receiving path from the transformer T_1 to the transformer T_7 or vice versa. Further amplification than this would tend to produce singing around the circuit, since the high frequency and low frequency circuits are not balanced by artificial lines. If, however, we transmit the upper side band and receive by means of the lower side band then we may obtain greater amplification without singing, because the filter TF_2 would be designed to transmit only those frequencies comprised within the upper side band of the carrier frequency and the filter RF_1 would be designed to pass only those frequencies lying within the lower side band of the carrier frequency, consequently the oscillations traveling outward from the circuit 9 would not be transmitted back through the circuit 8 to the modulating and demodulating device on account of the fact that the filter RF_1 would not pass the transmitted band of frequencies.

The circuit L_3 represents a low frequency signaling circuit having therein a low frequency filter F_3 by means of which currents of the voice frequency for example may be impressed upon and transmitted over the main transmission line ML simultaneously with the transmission of the bands of high frequency modulated carrier oscillations.

Figure 2 shows another form of terminal circuit which is characterized by the absence of balancing networks and is also characterized by the use of the opposite side bands of a common carrier frequency for what may be termed the east and west channels of transmission. Since the frequencies transmitted and received are different, the filters in the two sides of the circuit are adapted to prevent the passage of a common frequency, consequently the circuit will not sing over either the low or high frequency side, and networks for balancing the low frequency and the high frequency lines may be avoided. In the figure L_1 represents a low frequency line connected with the four-wire circuit having a low frequency band filter F_1 and a high frequency band filter F_2 in the transmitting path of the terminal circuit, and a high frequency band filter F_3 and a low frequency band filter F_4 in the receiving path of the terminal circuit. The input side of the transmitting and receiving paths is connected with the oscillator OA_1 by means of the transformer T_1. The output side of the oscillator is connected with a modulating and demodulating device MD_1 by means of the transformer T_2. The output side of the device MD_1 is connected with the output side of the receiving and transmitting circuits by means of the transformer T_3. Included in the transmitting path is a filter F_{10} whose function is to exclude from the transmitting path of the terminal circuit a group of frequencies ranging from the carrier frequency to a frequency in the neighborhood but somewhat below the lowest frequency transmitted by the band filter F_2. The terminal circuit B shown shown at the opposite end of the main transmission line ML is similar to that described, excepting that the amplifying device A_2 shown in the said circuit is non-oscillating.

This circuit arrangement will be better understood from the following description of its method of operation. Low frequency signaling currents arriving over the line L_1 pass through the filter F_1 and are impressed upon the oscillating-amplifying device OA_1. These oscillations are amplified and together with oscillations of carrier frequency generated in the device OA_1 are impressed by the transformer T_2 upon the modulating and demodulating device MD_1. The two bands of frequencies based upon a common carrier frequency are transmitted together with the carrier frequency to the branch 2 of the transmitting path. The filter F_2 is designed to transmit only that band which is desired for transmission in that direction, the other band being suppressed. The carrier current is suppressed by the filter F_{10} so that the only frequencies flowing to the main transmission line ML from the modulator-demodulator MD_1 are those contained in the band which is allowed to pass through the filler F_2. The oscillations of carrier frequency which are generated by the device A_1 will be impressed by the transformer T_1 upon the circuit 3, and pass through the band filter F_3 to the main line ML so that the

carrier frequency and one of the transmitted side bands are traveling simultaneously to the opposite terminal circuit. Both sets of oscillations pass through the high frequency band filter F_5 and are impressed upon the amplifying device A_2. By means of this device both the carrier oscillations and the side band oscillations are amplified and are impressed upon the modulating and demodulating device MD_2 by means of transformer T_4. The oscillations of the side band are demodulated in the devices MD_2 and the low frequency currents resulting therefrom are impressed by means of the transformer T_5 upon the circuit 4. These currents pass through the low frequency band filter F_6 to the low frequency line L_2.

