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L. ESPENSCHIED ET AL

HIGH FREQUENCY MULTIPLEX SIGNALING SYSTEM

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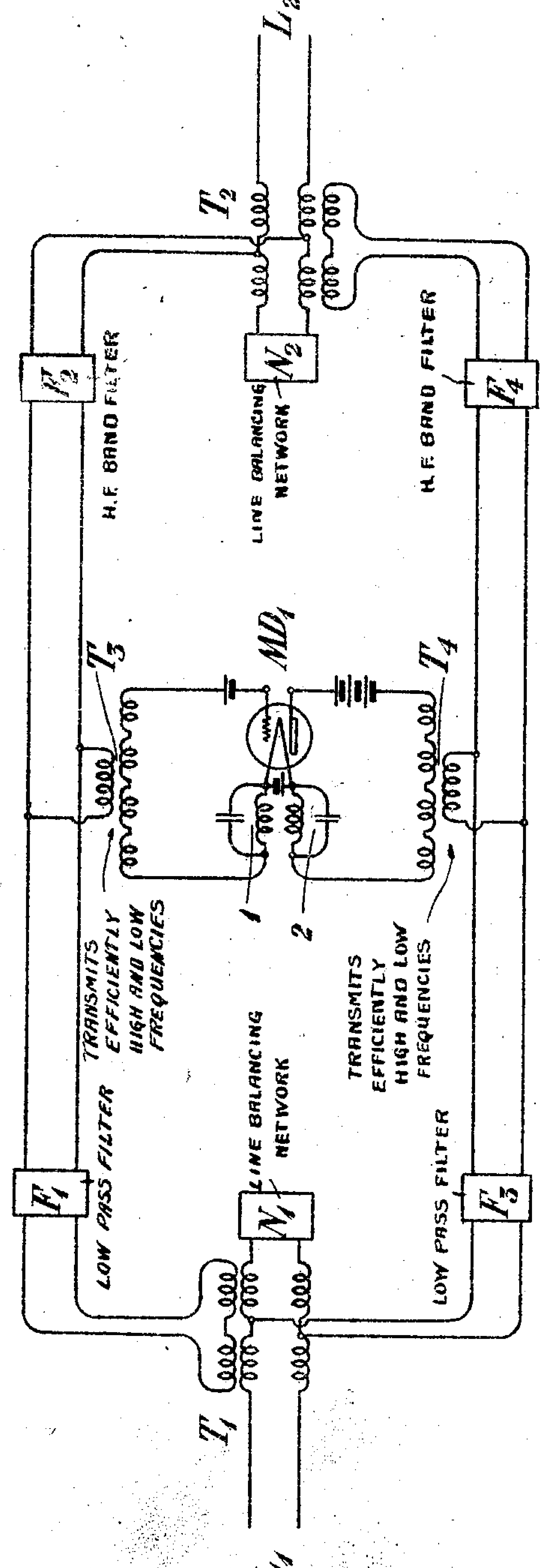

