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L. ESPENSCHIED

HIGH FREQUENCY SIGNALING SYSTEM

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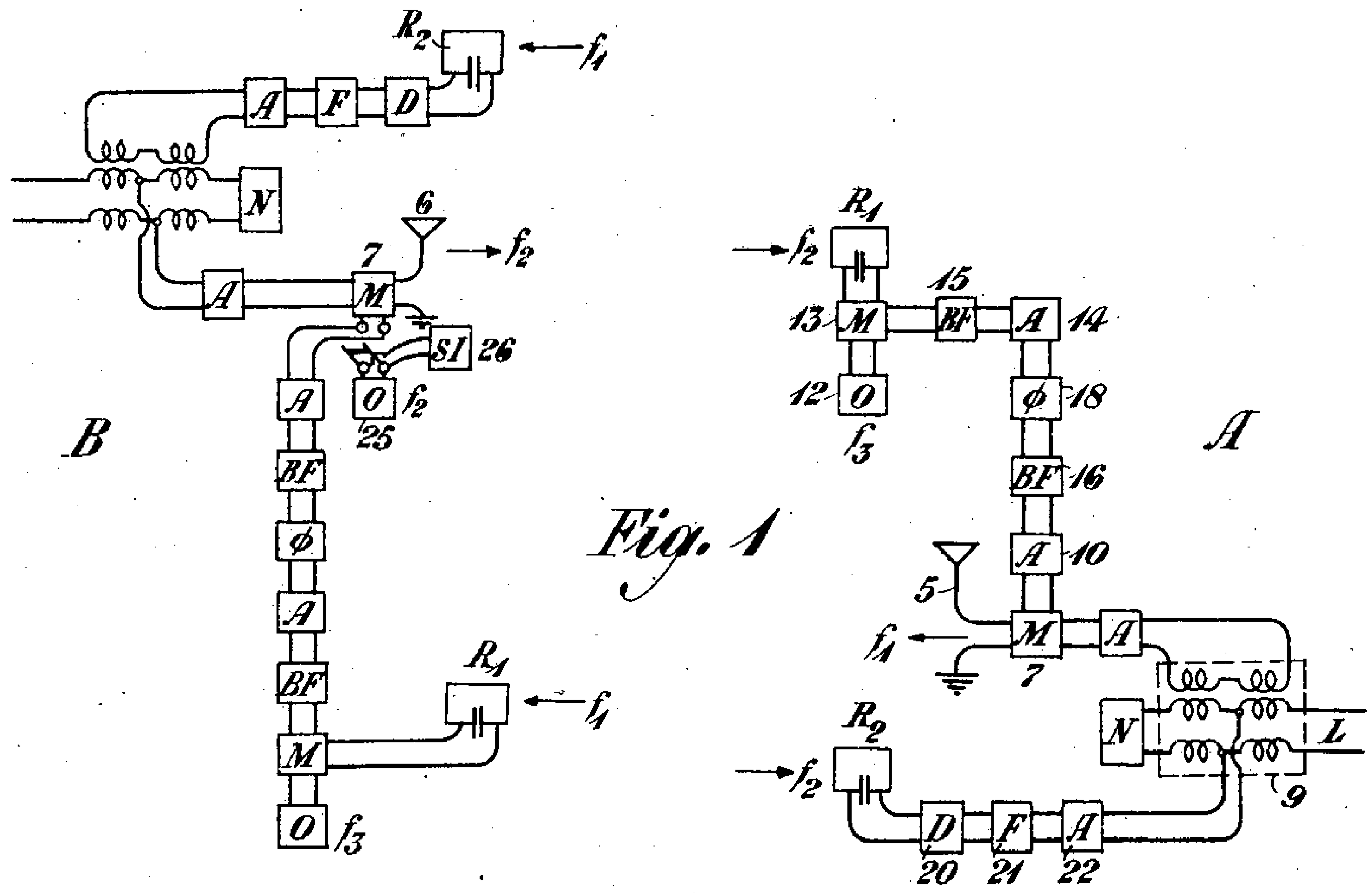

