H. A. AFFEL.
COMBINED CARRIER AND RADIO SYSTEM.
APPLICATION FILED SEPT. 30, 1919.

1,353,698. Patented Sept. 21, 1920.

2 SHEETS—SHEET 1.

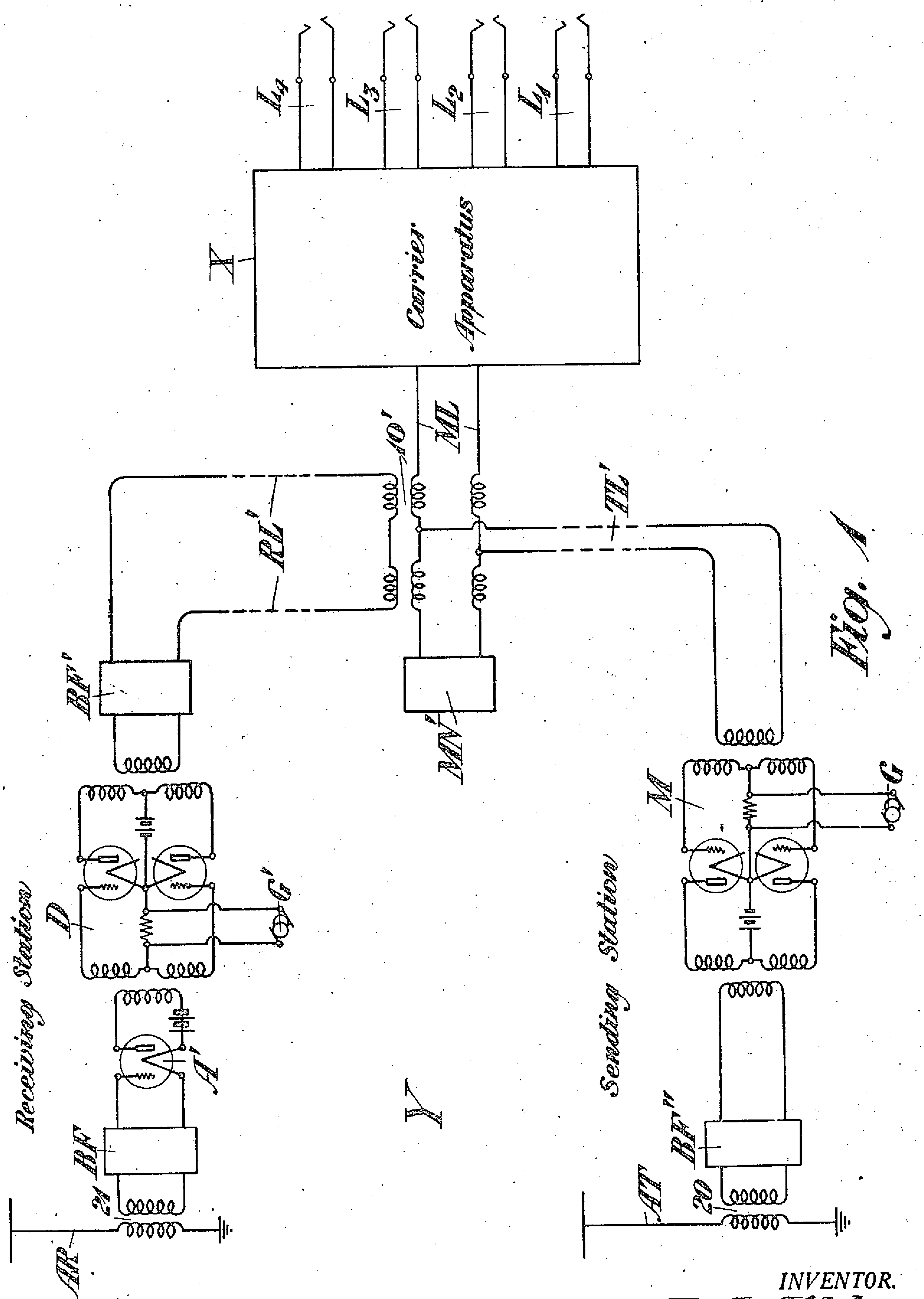

Fig. 1

