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HIGH FREQUENCY MULTIPLEX SIGNALING SYSTEM

Original Filed Sept. 30, 1919

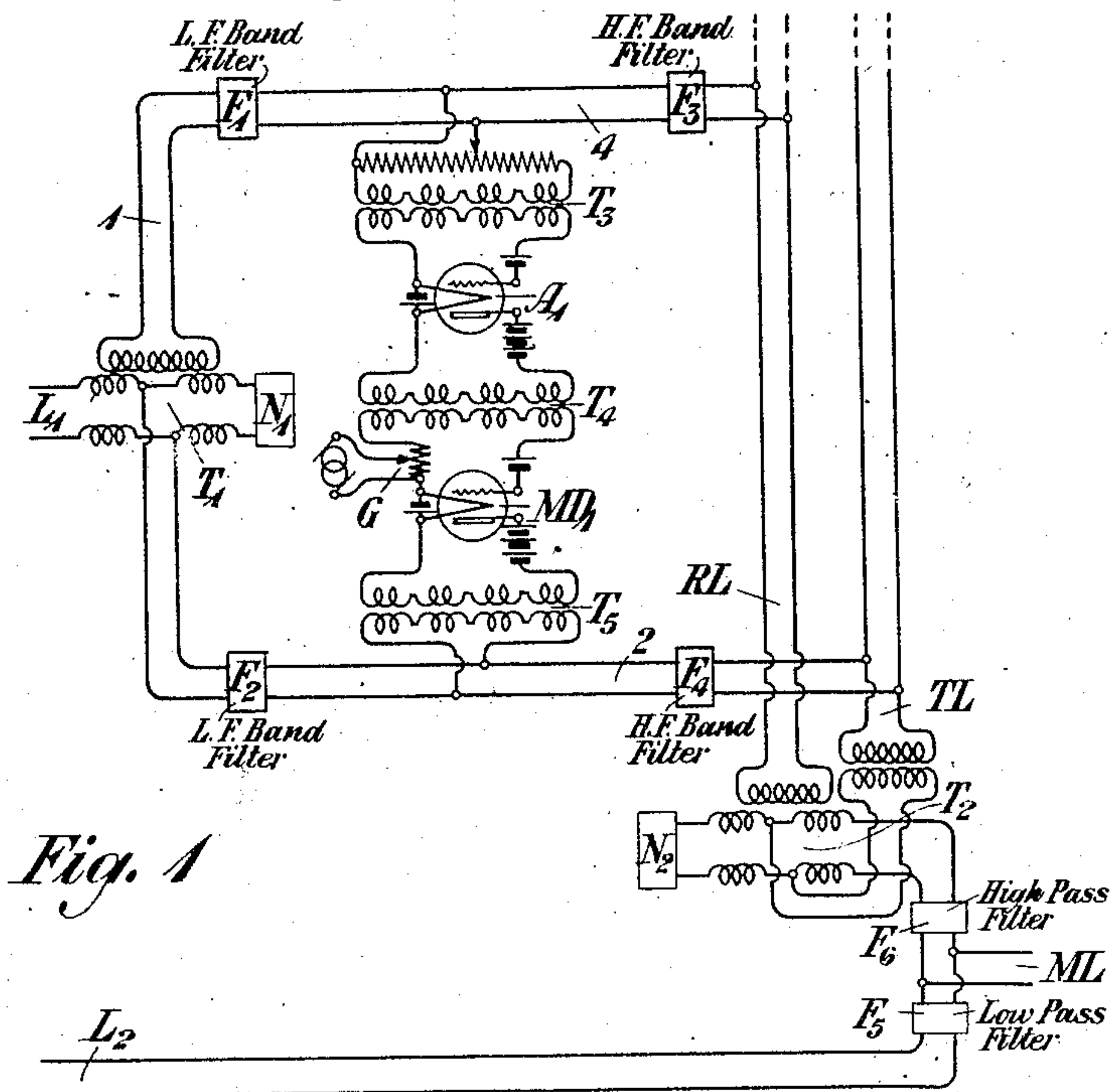


Fig. 1

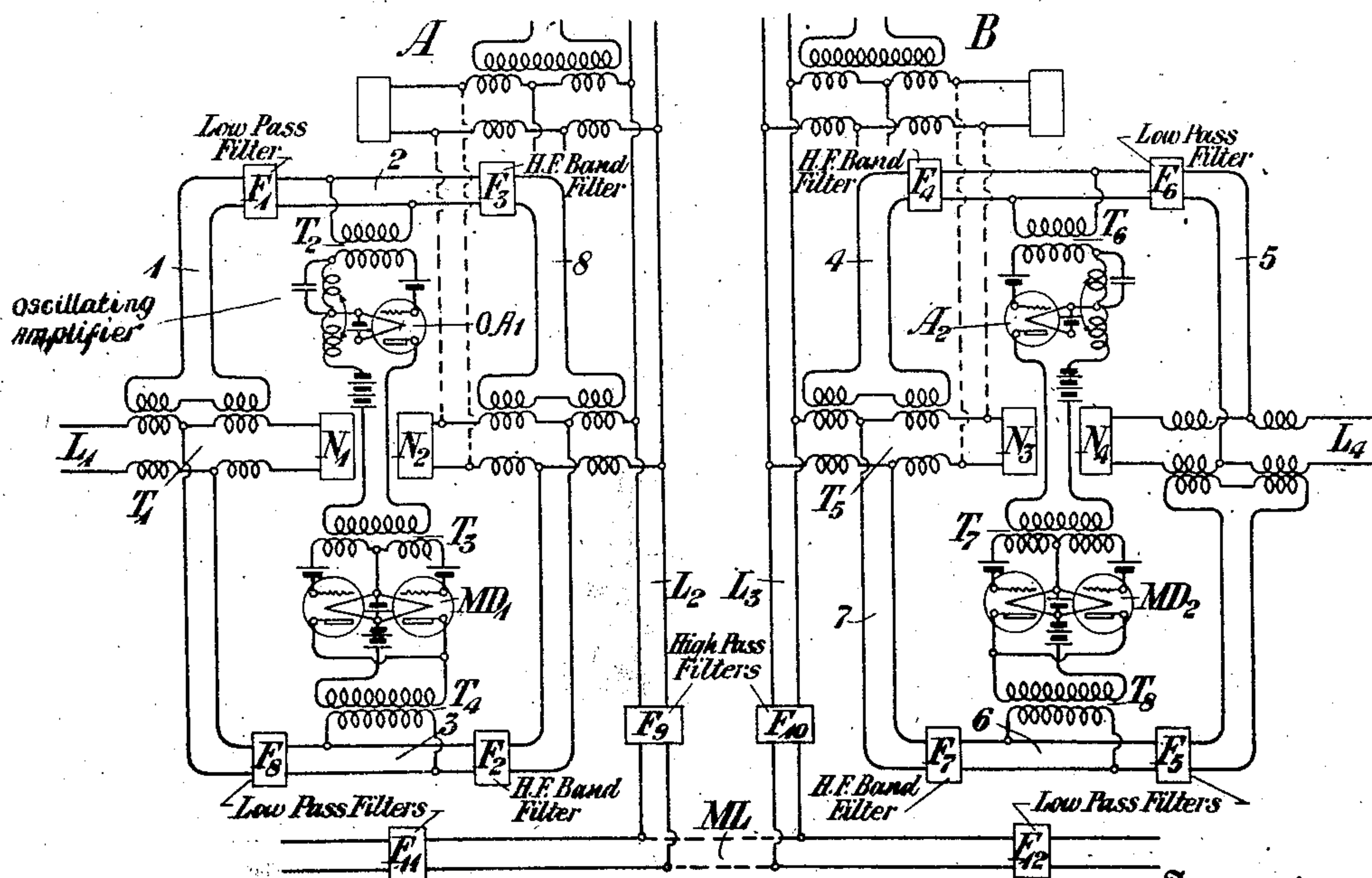


Fig. 2

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UNITED STATES PATENT OFFICE.

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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. 481,967.

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 system and more 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 co-pending 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 processes of modulation, 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 devise a circuit arrangement of the general character described above and adapted to generate oscillations of the carrier frequency to be used for modulation and demodulation of currents impressed upon the circuit with which the said source of carrier oscillations is connected, and also to be transmitted over the high frequency line to a distant terminal circuit wherein the said carrier oscillations may be reamplified for the purpose of local modulation and demodulation.

Other and further objects of this invention will be apparent from the following description when read in connection with the attached drawing of which Figure 1 shows a type of circuit having a single modulating and demodulating device, and Figure 2 shows a type of circuit characterized by a balanced modulating and demodulating device wherein the frequencies representing the amplification components are suppressed and only the side bands of frequencies are transmitted.