Low frequency currents set up in the line L_2 by means of the signaling apparatus associated therewith pass through the low frequency band filter F_7 to the amplifying device A_2. These currents together with the non-modulated carrier oscillations arriving from the terminal circuit at the other end of the same line are impressed simultaneously upon the modulating and demodulating device MD_2 and are modulated therein. The modulated high frequency oscillations arising therefrom are impressed by means of the transformer T_5 on the circuit 5. The high frequency band filter F_8 is adapted to pass that band of frequencies which is opposite to the band transmitted by the filter F_5 and to suppress the band of frequencies transmitted by the latter filter. That is to say, if the filter F_5 transmitted the lower band of frequencies based upon the carrier frequency the filter F_8 is designed to pass the upper band of frequencies based on the same carrier frequency. Filter F_9 is inserted in the transmitting circuit to suppress the carrier frequency. The frequencies transmitted by filter F_8 pass over the transmission line ML, through the filter F_3, and are impressed upon the amplifying device OA_1. The received oscillations are thereby amplified and together with the carrier oscillations arising within the device OA_1 itself are impressed upon the modulating and demodulating device MD_1. The received band of modulated frequencies are demodulated, and the resulting low frequency currents pass through the filter F_4 and the line L_1 to the signaling apparatus associated therewith. The type of modulating and demodulating device represented by MD_1 and MD_2 is adapted to eliminate the amplification components of both the high frequency and the low frequency oscillations so as to prevent singing around the two sides of the terminal circuit. One of the advantages of the circuit arrangement shown in this figure arises from the use of opposite side bands of the carrier frequency whereby balancing networks are rendered unnecessary, and another advantage arises from the transmittal of high frequency carrier oscillations from one terminal circuit to another terminal circuit whereby identity of frequency of the modulating and demodulating current is assured.

Figure 3 shows a circuit arrangement differing slightly from that shown in Figure 2. The principal difference arises in the structure of the translating circuit associated with the four-wire terminal circuit. In the structure shown in Figure 2 the balanced modulating and demodulating circuit was of a type designed to balance out and therefore eliminate the amplification components of both the high frequency and the low frequency currents. The oscillating circuit shown in Figure 3 differs from the foregoing in that it is designed to balance out only the amplification components of the low frequency currents. The carrier current oscillations generated in the device OA_1 together with the low frequency currents impressed upon the said device by the transformer T_1 are together impressed by the transformer T_2 upon the modulating and demodulating device MD_1. It will be noted that the windings of the transformer T_2 are adapted so that the middle coil C_1 is coupled with coil C_2 which is connected in the common conductor of the duplex translating device MD_1. The coil C_1 is traversed by the low frequency currents in consequence of which the low frequency currents will be impressed upon the common conductor. The coils C_3 and C_4 transmit primarily the high frequency oscillations so that the said oscillations are impressed across the input side of the translating circuit. The transformer T_3 connected with the output side of the device MD_1 has a plurality of coils connected with the line side which for best results may be connected in the manner shown in the drawing. The high frequency oscillations impressed by the coils C_3 and C_4 upon the input side of the translating device cause corresponding fluctuations in the output side of the said device, which in turn transmit these fluctuations to the coils 4 and 5, which are connected with the high frequency transmitting branch of the circuit. The low frequency currents which are impressed by means of the coil C_1 upon the common conductor of the translating device produce a flow of current in opposite directions in the output coil of the transformer T_3 so that the low frequency component is balanced out and eliminated. It will thus be seen that the arrangement shown in Figure 3 provides a suitable means for balancing out the low frequency component and the arrangement shown in Figure 2 to balance out the amplification components of both frequencies when such is desired.

It will be seen that the invention discloses

in this application comprises a terminal circuit arrangement characterized by the absence of balancing networks to balance the connecting line circuits, and further characterized by a translating circuit common to the transmitting and receiving paths of the terminal circuit adapted to modulate and demodulate the currents impressed thereon. The invention also comprises means for generating carrier frequency oscillations and transmitting them to the terminal circuit at the other end of the connecting line circuit and reamplifying the carrier frequency oscillations before impressing them upon the common modulating and demodulating device.

Although the invention has been disclosed in certain particular forms and arrangements of parts it is to be understood that the invention is not thus limited but is capable of embodiment in other and different forms without departing from the spirit and scope of the appended claims.

What is claimed is:

1. In a signaling system the combination with a high frequency transmission circuit of low frequency signaling circuits, four-wire connecting circuits individual to the said signaling circuits adapted to connect the said transmission circuit with each signaling circuit, each four-wire circuit having a translating circuit connected therewith, one of said translating circuits having means to generate oscillations of carrier frequency and the other translating circuit connected with the corresponding four-wire circuit at the opposite end of the said transmission circuit having means to amplify oscillations of the carrier frequency transmitted over the said transmission circuit from the said first translating circuit.