Fig. 1

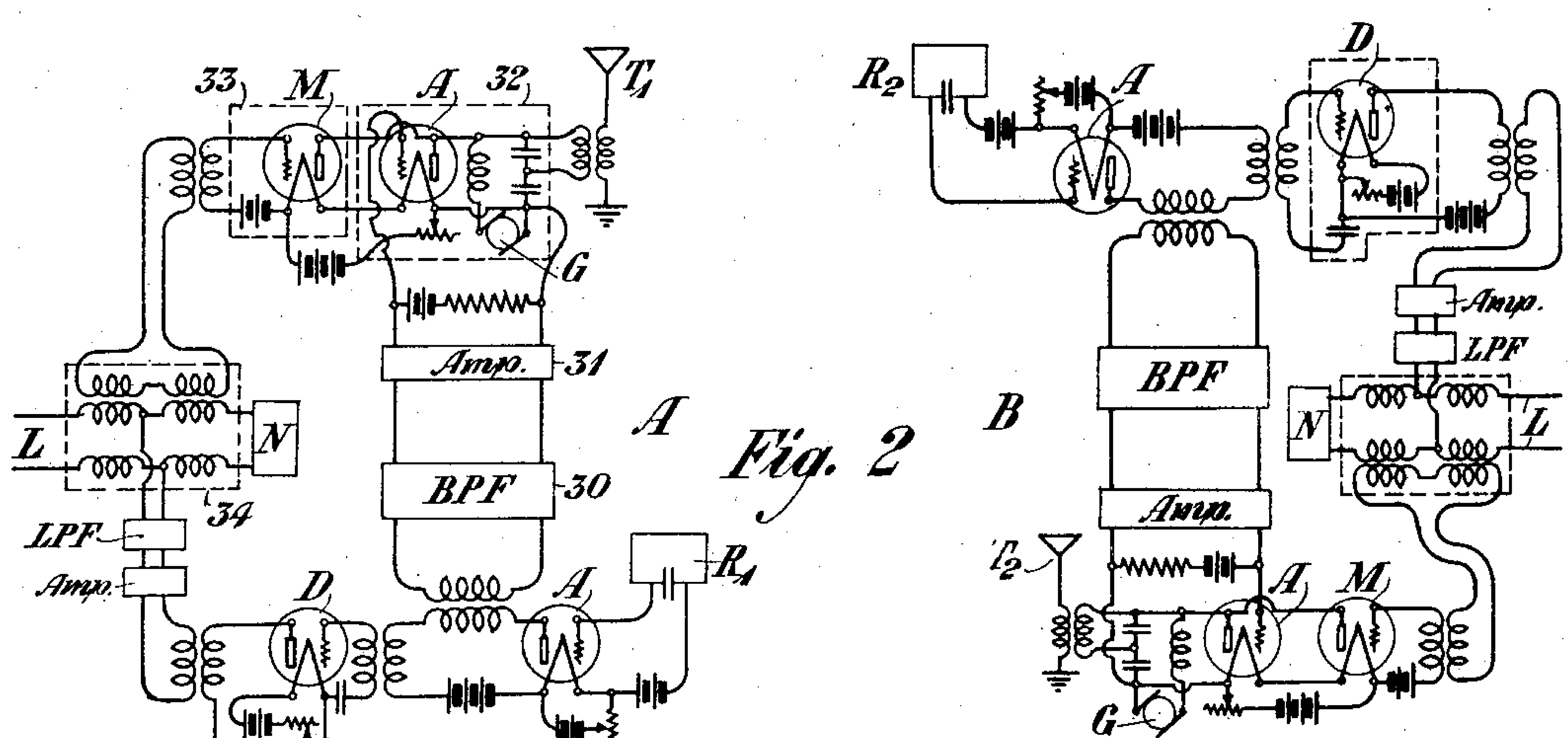

Fig. 2

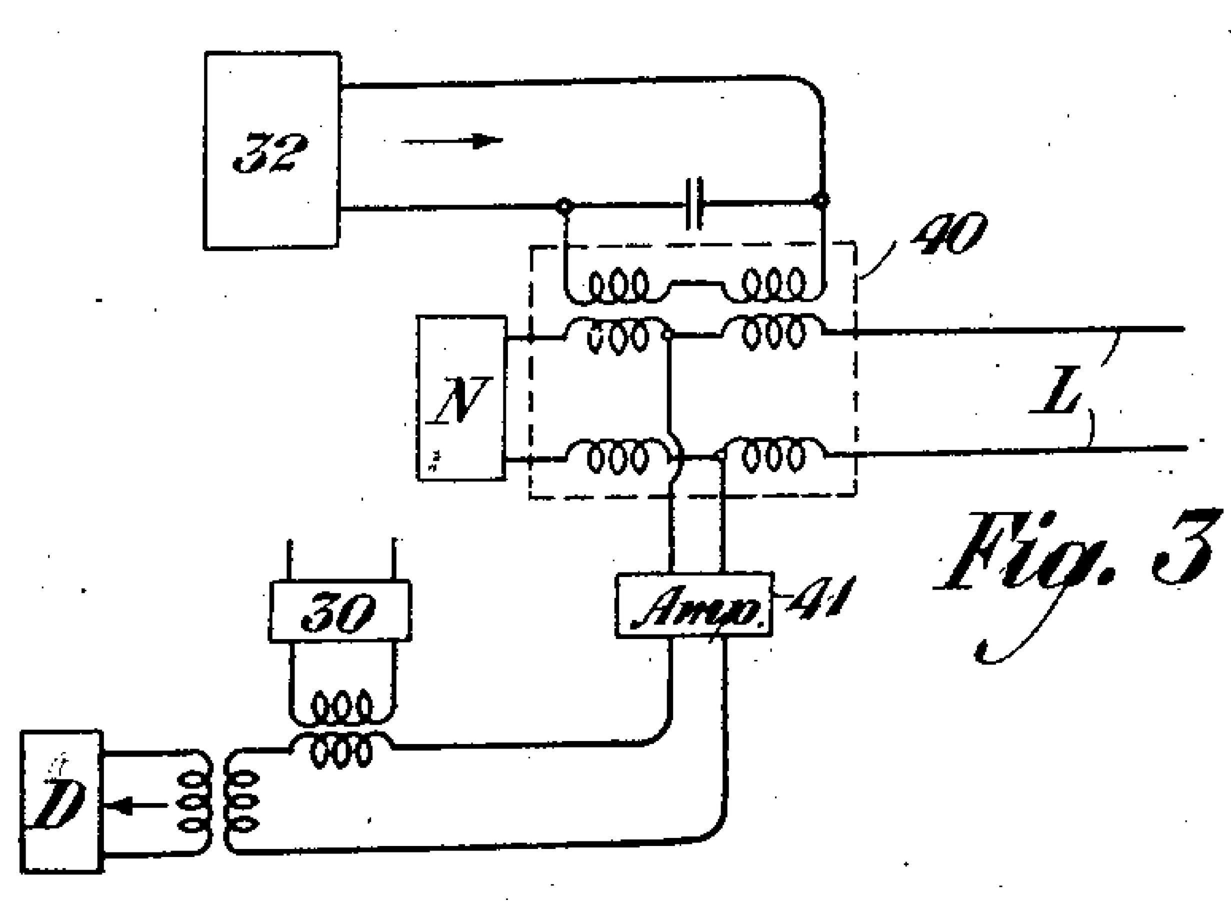

Fig. 3

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UNITED STATES PATENT OFFICE.

