July 24, 1928. 1,677,967

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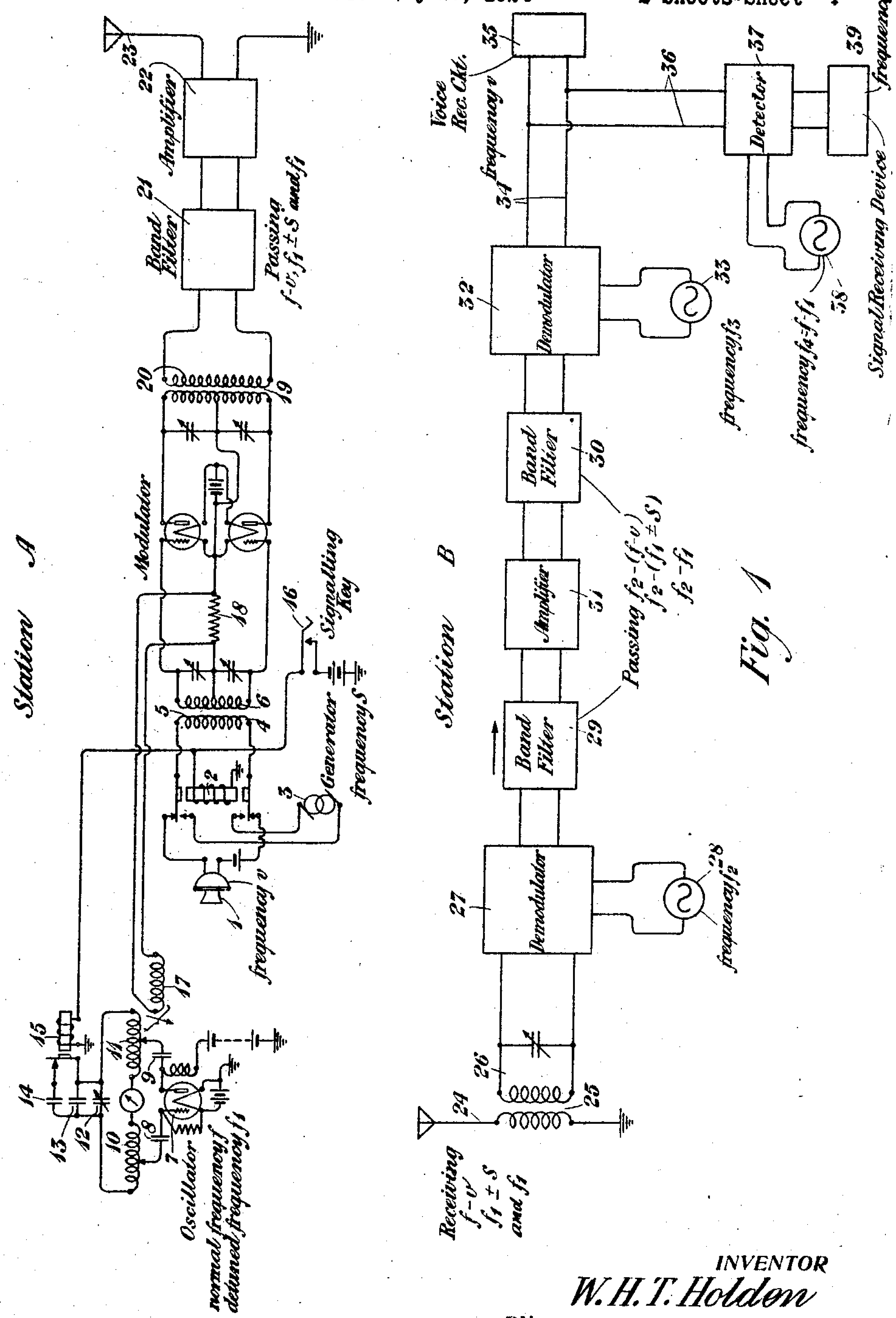
RADIO SIGNALING SYSTEM