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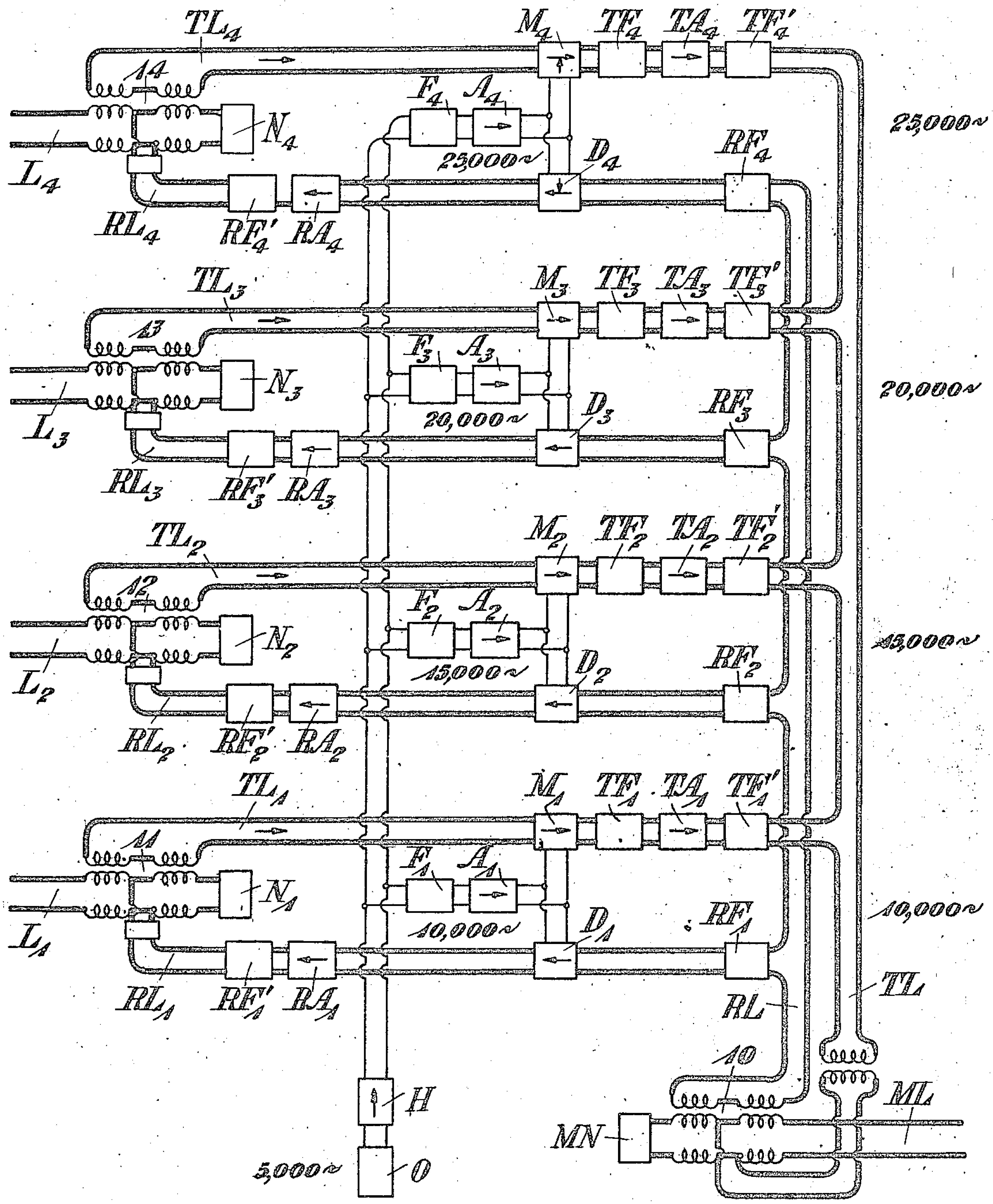

Fig. 2

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H. A. Affel

BY

[signature]

ATTORNEYS.