Fig.1

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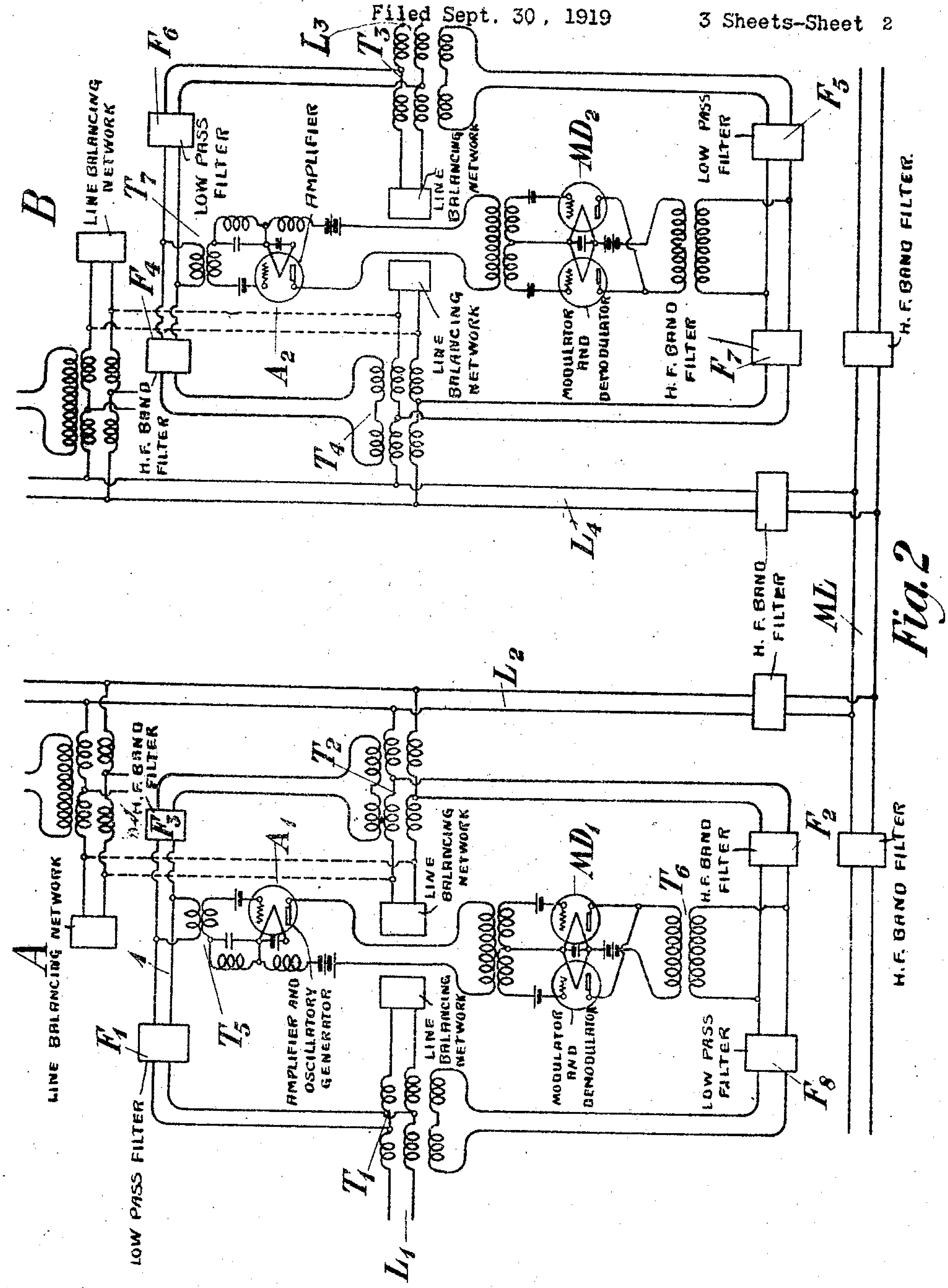

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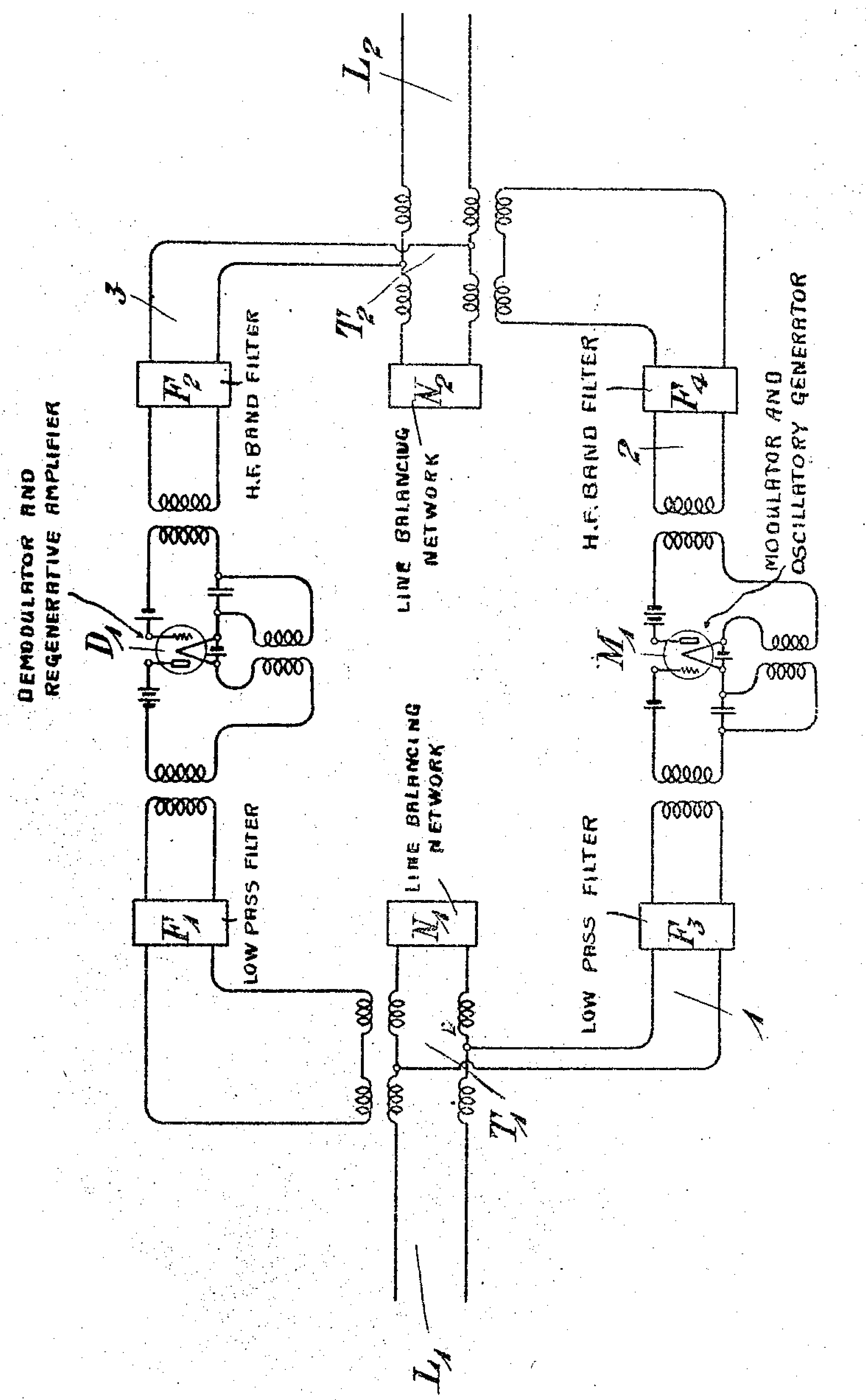