Figure 1 shows another variation of the general circuit characterized by the inclusion in the translating circuit of an amplifier which is adapted to amplify both the low frequency and the high frequency oscillations that may be impressed upon the translating circuit. A low frequency signaling circuit L_1 is connected with a terminal circuit by means of the triple winding transformer T_1 , having a network N_1 associated therewith to balance the line L_1 . Associated with the branches of the four-wire circuit are the low frequency band filters F_1 and F_2 , and the high frequency band filters F_3 and F_4 . The output side of the terminal circuit is connected with the branch transmission circuit TL , which is in turn connected with the main transmission line ML by means of the triple winding transformer T_2 . The input side of this terminal circuit is connected with the branch receiving circuit RL , which is likewise connected with the main transmission line by means of the transformer T_2 . A network N_2 is connected with the transformer T_2 to balance the main transmission line ML . Only one terminal circuit is shown connected with the transmission line, but it should be understood that any number of terminal circuits may be connected therewith, depending upon the number of different bands of frequencies that may be transmitted over the main transmission line. A low frequency signaling line L_2 , having inserted therein a low frequency filter F_5 , is connected with the main transmission line in order that low frequency signaling currents may be transmitted simultaneously with the high frequency carrier oscillations. The translating circuit which is bridged across the two-wire sides of the terminal cir-

circuit includes transformer T_3 and amplifier A_1 , a second transformer T_4 , a modulating and demodulating device MD_1 , and an output transformer T_5 . Associated with the modulating and demodulating device MD_1 is a source of unmodulated carrier oscillations G .

In the operation of this circuit arrangement low frequency signaling currents impressed upon circuit L_1 will pass through circuit 1 and be impressed by means of transformer T_3 upon the amplifier A_1 . These amplified low frequency oscillations then will be impressed by means of the transformer T_4 upon the device MD_1 , thereby modulating the high frequency carrier oscillations also impressed upon the device MD_1 by the generating circuit G . The modulated high frequency oscillations will be impressed by the transformer T_5 upon circuit 2 and will pass through the high frequency band filter F_1 and over the branch circuit TL to the main circuit ML . Since the filter F_2 is designed to pass only low frequency currents of, for instance, zero to 2,000 cycles, the modulated high frequency oscillations which are impressed upon circuit 2 which, based on a carrier frequency of, say, 10,000 cycles, may be from 8,000 to 12,000 cycles, will not pass through the filter F_2 , into the low frequency line L_1 . If we assume that the filter F_1 is designed to transmit a band of frequencies ranging from 10,000 to 12,000 cycles, the band of frequencies between 8,000 and 10,000 cycles will be suppressed and only the band included between 10,000 and 12,000 cycles will be transmitted. If the filter F_1 is designed to transmit the same band of frequencies, oscillations of those frequencies which are received over the main line ML and the branch line RL pass through the filter F_1 into the circuit 4, and will be impressed upon the amplifier A_1 by means of the transformer T_3 . This amplifier will amplify the modulated carrier current which will then be impressed by the transformer T_4 upon the modulating and demodulating device MD_1 . Since the oscillations from the generating circuit G are of the same frequency as the carrier oscillations, prior to modulation by voice frequencies, the latter oscillations will be demodulated, and the low frequency modulating current, i. e. the voice frequency, will be impressed upon the circuit 2 and will pass through the low frequency filter F_2 to the signaling apparatus associated with the line L_1 .

Since the modulating and demodulating device MD_1 shown in this figure is not of the duplex type, such as is shown, for example, in Figure 1, of my copending application, Serial No. 327,500, filed September 30, 1919, in which the carrier oscillations are prevented from passing to the output,

the oscillations of carrier frequency will, in the arrangement shown in Figure 1, be impressed on circuit 2 and transmitted over the branch circuit and the main transmission line ML to the terminal circuit at the other end, which may be assumed to be equipped with a terminal circuit similar to that shown in Figure 1. This unmodulated carrier current will pass through the amplifier in the other terminal circuit, and the amplified unmodulated carrier frequency may be used therein as the carrier current for the modulation and demodulation of signals in the terminal circuit at the distant end of the transmission circuit ML . This method insures the transmission of the signaling currents from each end by carrier frequencies which are identically the same in magnitude thereby avoiding the difficulty which arises when slight differences exist between the carrier frequencies transmitted from different ends of the same transmission circuit. Since the circuits L_1 and ML are balanced by the networks N_1 and N_2 respectively, singing around the circuit is substantially prevented. As a further protection against singing, the filter F_3 may be made to exclude the carrier frequencies by making the range of frequencies adapted to pass through the set filter vary, for example, from 10,200 to 12,000 cycles.