Filed May 29, 1924 2 Sheets-Sheet 1



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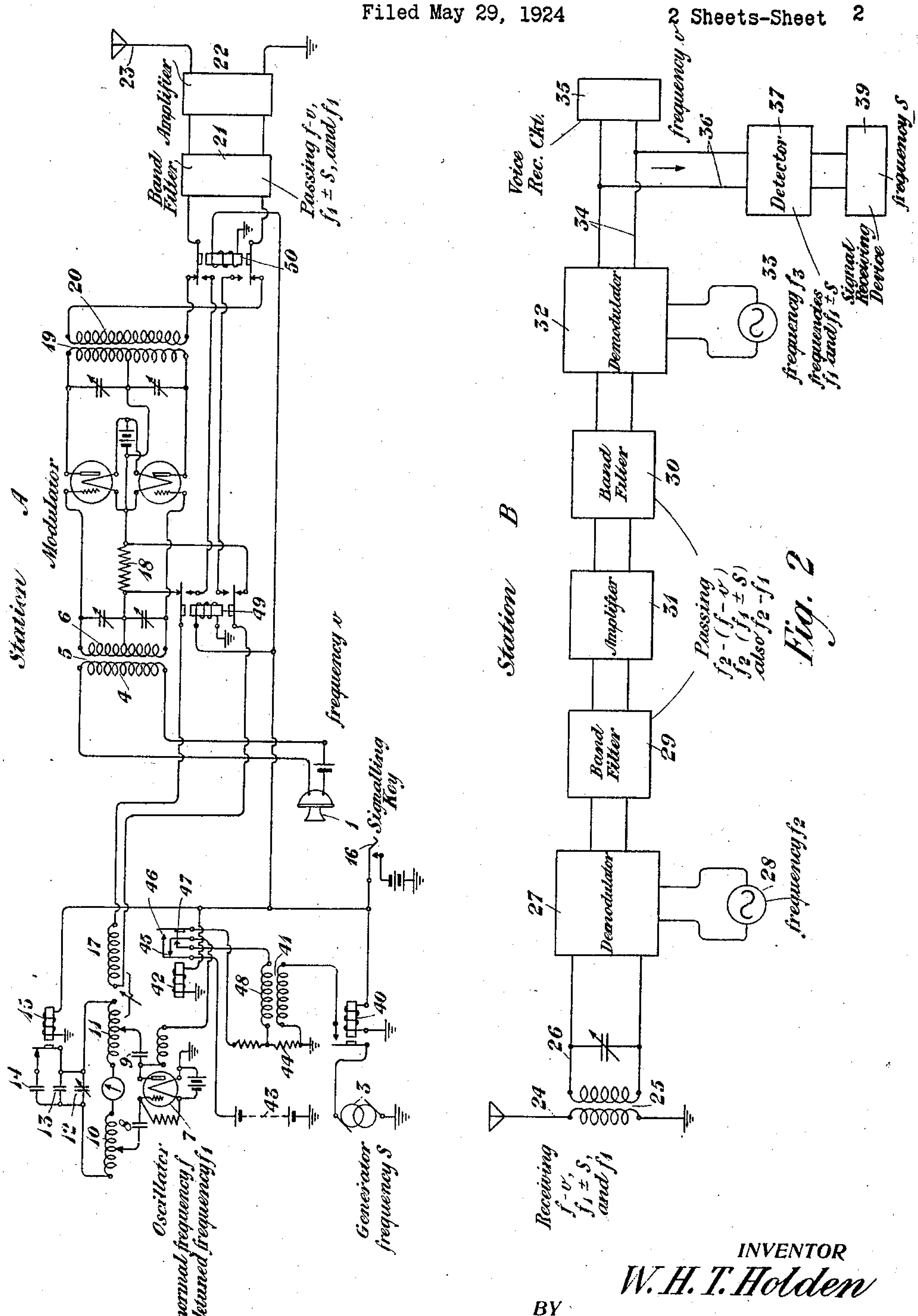

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Patented July 24, 1928. 1,677,967

UNITED STATES PATENT OFFICE.

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RADIO SIGNALING SYSTEM.

Application filed May 29, 1924. Serial No. 716,793.

This invention relates to radio signaling systems, and particularly to a method and means for transmitting a calling signal between the stations of such a system.

In a radio telephone system as in a wire telephone system having a plurality of stations, it is desirable that a subscriber shall be able to call another subscriber to his telephone, or to have the other subscriber called by an operator in order that the subscribers may talk with each other. The present invention is concerned with the transmission of such calling signals between stations of a radio telephone system. In the co-pending application of Demarest and Almquist, Serial No. 646,903, filed June 21, 1923, there is disclosed a method and means for transmitting a calling signal from one station, receiving the signal at another station and actuating a calling signal at the latter station. The method therein disclosed consists in modulating a carrier frequency with a low frequency of the order of 135 cycles and in transmitting the carrier and both its side bands to the distant receiving station. Since the same carrier frequency is used not only for signaling but also for transmitting the voice signals of the radio telephone system, difficulty may be experienced in transmitting the calling signal if the system is designed for transmitting a single side-band of frequencies, as for example, the carrier modulated by the voice frequency. The inherent difficulty will be apparent from the following illustration: assuming a carrier frequency of 50,000 cycles and that the voice frequencies range between 200 and 2,000 cycles, the product of modulation of these frequencies will be two bands, one ranging from 50,200 to 52,000 cycles and the other ranging from 48,000 to 49,800 cycles, and the unmodulated carrier of 50,000 cycles. If the filters of the system are adjusted to transmit, for example, only the frequencies within the lower side band, all of the frequencies above 49,800 cycles would be either entirely or substantially suppressed. It will be seen, therefore, that if we modulate the carrier frequency of 50,000 by 135-cycle current for the purpose of calling distant stations, the frequencies therein represented namely 50,135, 50,000 and 49,865 would fall within that part of the frequency spectrum which is substantially suppressed by the range of the filter at the transmitting station. That is to say, since the signaling frequencies are above 49,800, such signals could not be transmitted and received with any degree of accuracy or satisfaction.