Fig. 3

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UNITED STATES PATENT OFFICE.

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HIGH-FREQUENCY MULTIPLEX SIGNALING SYSTEM.

Application filed September 30, 1919. Serial No. 327,397.

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 and State of New York, respectively, have invented certain Improvements in High-Frequency Multiplex Signaling Systems, of which the following is a specification.

This invention relates to a high frequency multiplex signaling system and more particularly to a translating circuit arrangement associated with the terminal circuit of such systems whereby the received carrier oscillations may be reamplified by a re-entrant or feed-back connection associated with the translating circuit. In the multiplex signaling system in which the oscillations of carrier frequency are transmitted simultaneously with the oscillations of one of the modulated bands of frequencies based upon the carrier frequency it is desirable to amplify at the receiving end the oscillations of carrier frequency relatively more than those embraced within the side band. The object of so doing is to improve or insure good quality for the detected currents by causing the desired components of demodulation to be large in comparison with the undesired components. It is the object of this invention to reamplify the oscillations of carrier frequency in the translating circuit and to use these reamplified carrier oscillations in the translating circuit in order to effect the modulation and demodulation of the impressed currents.

This invention will be more fully understood from the following description when read in connection with the attached drawing, of which Figure 1 shows the application of the invention to a terminal circuit having a translating circuit common to both the transmitting and receiving paths, in which amplification, modulation and detection are performed by a single tube. Figure 2 shows the application to a terminal circuit having a common translating circuit in which amplification is performed by a device separate from the modulator and detector, and Figure 3 shows the application to a terminal circuit having a translating circuit individual to the transmitting and receiving circuits. In Figure I, L_1 represents a low frequency signaling circuit related to the terminal circuit by means of transformer T_1 and balanced by the network N_1. The high frequency signaling circuit L_2 is related to the terminal circuit by transformer T_2 and balanced by the network N_2. This terminal circuit is of the well known 22 type having incoming and outgoing sides, the incoming side being so connected as to impress modulated high frequency received oscillations and carrier currents upon the translating circuit, and the outgoing side being adapted to impress signaling currents upon the translating device from whence they pass to the line L_2. The incoming side has therein a high frequency band, filter F_2 and a low pass filter F_3. In a similar manner the outgoing side has associated therewith a low pass filter F_1 and a high frequency filter F_4. Both incoming and outgoing currents are impressed upon the translating circuit by transformer T_3 and are transmitted from the output side of the translating circuit by a transformer T_4. This translating circuit has therein a single translating device adapted to amplify, modulate and detect the impressed currents. Extending from the output side of the translating circuit to its input side is a feed-back or re-entrant connection having therein resonant circuits 2 and 1, which are sharply tuned to carrier frequency. This connection serves to permit the passage of oscillations of carrier frequency from the output side of the translating circuit to the input side, whereby these oscillations may be reamplified and impressed upon the translating device simultaneous with the impressed currents.