Figure 2 illustrates a further modification of the general circuit which is characterized by the translating circuit common to both the sending and receiving paths of the terminal circuit; by the direct transmission of the carrier frequency; by the balancing of the modulating and demodulating device in order to eliminate amplification components of the various frequencies; by the adaptation of the amplifier of one terminal circuit to operate as an oscillator of carrier frequency and the adaptation of the amplifier of the cooperating terminal circuit at the opposite end of the transmission line to re-amplify the oscillations transmitted from the said first terminal circuit, and by the utilization of the principle of multiple balancing whereby a single network may be adapted to balance the transmission line for a plurality of terminal circuits.

In the circuit arrangement shown in Figure 2, low frequency currents will be received over the line L_1 and passing into the branch 1 and through low frequency filter F_1 of the terminal circuit A will be impressed by means of the transformer T_2 upon the oscillating amplifier A_1 . By means of the feed back circuit shown in connection with this amplifier, the device may be made to oscillate at the desired carrier frequency. These carrier oscillations, together with the amplified low frequency currents, will be impressed by means of transformer T_3 upon the modulating and demodulating device

MD₁ and the carrier current will be modulated accordingly. This type of balanced tube circuit does not permit the passage therethrough of unmodulated carrier oscillations, so that the transformer T₁ will impress upon the circuit 3 only the bands of modulated frequency which are based upon the carrier frequency, excluding the carrier frequency itself. The high frequency filter F₁ will transmit that band of frequencies which it is designed to pass and the oscillations transmitted will pass over the branch transmission line L₂ and the main transmission line ML to the terminal circuit B at the other end of the said transmission line. The oscillating amplifier A₁ which is producing oscillations of carrier frequency will transmit this frequency through the transformer T₂ into the branch 2 and then through the high frequency band filter F₂ and over the line L₂ and ML to the terminal circuit B. The band of modulated oscillations and the oscillations of carrier frequency will be simultaneously impressed by means of the transformer T₁ upon the input branch 4 of circuit B and by means of transformer T₂ upon the amplifier A₂. Since this amplifier A₂ has associated with it a feed back circuit which is sharply tuned to carrier frequency, the oscillations of carrier frequency will be fed back, and will be reamplified thereby. These oscillations, together with the amplified oscillations of the band of received oscillations will be impressed by means of transformer T₁ upon the modulating and demodulating device MD₂. The band of received oscillations will be demodulated accordingly and the low frequency currents resulting therefrom will pass through the low frequency filter F₃ into the low frequency line L₄.

Low frequency currents set up by signaling apparatus connected with the line L₁ will be impressed upon branch 5 of the terminal circuit B, and passing through the filter F₄, will be impressed upon the amplifier A₂. These low frequency oscillations, together with unmodulated high frequency carrier oscillations received from the other terminal A of this circuit, will pass through the said amplifier and will be impressed by the transformer T₁ upon the modulating and demodulating device MD₂. This device is similar to the device MD₁ in that it will pass the modulated side bands of the carrier frequency, but will not transmit the carrier frequency itself. Accordingly the said modulated bands will be impressed by means of the transformer T₁ upon the branch 6 and oscillations of that band which the high frequency band filter F₁ is adapted to pass, will be transmitted over the branch 7 and the circuits L₃, ML, L₂ to the branch 8 of the terminal circuit A. These oscillations will pass through the high frequency band filter

F₂ and will be impressed upon the oscillating amplifier A₁. This band of frequencies will be amplified thereby and together with the oscillations of carrier frequency generated by A₁, will be impressed by means of the transformer T₁ upon the modulating and demodulating device MD₁. The band of modulated oscillations will be demodulated and the low frequency current resulting therefrom will pass into the circuit 3, and through the low frequency filter F₃ into the low frequency line L₄. The balanced modulating and demodulating device used in each of the terminal circuits is of a type in which the amplification components of both high and low frequencies are eliminated so that under conditions of substantially perfect balance the device produces no straight amplification. The advantage derived from the use of this type of balanced translating circuit as applied to the present type of terminal circuit is that it prevents the circuit from singing around either the high or low frequency side. Another important feature disclosed by the circuit arrangement shown in this figure consists in the transmission of the unmodulated carrier current from one terminal circuit to another terminal circuit at the opposite end of the main transmission line, and the reamplifying of said carrier current at the other terminal so that it may be used therein as the basis of transmission of the low frequency currents from that terminal to the said first mentioned terminal. This insures the maintenance of the same frequencies at each end of the line, and since the demodulation is based on homodyne principles the difficulty which arises when the received frequency and the demodulating frequency are different is thereby avoided.