It is the object of this invention to provide a method and means for avoiding such difficulty in signaling in a system employing single side band transmission as described above.

This invention will be clearly understood from the following description, when read in connection with the attached drawing, of which Figure 1 shows the invention in its simplest form, and Fig. 2 shows a preferred modification of the invention.

In Fig. 1 there is shown at the top a transmitting circuit at station A and at the bottom a receiving circuit at station B. It is to be understood that station B may also have a transmitting circuit such as that shown at station A, and similarly, station A may have a receiving circuit such as that shown at station B. The transmitting circuit at station A is designed and intended for the transmission of a calling signal and also of voice modulated waves. In the figure, the transmitter 1 represents symbolically any form of voice transmitting device, the frequency of which will be designated v. The transmitter is connected with the outer contacts of the relay 2. The inner contacts of this relay are connected with a source of current, preferably of relatively low frequency. This frequency, which will be designated s, is intended to modulate a carrier frequency f_1 and serves to operate the signal receiving apparatus at the distant called station. The armatures of relay 2 are connected with the primary winding 4 of the transformer 5, the secondary winding 6 of which is connected with the modulator. This modulator is preferably of the type shown in the patent to Carson, No. 1,449,382, dated March 27, 1923, which is characterized by the suppression of the carrier frequency. The source of carrier frequencies for signals and speech is the oscillator represented schematically at the left-hand side of the drawing, comprising a vacuum tube 7, a plurality of stopping condensers 8 and 9, inductances 10 and 11, and tuning condensers 12, 13 and 14, which, when taken together with the inductances, serve to control the frequency of oscillation. The frequency of the circuit including condensers 12, 13 and 14 will be designated f. A relay 15, controlled by the signaling key 16, which also controls the operation of relay 2, serves to disconnect the condenser 14 from the oscillatory circuit and to cause a different frequency f_1 to be produced by the oscillator. The oscillatory circuit is coupled with the winding 17 of the output circuit, which is connected across the impedance 18 of the modulator. As described in the said patent to Carson, this carrier frequency, by virtue of the manner in which it is applied to the modulator, will be suppressed at all times. The output side of the modulator is connected by transformer 19 with the output circuit containing a band filter 21 (which, for illustration, is assumed to pass the band $f-v$), and an amplifier 22, the output side of which is connected with the antenna 23.

The receiving circuit at station B is of the type involving double detection of the received signal, which, as is well known, is more highly selective than other types of receiving circuits. However, it is to be understood that double detection is not necessary, and consequently any of the similar well known types may be used. The receiving circuit at station B comprises the antenna 24 coupled by the transformer 25 with a tuned receiving circuit 26, the tuning of which is broad enough to receive the band of frequencies $f-v$ transmitted from station A. This tuned circuit is connected with the input side of the demodulator 27 having a source of current 28 of frequency f_2 connected therewith. 29 and 30 are filters adapted to pass a band of predetermined width as that represented by $f_2-(f-v)$, and to impress it upon the amplifier 31. 32 is a demodulator having a source of modulating current 33 of the frequency f_3 connected therewith. The output side of the demodulator is connected by conductors 34 either with the voice frequency receiving circuit 35 or with a signal receiving circuit 36, the latter of which comprises a detecting device 37 having connected therewith a source 38 of beat frequency f_4 which equals $f-f_1$. The output side of the detector 37 is connected with signal receiving apparatus 39 responsive to the signaling frequency s, which for the purpose of illustration, will be assumed to be 135 cycles.