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HIGH-FREQUENCY SIGNALING SYSTEM.

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This invention relates to high frequency signaling and especially to a method and means for effecting high frequency carrier transmission by wire or radio, which is characterized by the manner in which the carrier current is derived. Instead of being generated locally and independently at the transmitting station, these oscillations are set up as the result of high frequency singing around the complete circuit including transmitter and receiver.

Briefly, the invention consists in the use of carrier oscillations received at one station from the remote station to control the generation of carrier oscillations at the first station, these latter to be picked up at the remote station to control the generation of carrier oscillations at that station. The system is adapted for signaling in the two directions on the same frequency or on different frequencies, as will appear later.

Reference may be had to the accompanying drawings in which Fig. 1 is a circuit illustrating the application of this invention to radio signaling; Fig. 2 is a modification of the circuit of Fig. 1; and Fig. 3 is a detail of part of the circuit in case it is to be applied to wire signaling.

Referring more particularly to Fig. 1, there is shown a complete signaling system comprising the necessary equipment at two stations, A and B. At the station A there is a radiating antenna 5 adapted to transmit modulated carrier oscillations of frequency f_1, the oscillations for this transmission being obtained from the output circuit of an amplifier modulator 7. To obtain such modulated high frequencies, it is necessary to supply the message which is to be transmitted and also the high frequency oscillations which are to act as the carrier. The first of these comes over the line L through the standard hybrid coil 9 used for duplex telephony, the incoming speech message being impressed on the modulator 7. At the same time there is impressed on this modulator high frequency carrier oscillations from an amplifier 10.

One of the main features of my invention consists in the manner in which oscillations are obtained for the amplifier 10. The method consists in receiving on an antenna, which, in this case, I have shown as a loop antenna R_1, oscillations of carrier freqency f_2 from the station B and using these received signals to control the generation of the necessary high frequency oscillations for the transmitter 5. In this case the received oscillations of carrier frequency f_2 are combined with locally generated oscillations of frequency f_3 from the oscillator 12 in the modulating device 13. In accordance with the well known property of a modulating device, there will appear in the output of the modulator 13 frequencies equal to the sum and to the difference of the oscillations f_3 and f_2. One of these oscillations, such, for example, as f_2+f_3 is then amplified by the amplifiers 14 and 10 to as great an extent as is necessary, being then used as the primary source of oscillations for the modulator 7.

The signals received on the antenna R_1 are, in general, modulated with the message to be received at that station, and, in addition to the carrier frequency f_2 there will, in general, be present the side bands $f_2 \pm s_2$, where s_2 represents the audiofrequency of the message to be received. It is important, of course, to eliminate these side frequencies, and I therefore insert filters 15 and 16, preferably of the band-passing type, which are so adjusted as to permit the passage of the carrier frequency f_2, but to eliminate all other frequencies. Obviously, instead of using wave filters such as shown, it would be feasible to substitute sharply tuned circuits which are responsive to substantially one frequency only. At times it will also be convenient to shift the phase of the high frequency oscillations impressed on the modulator 7, and for this purpose it is convenient to introduce a phase-shifting device 18.

The generating apparatus at the station B is identically the same, except that the difference between the received and the locally generated oscillations is used rather than the summation frequency, it being understood that the local generator at the station B is held to the same frequency f_3 as the local generator at the station A. Thus when oscillations have been initiated at the station A, radiating at the frequency f_1, these will be received on the receiver R_1 at the station B and combined with the local oscillations to yield a frequency f_1-f_3, which may be given the designation f_2. After suitable filtering and amplification, this derived frequency is radiated from the station B and received at R_1

of station A. There it is combined with the locally generated oscillations f_3, yielding f_2+f_3, which, it will be noted, is equal to f_1, the frequency radiated from station A. Thus a complete cycle is set up, tending, under suitable conditions, to maintain itself.