UNITED STATES PATENT OFFICE.

HERMAN A. AFFEL, OF BROOKLYN, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

COMBINED CARRIER AND RADIO SYSTEM.

1,353,698. Specification of Letters Patent. **Patented Sept. 21, 1920.**

Application filed September 30, 1919. Serial No. 327,458.

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 Combined Carrier and Radio Systems, of which the following is a specification.

This invention relates to a signaling system and more particularly to arrangements for combining a wire carrier system with a radio system.

One of the features of this invention relates to the provision, in a system, in which a plurality of signals may be simultaneously transmitted over a common circuit by means of carrier currents, of means for relating the carrier system to a radio system in such a manner that the carrier frequencies which are ordinarily too low for radio transmission may be stepped up to radio frequency.

Another feature of the invention relates to a signaling system in which low frequency signaling currents are transmitted in a low frequency condition to a station at which they are translated into carrier currents and as such transmitted over a wire line to a radio station, where they are again translated into higher frequencies for radio transmission, the system being also arranged so that the converse frequency translation takes place for transmission in the opposite direction.

The invention may now be more fully understood from the following description when read in connection with the accompanying drawing, Figure 1 of which is a schematic diagram of one embodiment of the invention and Fig. 2 of which is a schematic diagram of the carrier terminal apparatus constituting one of the elements of the invention.

Referring to Fig. 1, ML designates a main carrier transmission line extending from a carrier station at which terminal carrier apparatus X is located, to a radio station Y. At the radio station the line ML is associated through a transformer 10′ with a radio receiving circuit RL′ and with a radio transmitting circuit TL′. An artificial line or network MN′ is provided for balancing the line ML, thereby rendering the circuits TL′ and RL′ substantially conjugate.

The circuit TL′ is associated with the transmitting antenna AT, through a transformer 20 and includes a modulator M and a band filter BF″. The modulator M may be of any well known type, but is illustrated as a duplex vacuum tube modulator of the general type disclosed in the U. S. application of John R. Carson, Serial No. 157,413, dated March 26, 1917. This modulator is supplied with carrier currents of radio frequency from a source G, which may be of any suitable character and is so arranged that normally the carrier frequency is suppressed, but when the band of modulating currents is supplied to the circuit TL′, the carrier frequency from the source G is modulated by the modulator M, so that a double band of frequencies appears in the output circuit of the modulator M. The band filter BF″ is preferably of the general type disclosed in the U. S. patents to George A. Campbell, Nos. 1,227,113 and 1,227,114, issued May 22, 1917. This filter may be so designed as to transmit one of the side bands, preferably the upper, and suppress the other, so that the modulator M, in conjunction with the band filter BF″, operates to step up the band of carrier frequencies supplied to the circuit TL′ to a band of equal width, but of radio frequency.

The receiving circuit RL′ is associated with the receiving antenna AR through a transformer 21 and includes a band filter BF, an amplifier A′, detector D and band filter BF′. The band filter BF is similar to the filter BF″ and is designed to pass a frequency band of the same width, but where, as is usually the case, radio transmission and reception take place at different frequencies, this band will be sufficiently separated from the band transmitted by the filter BF″ to provide for frequency discrimination between oppositely directed transmissions. The amplifier A′ may be of any well known type, but as illustrated is an ordinary vacuum tube amplifier. The detector D is preferably a duplex vacuum tube detector of the type disclosed in the U. S. application of John R. Carson, Serial No. 157,414, dated March 26, 1917. In accordance with the well known principles of homodyne detection, this duplex detector is supplied from the generator G′, with oscillations of the basic radio frequency assigned to the receiving channel, where radio transmission and reception are to take place at different frequencies the frequency supplied to the generator G′ will be different from that supplied to the generator G and will be so chosen that when combined with the band of frequencies transmitted through the filter BF, the band will be stepped down in the same position in the frequency spectrum, as the band transmitted over the main line ML. The filter BF′ is also of the Campbell type and is designed to suppress the upper side band appearing in the output circuit of the demodulator and pass the lower side band which, as above stated, will coincide with the band of carrier frequencies transmitted by the line ML.