2. In a signaling system the combination with the high frequency transmission circuit of a low frequency signaling circuit, a four-wire connecting circuit and means to impress low frequency and high frequency currents upon the translating circuit from their respective signaling circuits, the said connecting circuit having associated therewith a translating circuit comprising an amplifying circuit having a feed-back connection tuned to a definite frequency designed to generate carrier frequency oscillations, and also to amplify currents of other frequencies impressed thereon, and a modulating-demodulating circuit adapted to receive the carrier current and said other currents, and characterized by means to modulate and demodulate said other currents, and also by means to suppress the linear components of modulation and demodulation.

3. In a high frequency signaling system comprising two line circuits each transmitting a frequency different from that of the other and connected by a four-wire circuit characterized by a translating circuit common to the transmitting and receiving paths of the four-wire circuit and having a source of carrier frequency current associated therewith, the method of signaling which consists in generating carrier frequency current, amplifying the currents of a band of frequencies transmitted by one of the line circuits, demodulating the currents of the said band by the carrier current, transmitting the current produced by such demodulation and suppressing the transmission of the carrier frequency current.

4. In a high frequency signaling system comprising two line circuits each transmitting a frequency different from that of the other and connected by a four-wire circuit characterized by a translating circuit common to the transmitting and receiving paths of the four-wire circuit and having a source of carrier frequency current associated therewith, the method of signaling which consists in simultaneously modulating the carrier frequency, in accordance with the frequency transmitted by one line circuit, and demodulating the frequency transmitted by the other line circuit and transmitting the frequencies resulting from such modulation and demodulation.

5. In a signaling system, the combination with a low frequency signaling circuit of a high frequency signaling circuit, a four-wire circuit having a translating circuit connected therewith, and means to impress low frequency and high frequency currents upon the translating circuit from their respective signaling circuits, the said translating circuit having means to generate high frequency carrier currents to amplify the impressed currents and to modulate and demodulate the amplified currents by means of the generated carrier currents.

6. In a signaling system, the combination with a low frequency signaling circuit of a high frequency signaling circuit, a four-wire connecting circuit characterized by a translating circuit bridged across the two-wire branches of the four-wire circuit, and means to impress low frequency and high frequency currents upon the translating circuit from their respective signaling circuits, the said translating circuit comprising a feed-back oscillation circuit designed to generate carrier frequency current, and modulating and demodulating circuit adapted to have impressed thereon a carrier current and also currents impressed upon the four-wire circuit by the low frequency and the high frequency signaling circuits whereby the said latter currents may be modulated and demodulated.

7. In a signaling system, the combination with a high frequency transmission circuit of low frequency signaling circuits, four-wire connecting circuits individual to each

signaling circuit and connected with the said transmission circuit, each of said four-wire circuits having a translating circuit connected therewith, and means to impress low frequency and high frequency currents upon the said translating circuits from their respective signaling circuits and from the transmission circuit, each translating circuit embodying a feed-back oscillation circuit and a modulating-demodulating circuit, the said modulating-demodulating circuit having its input and output sides conjugately related to suppress both the carrier and the signaling currents, and to transmit only the currents resulting from modulation and demodulation.

8. In a signaling system, the combination with a high frequency transmission circuit of a low frequency signaling circuit, a four-wire circuit connecting the said transmission circuit and the said signaling circuit and having a translating circuit associated therewith, and means to impress low frequency and high frequency currents upon the said translating circuit, the said translating circuit having means to generate high frequency carrier oscillations and also to amplify low frequency signaling currents and high frequency signaling currents impressed thereon, a second low frequency signaling circuit and a second four-wire connecting circuit having a translating circuit containing means to reamplify oscillations of carrier frequency received over the said transmission line from the said first mentioned four-wire circuit and to amplify other currents impressed upon the said second translating circuit.

9. In a signaling system, the combination with a high frequency transmission circuit of a low frequency signaling circuit, a four-wire connecting circuit having associated therewith a translating circuit comprising an amplifying circuit having a feed-back connection tuned to a definite frequency, and means to impress low frequency and high frequency currents upon the said translating circuit from the said signaling circuits, the said translating circuit having means to generate carrier frequency oscillations and to amplify currents of other frequencies impressed thereon, and a modulating-demodulating circuit having means to receive the carrier current and the said other currents and to modulate and demodulate the said other currents.

In testimony whereof, I have signed my name to this specification this 15th day of April, 1921.

LLOYD ESPENSCHIED.