The mode of operation of the circuit in which this invention is embodied is as follows: Low frequency signaling currents in the circuit L_1 will be transmitted by the transformer T_1 to the outgoing side of the translating circuit passing through the low pass filter F_1. These low frequency currents are impressed upon the input side of the translating circuit by means of the transformer T_3 which is adapted to transmit efficiently both low frequency and high frequency currents. The low frequency current impressed upon this device serves to modulate therein the high frequency currents of carrier frequency received over the line L_2 from a source at the other end of the said line. The mode of transmission of the oscillations of carrier frequency will be clearly set forth hereafter. The modulated high frequency oscillations will pass through the high frequency band filter F_4 and over the transmission line L_2 to the terminal circuit at the opposite end of the side line. The filter F_4 is a high frequency band filter adapted to pass oscillations of those frequencies lying within a certain band of frequencies based upon the carrier frequency and to suppress the other frequencies based upon the same carrier frequency. The terminal circuit at the opposite end of the line L_2 is adapted to transmit the oscillations of the carrier frequency and also oscillations of those frequencies lying within one of the side bands. These oscillations will be impressed upon the incoming circuit by the transformer T_2 and passing through the band filter F_2 will be impressed by means of the transformer T_3 upon the translating circuit. The oscillations of carrier frequency which pass through the translating device are fed back over the re-entrant circuit 2—1 between the output and input sides of the translating circuit, and are amplified thereby. The circuit 2—1 is sharply tuned to be resonant at the carrier frequency thereby preventing the feeding back of other frequencies. By adjusting the translating circuit the oscillations of carrier frequency may be given the desired degree of amplification. The resulting detected currents will be impressed by the transformer T_4 upon the in oming low frequency side of the terminal circuit, and since these currents are of low frequency they will pass through the low pass filter F_3 and be impressed upon the low frequency signaling circuit L_1.

Figure 2 shows another form in which this invention may be applied to a carrier system in which the terminal circuits are provided with a single translating circuit common to both the transmitting and receiving paths of the said circuit. In the figure L_1 represents a low frequency signaling circuit connected with the four-wire terminal circuit A by means of the transformer T_1. The high frequency side of this terminal circuit is connected with the branch high frequency line L_2 by transformer T_2. B represents another four-wire terminal circuit having the low frequency line L_3 connected thereto by the transformer T_3. The high frequency side of the circuit B is connected with branch transmission line L_4 by transformer T_4. A main transmission line ML connects the two terminal circuits. The translating circuit of the terminal A embodies an amplifier A_1 which is adapted to oscillate at carrier frequency by means of a feed back connection. The output side of this oscillating amplifier is connected with the input side of a balanced modulating and demodulating device MD_1 which is so designed as to suppress the amplification components of both the high frequency and low frequency currents impressed upon the said device. The translating circuit of the terminal circuit B is also equipped with an amplifier having a feed back connection which is designed to re-amplify oscillations of carrier frequency impressed upon it. The output side of this amplifier A_2 is connected with the input side of a balanced modulating and demodulating device MD_2 which is of a type similar to MD_1. In the operation of the circuit shown in Figure 2 low frequency signaling currents arising within the line L_1 will pass through low frequency filter F_1 and be impressed upon the amplifier A_1 by transformer T_1. The amplified currents on the output side of A_1, together with the unmodulated carrier frequency arising from the oscillating circuit will be impressed upon the modulating and demodulating device MD_1. The modulated high frequency oscillations will be impressed upon the output side of the circuit A by transformer T_6 and will pass through the high frequency band filter F_2 and will be transmitted over the circuits M_2, ML, L_4 to the terminal circuit B. Simultaneous with the transmission of these modulated oscillations the unmodulated carrier frequency set up by the oscillating amplifier A_1 will be impressed upon the input circuit 1 of the terminal circuit A, and will pass through the band filter F_3 which is designed to transmit also the carrier frequency and will be transmitted over the circuits L_2, ML, and L_4 to the terminal circuit B. The transmitted side band and the carrier frequency will pass through the band filter F_4 and will be impressed by the transformer T_7 on the amplifier A_2. Since the feed back connection is tuned to carrier frequency, oscillations of this frequency may be re-amplified the desired amount and impressed together with the side band upon the input side of the translating device MD_2. The low frequency signaling current resulting from demodulation will pass through the low frequency filter F_5 into the circuit L_3, and will actuate the signaling apparatus associated therewith. The low frequency signaling currents set up in the line L_3 to be transmitted will pass through the low frequency filter F_6 and will be impressed upon the amplifier A_2. These low frequency currents will be amplified thereby, and together with the reamplified carrier frequency will be impressed upon the modulating and demodulating device MD_2. The modulated high frequency oscillations resulting therefrom will pass through the band filter F_7 and over the circuits L_4, ML, and L_2 to the terminal circuit A. The frequencies of the band which the filter F_3 is designed to transmit will pass therethrough and will be impressed upon the amplifier A_1. These frequencies, together with the modulated carrier frequency generated by the oscillating carrier A_1 will be impressed upon the translating device MD_1 and the low frequency signaling currents resulting from demodulating will pass through the low frequency filter F_8 into the low frequency line L_1 and will actuate the signaling apparatus associated therewith. From the foregoing it will be seen that by means of the arrangement shown in Figure 2, the unmodulated oscillations of carrier frequency may be transmitted from one terminal circuit to its cooperating terminal circuit at the opposite end of the line, and by means of a feed back connection associated with the amplifier in the translating circuit and tuned to carrier frequency the transmitted carrier frequency may be re-amplified to any degree desired and used for the purpose of demodulating the received oscillations or to serve as the carrier for low frequency signaling currents to be transmitted. By this arrangement the identity of frequency of the carrier at the two cooperating terminals is assured and amplification of the carrier frequency and of the frequencies in the received side band may be effected.