For the purposes of receiving the signal message, I have shown in Fig. 1 at station A a second antenna R_2 of the loop type, which will also pick up the signal from the station B, whose carrier frequency is f_2. This signal may be treated in the usual manner to yield the signal message, such for example, as being impressed on a detector 20, passed through a suitable filter 21 and amplified in the device 22, whereupon it may be impressed on the hybrid coil 9 for transmission over the line L. A corresponding arrangement for reception is shown at station B.

To initiate the generation of oscillations, it is necessary to send out a train of waves from the one station or the other. For this purpose, I may resort to a shock excitation of one station or the other, but if this is not sufficient, I may use at either or both stations a small generator of suitable carrier frequency. At station B, for example, this would comprise a local generator of oscillations 25 of frequency f_2, which may be of sufficient amplitude so that when connected to the modulator 7 of station B full amplitude oscillations will build up for radiation from the antenna 6. Having started the system in operation, however, this oscillator may then be dissociated. It will be important, of course, in this connection to have the oscillations derived from the receiver in phase with the oscillations from the generator 25, and for this purpose it will be convenient to use the phase-shifting device 18 mentioned above. Also to indicate that synchronism has been obtained, it will be desirable to have some synchronizing indicating instrument associated with the system, such, for example, as 26, shown at station B.

It is apparent that suitable precautions must be used to prevent the singing of one station on itself, that is, oscillations picked up at R_1 of station A from its own radiating antenna 5 must be sufficiently small in intensity, so that oscillations of the corresponding frequency are not set up thereby. To this end, a number of expedients may be used. One obvious expedient is to have the antenna R_1 fairly well removed from the antenna 5, and also to have it of such a form as to be strongly directional. It should then be so orientated as to show least sensitivity to its own radiating antenna. This is readily accomplished in the case of the loop antenna by placing the plane of the loop at right angles to the radial line from the antenna 5 to the loop. At the same time the loop may be so located as to show maximum sensitivity to the waves from the remote station. The effect of the transmitter upon its own receiver is also reduced in the case illustrated by virtue of frequency selection, as well as directional selection, the transmitting and receiving frequencies being materially different. The necessary condition is that the gain through the radio circuits, consisting of the receiver amplifier 14 and the transmitter power amplifier 10, shall be greater than the loss between the transmitter 6 of station B and the receiver R_1 of station A. Also the loss between the transmitter 5 of station A and the receiver R_1 of that station shall be greater than the gain of the amplifiers 14 and 10. The same conditions apply to each terminal.

In the figure thus described, transmission takes place in one direction on one frequency and in the other direction on a different frequency. The system may be devised to transmit in both directions on one frequency. Referring to Fig. 2, station A is shown as comprising the radiating antenna T_1 and the receiving antenna R_1, which latter is preferably of the loop antenna type or other highly directional form of antenna. At the station B there is a corresponding radiating antenna T_2 and receiving antenna R_2. Oscillations of carrier frequency f from the antenna T_2 are picked up at the station A by the antenna R_1. A portion of the energy is transmitted to a detector D from whence, after suitable amplification and filtration, the detected message is transmitted over the line L. A portion of the energy received on the antenna R_1 is sent through a different channel, comprising a band filter 30, which permits the passage of the carrier frequency only, eliminating, in particular, the side bands of the received wave. After suitable amplification in 31, the oscillations are impressed on the grid of a power amplifying system 32, of a form now well known in the art, and comprising a vacuum tube amplifier with suitable source of power G. The power delivered by this amplifier 32 to the radiating antenna T_1 may be controlled in accordance with the message to be transmitted by means of a modulator 33, which receives the signal in the usual way from the line L through the hybrid coil 34.

The station B is identical to the station A, and, as a result, each station is adapted to generate oscillations of the carrier frequency, the generation of these oscillations being controlled by the reception of oscillations of this same frequency from the remote station.