This circuit arrangement also illustrates another method whereby a single network at each end of the main transmission line may be utilized to balance the said line for a plurality of terminal circuits. In the said circuit arrangement a plurality of triple winding transformers are connected with the branch transmission lines, each transformer being individual to a terminal circuit and a network N₂ is adapted to balance the main transmission line for all of the terminal circuits associated with the said line. This multiple balancing system may be termed a bridge type, as distinguished from the differential type employing a triple winding transformer common to all terminal circuits, as, for example, that shown in Figure 1 of my copending application, Serial No. 327,500, filed September 30, 1919. The advantage of the arrangement shown in Figure 2 arises from the fact that each terminal circuit is made essentially a separate unit which is conducive to flexibility and is more efficient due to the greater efficiency of a transformer that is designed for the par-

particular frequency to which the terminal circuit is adjusted.

Although this invention has been disclosed as embodied in a particular form and arrangement of parts, it is to be understood that it 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 of a low frequency circuit, a high frequency circuit, a four-wire circuit connecting the said high frequency and low frequency circuits and networks adapted to balance the said high frequency and low frequency circuits, the said four-wire circuit having associated therewith a translating circuit common to the transmitting and receiving paths and having means to amplify currents impressed thereon and means to modulate and detect the same.

2. In a signaling system, the combination of a low frequency circuit, a high frequency circuit, a four-wire circuit, transforming means to connect the said four-wire circuit with the said high frequency and low frequency circuits, and networks associated with the said transforming means to balance the said high frequency circuit and said low frequency circuit, the said four-wire circuit having a translating circuit common to the transmitting and receiving paths and having means to amplify currents impressed thereon and means to modulate and detect the amplified currents.

3. In a signaling system, a combination with a high frequency transmission circuit of two low frequency signaling circuits, four-wire terminal circuits adapted to connect the said high frequency transmission circuit with each of said low frequency signaling circuits, one of said four-wire circuits having means associated therewith to generate oscillations of carrier frequency and to transmit them over the said transmission circuit the other of said four-wire circuits having means to reamplify oscillations of the carrier frequency received over the said transmission circuit from the said first four-wire circuit.

4. In a signaling system, a combination with a high frequency transmission circuit of two low frequency signaling circuits, and four-wire terminal circuits adapted to connect the said high frequency transmission circuit to each of said low frequency signaling circuits, each of said four-wire circuits being characterized by a translating circuit means for modifying currents and also characterized by filters adapted to guide the received and transmitted currents through the said four-wire circuits, one of said four-wire circuits having means for generating oscillations of carrier frequency and means

to transmit the said oscillations to the other of said four-wire circuits which has means for reamplifying the received oscillations.

5. In a signaling system, a four-wire circuit comprising a receiving path and a transmitting path, and a translating circuit common to both paths and having means for generating oscillations of carrier frequency.

6. In a signaling system, a four-wire circuit comprising a receiving path, a transmitting path and a translating circuit common to both paths and having means for amplifying currents traversing both of said paths and means for modulating and demodulating the said currents.

7. In a signaling system, a four-wire circuit comprising a receiving path and a transmitting path, and a translating circuit common to both paths and having means for regeneratively amplifying oscillations of the carrier frequency impressed thereon and means for modulating and detecting the currents of other frequencies impressed upon the translating circuit by means of the said reamplified carrier oscillations.

8. In a four-wire terminal circuit associated with line circuits, the combination with two two-wire branches of a high frequency band filter and a low frequency filter in each of said two-wire branches, transforming means to connect the four-wire circuit with the said line circuits, a translating circuit, and means for impressing upon the translating circuit the currents from one of the said two-wire branches, the said translating circuit comprising a feedback oscillation circuit adapted to generate oscillations of carrier frequency and to amplify all other currents impressed thereon and also comprising a modulating and demodulating device to modulate and detect the currents impressed upon the said translating circuit.

9. In a signaling system, a combination with a transmission circuit of two four-wire circuits, one four-wire circuit having means for generating oscillations of carrier frequency and the other having means for reamplifying oscillations of carrier frequency received over the said transmission circuit from the said first-mentioned four-wire circuit.

10. In a carrier current system, the combination with a high frequency line of a low frequency line, means for modulating currents flowing from said low frequency line to said high frequency line, said means acting also to detect currents flowing from said high frequency line to said low frequency line and an amplifier in series with the said means for amplifying all of said currents.

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

LLOYD ESPENSCHIED.