Figure 3 shows a two way terminal circuit having a modulating and a detecting device connected with the transmitting and receiving paths respectively. In this figure L_1 represents a low frequency signaling line and L_2 a line for the transmission in each direction of high frequency signaling currents. The line L_1 is related to the terminal circuit by the transformer T_1 having a network N_1 associated therewith adapted to balance the line L_1. The line L_2 is related to the terminal circuit by means of the transformer T_2 having associated therewith the net work N_2 adapted to balance the line L_2. In the transmitting side of the circuit is the low pass filter F_3 and the high frequency band filter F_4, and likewise in the receiving side of the circuit are the low pass filter F_1 and the high frequency band filter F_2. Associated with the transmitting path is a translating circuit M_1 which has associated with it a re-entrant circuit which is adapted to oscillate at the carrier frequency and thereby to serve as the generator of oscillations of that frequency. In the receiving side of the circuit is a translating circuit D_1 which has associated therewith a re-entrant circuit which is sharply tuned to the carrier frequency, and is adapted to re-amplify oscillations of carrier frequency which are impressed upon the translating circuit D_1 together with the oscillations of the side band frequencies. This invention will be better understood from the following description of its mode of operation:

Low frequency signals set up in the line L_1 will be impressed upon the transmitting circuit 1 and passing through the low pass filter F_3 will be impressed upon the modulating circuit M_1. These signaling currents will modulate the high frequency oscillations set up within the circuit M_1 by the re-entrant connection and the modulated high frequency oscillations resulting therefrom will be transmitted to the circuit 2. The filter F_4 may preferably be designed to transmit one of the side bands and to suppress the other side band, and the carrier frequency. The oscillations of the transmitted side band will be impressed upon the line L_2 by the transformer T_2 and will be transmitted to the other terminal of the transmission line. The high frequency band filter in the transmitting path of the terminal circuit at the other end of the line L_2 may be assumed to be of a type that is designed to transmit the carrier frequency together with one of the side bands. Therefore oscillations of both the carrier frequency and of the side band frequencies will be received over the line L_2 will be impressed by the transformer T_2 upon the receiving circuit 3. These oscillations will pass through the high frequency band filter F_2 and be impressed upon the detecting circuit D_1. Since the re-entrant circuit associated with the detecting circuit is tuned to the carrier frequency, oscillations of that frequency will be re-amplified thereby to a greater degree than the oscillations of the side band frequencies. This amplified carrier current demodulates or detects the oscillations of the side band and the resulting detected current passes through the low pass filter F_1 to the low frequency signaling circuit L_1. It will be apparent from the foregoing description that the arrangement shown in Figure 3 provides means for the selective amplification of the carrier current, which is received simultaneously with the side band currents, and for using this amplified carrier current to detect the oscillations of the side band.