Here, also, it is important that the generation of oscillations shall not be controlled by the radiation from one antenna, being picked up by the receiver of the same station. In other words, the condition must be fulfilled that the gain through the radio circuits, consisting of the amplifiers 31 and 32 of station A, shall be greater than the loss between the transmitter T_2 and the receiver R_1. Also, the loss between the transmitter T_1 and the receiver R_1 shall be greater than the gain from the amplifiers 31 and 32.

While I have described the invention as relating especially to radio signaling, it is, of course, apparent that it is equally well adapted for high frequency signaling on wires. Fig. 3 shows one method for associating the apparatus of one station with the transmission line in order to obtain the desired results. For example, the power to be transmitted and coming from that portion of the apparatus corresponding to 32 of Fig. 2 is impressed on a balanced hybrid coil 40, which has associated with it the balancing network N and the line L. To the conjugate points of the coil 40 is connected the receiving apparatus, comprising, if desired, an amplifier 41, the circuit then leading to the detector D, as shown in Fig. 2, and to the filter 30 of the same figure, the portion of the energy passing through the filter 30 being used to control the power transmitted through the circuit 32. Since the coil 40 is balanced, power coming from the circuit 32 produces no effect on the amplifier 41 and its associated apparatus. On the other hand, the high frequency signal coming from the line L is transferred, through the amplifier 41, to its associated apparatus, whereupon it performs the same functions as described in connection with Fig. 2.

Many variations may be made in the circuit, which are shown for illustrative purposes only. For example, in Fig. 2 I have shown at each station one receiving antenna only, whereas in Fig. 1 two such antennæ are shown, one to pick up the energy for the interpretation of the message and the other for the control. Obviously, in Fig. 1, these two antennæ could be combined into one, as in Fig. 2, and, on the other hand, if desired, two separate receiving antennæ may be used in Fig. 2.

What is claimed is:

1. In a high frequency signaling system involving a pair of intercommunicating stations, each having a receiver and a transmitter but including no means for independently generating carrier oscillations, the method of deriving carrier currents for duplex signaling, which consists in setting up a singing condition between the two stations, whereby carrier oscillations are automatically emitted from each station, modulating the oscillations at each station with the message to be transmitted and detecting these at the other station.

2. In a high frequency signaling system, the method of deriving carrier currents for duplex signaling, which consists in receiving signals from one station on a carrier frequency, combining with said carrier frequency a locally generated frequency to yield a sum and difference frequency controlled by the received frequency, amplifying one of the controlled frequencies and transmitting it back to the other station.

3. In a high frequency signaling system, the method of deriving carrier currents for duplex signaling, which consists in receiving signals from one station on a carrier frequency, combining with said carrier frequency a locally generated frequency to form a sum and a difference frequency, amplifying one of these, modulating it and transmitting it back to the other station.

4. In a high frequency signaling system, a pair of intercommunicating stations each comprising a circuit for receiving modulated carrier oscillations from the other station, a circuit for receiving a portion of said oscillations and adapted to suppress all but the carrier frequency of the received oscillations, and means whereby said carrier frequency is caused to control the generation of oscillations for transmission in the reverse direction to the other station.

5. In a high frequency signaling system, a pair of intercommunicating stations each comprising a circuit for receiving modulated carrier oscillations from the other station a circuit for receiving a portion of said oscillations, a wave filter associated therewith for suppressing all but the carrier frequency of the received oscillations, and means whereby said carrier frequency is caused to control the generation of oscillations for transmission in the reverse direction to the other station.

6. In a high frequency signaling system, a pair of intercommunicating stations each comprising a receiving circuit and a generator of oscillations, means for causing oscillations received from the other station to control the generation by said generator of oscillations for transmission in the reverse direction to the other station, and a second circuit for receiving a portion of the incoming oscillations and means in said second circuit to detect them to the signaling frequency.