The carrier apparatus X is illustrated in more detail in Fig. 2. As indicated, the line ML at the carrier terminal is associated, through a balanced transformer 10, with common transmitting and receiving circuits TL and RL, respectively, which are rendered conjugate with respect to each other by balancing the main line ML with the artificial line MN in a well known manner. A plurality of low frequency signaling lines L_1, L_2, L_3 and L_4 are associated with the transmitting and receiving circuits TL and RL through transmitting channels TL_1, TL_2, etc. and receiving channels RL_1, RL_2, etc. The apparatus associated with the transmitting and receiving channels corresponding to each low frequency line is in general similar and a description of the apparatus in one instance will suffice for all. For example, the transmitting channel TL_4, which is rendered conjugate with respect to the receiving channel RL_4 by means of the usual balanced transformer 14 and artificial line N_4, includes a modulator M_4, band filter TF_4, amplifier TA_4 and band filter TF'_4.

The modulator M_4 will be similar to the modulator M of Fig. 1 and is supplied with carrier currents of the basic frequency assigned to this channel which, for purposes of illustration, is indicated as being 25,000 cycles. The filter TF_4 in the output circuit of the modulator M_4 is a band filter of the Campbell type, adapted to transmit carrier frequencies, but suppresses low frequency components. The amplifier TA_4 may be an amplifier of any type, but is preferably a vacuum tube amplifier. The band filter TF'_4 is of the Campbell type and is so designed as to transmit one of the side bands resulting from the modulator of the carrier frequency by low frequency signaling currents while suppressing the other.

The receiving channel RL_4 includes a filter RF_4, a detector D_4, an amplifier RA_4 and a filter RF'_4. The band filter RF_4 is similar to the band filter TF'_4 and may be arranged to transmit the same band of frequencies. The demodulator D_4 is preferably of the same type as the demodulator D of Fig. 1 and is supplied with homodyne currents of the carrier frequency assigned to the channel, which, as above stated, may be 25,000 cycles. The amplifier RA_4 may be any type of amplifier, but is preferably a vacuum tube amplifier. The filter RF'_4 may be a so-called low pass filter of the Campbell type and is designed to transmit a band of frequencies extending from zero up to the upper frequency employed in low frequency signaling. If the signaling currents to be transmitted are voice currents, the upper limit of this filter may be in the neighborhood of 2,000 cycles.

Similar apparatus is associated with the transmitting and receiving channels of the other low frequency lines, the only essential difference being that the frequencies assigned to the channels are different. In the case indicated, the frequency 20,000 cycles is assigned to the channels associated with the line L_3, 15,000 cycles to the channels associated with the line L_2 and 10,000 cycles assigned to the channels associated with the line L_1.

In order to produce these carrier frequencies a basic frequency may be generated by means of any suitable generator such as a vacuum tube oscillator O. The basic frequency generated is, for purposes of illustration, indicated as above 5,000 cycles. A harmonic producer H, which may be a distorting tube arrangement of the character disclosed in the U. S. application of B. W. Kendall, Serial No. 139,530, filed December 29, 1916, is provided for the purpose of producing harmonics of the fundamental frequency. The second, third, fourth and fifth harmonics are indicated as being supplied through filtering circuits F_1, F_2, F_3 and F_4, respectively, to amplifiers A_1, A_2, A_3 and A_4. These filtering circuits may be either Campbell filters or ordinary tuned circuits, but are preferably the latter. The harmonics, after being amplified to the desired value, are then supplied to the modulators and demodulators of the transmitting and receiving channels.