By re-amplifying selectively the oscillations of carrier frequency the quality of the detected currents is improved by causing the desired components of demodulation to be large compared with the undesired components. The desired components are those representing modulation between the carrier supply and the band of frequencies representing the side band while the undesired components of demodulation are those representing modulation between the component currents within a side band or between two opposite side bands. By making the carrier oscillations supplied to the detector or demodulator large in comparison with the side band oscillations, the components of demodulation are similarly large compared with the components representing cross modulation between the side band currents. The practical value of this selective amplification of the carrier employed at the receiving end permits of a reduction in the magnitude of the oscillations of carrier frequency transmitted from the sending end resulting in conserving energy which is important in the case of radio-transmission, and further resulting in a reduced load upon repeaters, which is advantageous in connection with wire carrier current transmission.

Although this invention has been shown as embodied in a particular form, it is apparent that it is capable of embodiment in other and different forms within the scope of the appended claims.

What is claimed is:

1. The method of modulating oscillations in a system characterized by means for the conversion of low frequency variations into high frequency oscillations which consists in simultaneously impressing the low frequency variations and unmodulated carrier oscillations upon a translating circuit, regeneratively amplifying the said carrier oscillations, and simultaneously modulating the said amplified carrier oscillations by the low frequency variations, and transmitting the said modulated oscillations.

2. The method of demodulating oscillations in a system characterized by means for the conversion of high frequency modulated oscillations into low frequency signaling variations, which consists in simultaneously impressing the said modulated high frequency oscillations and unmodulated carrier oscillations upon a translating circuit, selectively amplifying the said carrier oscillations, impressing the amplified carrier oscillations and the modulated high frequency oscillations upon a detecting device, and transmitting the resultant low frequency variations.

3. The method of modulating and demodulating oscillations in a system characterized by means for the conversion of low frequency variations into high frequency oscillations and vice versa, which consists in simultaneously impressing low frequency variations, modulated high frequency oscillations, and unmodulated carrier oscillations upon a translating circuit, selectively amplifying the said carrier oscillations, impressing the said variations and said oscillations upon a modulating and demodulating device, and transmitting the modulated high frequency oscillations and low frequency variations resulting from the modulation and demodulation of the said variations and modulated oscillations by said carrier oscillations.

4. In a signaling system, the combination with an input circuit having sources of currents of different frequencies connected therewith of an output circuit, a translating circuit having a thermionic vacuum tube connected therewith adjusted to modulate and amplify voltages impressed thereon, and having a feed-back connection between the output and input sides of said tube selective to a particular frequency whereby the regenerative amplification of the voltage of the particular frequency may be effected.

5. In a signaling system, the combination with a thermionic vacuum tube adapted to modulate and amplify voltages impressed thereon, of a source of carrier frequency, a source of different frequency whereby said carrier frequency may be modulated, an input circuit for impressing voltages of said frequencies upon said vacuum tube, an output circuit, and a reentrant feed-back circuit between said output and input circuits tuned to carrier frequency whereby the regenerative amplification of the said carrier frequency may be effected.

6. In a signaling system, the combination with a thermionic vacuum tube adapted to demodulate and amplify voltages impressed thereon, of a source of carrier frequency, a source of modulated carrier frequency to be demodulated by the said carrier frequency, an input circuit for impressing voltages of said frequencies upon said vacuum tube, an output circuit, and a reentrant feed-back circuit between said output and input circuit selective to the carrier frequency whereby the regenerative amplification of the said carrier frequency may be effected.

7. In a signaling system, the combination with a low frequency transmission line, of a high frequency transmission line, a four-wire circuit connecting together said transmission lines, a translating circuit having a modulating and amplifying device connected with said four-wire circuit and arranged to have the low frequency and high frequency currents impressed thereon, the said translating circuit having a feed-back connection tuned to a definite frequency whereby currents of that frequency may be reamplified.

8. In a signaling system, the combination with a transmitting circuit, of a receiving circuit, a four-wire circuit connected with said transmitting and receiving circuits and balanced with respect thereto, a translating circuit having amplifying and demodulating means connected therewith, means for impressing currents from said transmitting

and receiving circuits upon said translating circuit, whereby demodulation may be effected, and the said translating circuit having a reentrant feed-back connection between the input and output sides of said amplifying and demodulating means selective to a predetermined frequency, whereby the currents of that frequency may be regeneratively amplified.

In testimony whereof, we have signed our names to this specification this 29th day of September, 1919.

LLOYD ESPENSCHIED.
HERMAN A. AFFEL.