7. In a high frequency signaling system, a circuit for receiving modulated high frequency oscillations from a remote station, a local generator of oscillations, means for combining the received and the locally generated oscillations to a sum and a difference frequency controlled by the received frequency, means for amplifying one of these and transmitting it back to the other station.

8. In a high frequency signaling system, a circuit for receiving modulated high frequency modulated carrier oscillations from a remote station, a circuit for receiving a portion of said oscillations, means for filter-

ing out therefrom all but the carrier frequency, a local generator of oscillations, means for combining the received and locally generated oscillations to a sum and a difference frequency controlled by the received frequency, means for amplifying one of these and transmitting it back to the other station, a second circuit for receiving another portion of the received oscillations and adapted to detect them to the signaling frequency.

9. In a high frequency signaling system involving a pair of intercommunicating stations, each having a receiver and a transmitter but including no means for independently generating carrier oscillations, the method of deriving carrier currents for duplex signaling which consists in setting up a singing condition between the two stations whereby carrier oscillations are automatically emitted from each station.

10. In a high frequency signaling system involving a pair of intercommunicating stations each having a receiver and a transmitter but including no means for independently generating carrier oscillations, the method of deriving carrier currents for duplex signaling, which consists in producing a condition such that the loss in transmission from the transmitter of one station to the receiver of the other will be less than the gain in transmission from the receiver of one station to the transmitter of the same station whereby carrier oscillations are automatically emitted from each station.

11. In a high frequency signaling system involving a pair of intercommunicating stations each having a receiver and a transmitter but including no means for independently generating carrier oscillations, the method of deriving carrier currents for duplex signaling, which consists in producing a condition such that the loss in transmission from the transmitter of one station to the receiver of the other will be less than the gain in transmission from the receiver of one station to the transmitter of the same station and the loss in transmission from the transmitter of a station to the receiver at that station will be greater than the gain in transmission from the receiver to the transmitter whereby carrier oscillations are automatically emitted from each station without causing singing between the transmitter and receiver of each station.

12. In a high frequency signaling system, a pair of intercommunicating stations each comprising a receiver and a transmitter but including no means for independently generating carrier oscillations, a circuit at each station for transmitting currents received by the receiver to the transmitter and amplifying means in said circuit, the transmission conditions of the system being so adjusted that the loss in transmission from the transmitter of one station to the receiver of the other will be less than the gain in transmission from the receiver to the transmitter of a given station whereby carrier oscillations will be automatically emitted from each station.

13. In a high frequency signaling system, a pair of intercommunicating stations each comprising a receiver and a transmitter but including no means for independently generating carrier oscillations, a circuit at each station for transmitting currents received by the receiver to the transmitter and amplifying means in said circuit, the transmission conditions of the system being so adjusted that the loss in transmission from the transmitter of one station to the receiver of the other will be less than the gain in transmission from the receiver to the transmitter of a given station, while the loss in transmission from the transmitter to the receiver of a given station will be greater than the gain from the receiver to the transmitter whereby carrier oscillations will be automatically emitted from each station without producing singing between the transmitter and receiver of each station.

14. In a high frequency signaling system, a pair of transmitting stations, each station including separate transmitting and receiving antennæ, local circuits for connecting the receiving antenna of each station to the transmitting antenna thereof, said local circuits and antennæ being incapable of independently generating oscillations, means to set up a singing condition between the two stations over a path from the transmitting antenna of one station to the receiving antenna of the other station, from the receiving antenna of the other station to the local transmitting antenna thereat, from said local transmitting antenna to the receiving antenna of the first station, and from the receiving antenna at the first station to the transmitting antenna thereat, means to modulate, in accordance with signals, the oscillations transmitted from the transmitting antenna at one station to the receiving antenna at the other station as the result of said singing condition, and means at each station to detect the signals so transmitted.

In testimony whereof, I have signed my name to this specification this 14th day of August, 1922.

LLOYD ESPENSCHIED.