Further details of the apparatus may be understood from a description of the operation which is as follows: Low frequency signals incoming from the lines L_1, L_2, L_3 and L_4 are transmitted by the transmitting channels TL_1, TL_2, TL_3 and TL_4 and impressed upon the modulators M_1, M_2, M_3 and M_4. The modulated carrier currents are then passed through the filters TF_1, TF_2, F_3 and TF_4, amplified by the amplifiers TA_1, TA_2, TA_3 and TA_4 and then passed through the filters TF'_1, TF'_2, TF'_3 and TF'_4. These filters suppress one of the side bands in each channel, for instance, the upper side band, and transmit the other, so that the four bands are impressed upon the common transmission circuit TL and transmitted through the transformer 10 to the main line ML. These carrier frequencies, upon arriving at the radio station, are transmitted to the circuit TL′ and modulate the radio frequency supplied to the modulator M, thereby producing two side bands of radio frequency in the output circuit of said modulator. The band filter BF″ suppresses the lower side band and transmits the upper, which is then radiated by the antenna AT.

A band of radio frequencies received by the antenna AR is passed through the band filter BF and amplified by the amplifier A′. The amplified band is then impressed upon the demodulator D and upon beating with the radio frequency supplied by the source G′ appears in the output circuit of the detector D as two side bands, one stepped up with respect to the band received by the antenna and one stepped down in frequency with respect to said band. The band filter BF′ suppresses the upper band and transmits the lower side band, which is then transmitted through the transformer 10′ to the main line ML. After being transmitted over said main line, the received carrier frequencies are transmitted through the transformer 10 into the common receiving circuit RL and are selected by the filters RF_1, RF_2, etc. into the corresponding receiving channels. The received modulated frequencies are then impressed upon the detectors D_1, D_2, D_3 and D_4 and by the homodyne action of the detectors the low frequency signals in accordance with which the radio frequencies were modulated at the distant transmitting station, appear in the output circuits of the detectors. These low frequency currents are amplified by the amplifiers RA_1, RA_2, RA_3 and RA_4 and after being passed through the filters RF'_1, RF'_2, etc. are transmitted to the lines L_1, L_2, L_3 and L_4, respectively.

It will be understood that the frequencies referred to in the preceding description and indicated on the drawing are merely illustrative and that in practice other frequencies may be used, as conditions may require. It will also be obvious that 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 I claim is:

1. In a signaling system, a plurality of low frequency signaling lines incoming to a carrier station, means at said carrier station for translating signals from said lines into carrier currents, a carrier transmission line upon which said translated signals may be superposed, said carrier line extending from said carrier station to a radio station, and means at said radio station for translating said carrier frequencies into radio frequencies for radiation to a distant radio receiving station.

2. In a signaling system, a low frequency transmission line, a carrier transmission line, means for translating signals transmitted over said low frequency line into carrier frequencies for transmission over said carrier transmission line, and means associated with said carrier line for translating said carrier frequencies into radio frequencies for radiation to a distant radio receiving station.

3. In a signaling system, a radio receiving station, a carrier transmission line extending from said radio receiving station to a carrier station, means at said radio station to translate radio frequencies into carrier frequencies for transmission over said carrier line to said carrier station, a plurality of low frequency signaling lines incoming to said carrier station, and means at said station for translating the carrier frequencies transmitted over said carrier line into low frequency signals for transmission to said low frequency lines.

4. In a signaling system, a radio receiving station, means at said station to translate radio frequencies into carrier frequencies, a carrier transmission line extending from said radio receiving station to a distant carrier station for transmitting said carrier frequencies to said carrier station, and means at said carrier station to translate said carrier frequencies into low frequency signaling currents.

In testimony whereof, I have signed my name to this specification this 29th day of September 1919.

HERMAN A. AFFEL.