The nature of the invention will be better understood if first the method of transmitting voice signals is described, and then the transmission of signals, although this is contrary to the usual sequence of operation. Let us assume that the subscriber at station A is talking with a subscriber at station B. Current of the voice frequencies ranging from 200 to 2,000 cycles created by the transmitter 1 will be impressed by the transformer 5 upon the input side of the modulator. Simultaneous with the impression thereon of the voice frequency v, there will also be impressed thereon oscillations of the carrier frequency f created by the oscillator, which will be assumed to be of the order of 50,000 cycles. This frequency will be determined by the magnitudes of the inductances 10 and 11 and of the condensers 12, 13 and 14. The voice frequencies will modulate the carrier frequency and the currents impressed upon the windings of transformer 19, will, in turn, be impressed upon the input of the band filter 21. These currents will contain the frequencies present in two side bands $f-v$ and $f+v$, that is to say, one side band represents 48,000 to 49,800 cycles and the other 50,200 to 52,000 cycles. If the band filter 21 is adjusted to transmit only the lower side band, $f-v$, it will transmit the frequencies ranging from 48,000 to 49,800 cycles, and will suppress other frequencies. The current of the lower side band will be amplified by 22 and radiated by the antenna 23. The transmitted wave containing these frequencies will be received by the antenna 24 at station B and since the frequencies are within the range $f-v$ for which the circuit 26 is adjusted, the current will be impressed upon the demodulator 27 and will therein be beaten with current of the frequency f_2 which will be assumed to be 20,000 cycles. One of the resulting side bands $f_2\pm(f-v)$, namely that containing the range of frequencies, 28,000 to 29,800 cycles, will be selected by the filter 29. The resultant current will be amplified by 31 and further selected by the filter 30. This side band will again be beaten in the demodulator 32 with current of the frequency f_3, assumed to be 30,000 cycles produced by the oscillator 33 and the resultant frequency viz., 200 to 2,000 cycles will be impressed upon the circuit 34 and will be heard by the subscriber at the voice receiving apparatus 35.

Having in mind how the system works during the transmission of a single side band $f-v$ representing the modulation of the carrier by the voice frequency, the method of transmitting a calling signal will now be described. For the purpose of simplicity, it will be assumed that the key 16 is a simple hand key and the character of the calling signal is a continuous modulation of the carrier by 135-cycle current as long as the key is operated. The key 16 will be closed, thereby operating relays 2 and 15 by current from the battery connected with the key. The operation of relay 2 connects the 135-cycle oscillator 3 with the modulator, the connection including the inner contacts of relay 2 and the transformer 5. The operation of relay 15 serves to disconnect the condenser 14 and thereby changes the constants of the oscillatory circuit, which in turn changes the frequency of the oscillations. This frequency designated f_1 is changed so that it lies within the band $f-v$ passed by the band filter 21, that is to say, the frequency lies within the band represented by 48,000 to 49,800 cycles. The voltage of this new carrier frequency f_1, which, for the purpose of illustration, will be assumed to be 49,000 cycles, will be impressed across the impedance 18 and will be modulated by 135 cycles produced by the generator 3. The products of modulation are the currents of the frequency of 48,865, 49,135. All of these frequencies lie within the band transmitted by the filter 21. They accordingly are passed to the amplifier 22 and are radiated by the antenna 23. These frequencies are received by the antenna 24 at station B and impressed by the selective circuit 26 upon the modulator 27.

In the receiving circuit at station B the impressed waves of the signal band of frequencies $f_1 \pm s$, that is to say, the frequencies of 48,865 and 49.135 cycles, will be impressed upon the modulator 27 and will be beaten with the frequency f_2, namely 20,000 cycles from the local source of oscillations 28. Two of the resultant frequencies, 28,865 and 29,135 cycles, representing the negative component of modulation viz, $f_2-(f_1 \pm s)$, will be transmitted through the band filter 29 and will be amplified by the amplifier 31, which is designed and adjusted for good amplification of the band of frequencies transmitted by the filter 29. The output currents of this amplifier will be transmitted through the band filter 30 and impressed upon the demodulator 32 wherein the frequencies, 28,865 and 29,135 cycles, will be beaten with the frequency f_3 of 30,000 generated by the local oscillator 33. The resultant frequencies, that is to say, 965 and 1135 cycles, will be impressed upon the circuit 34 and in turn will be impressed by the circuit 36 upon the detector 37 having a local source of oscillations 38 of the frequency f_4 of 1,000 cycles connected therewith. The resultant frequency of 135 cycles will be impressed upon the signal receiving device 38 wherein it will actuate a signaling device responsive to this frequency. Upon the reception of this signal, the subscriber at station B would remove his receiver from its switchhook and receive the call from the distant subscriber at station A.

In the system just described, the carrier frequencies for the voice and the signals are suppressed by the type of modulator used, so that it is necesary at the receiving end to supply both of these frequencies in order to detect the superimposed voice and signal frequencies. Consequently in the type of receiving circuit shown at station B of Fig. 1, three sources of beating frequencies are required.

The arrangement shown in Fig. 2 is characterized by the transmission of the signal carrier frequency together with the signal side-bands, so that it is not necessary to supply locally at the receiving station one of the frequencies necessary for the detection of the signal. In Fig. 2, the same reference symbols have been used as in Fig. 1 to represent the same or similar parts. The oscillator 7 has connected therewith the stopping condensers 8 and 9, the tuning inductances 10 and 11 and the tuning condensers 12, 13 and 14, the last of which is adapted to be disconnected from the oscillating circuit by operation of the relay 13 controlled by the signaling key 16. The signaling key also controls relays 40 and 42 the former of which connects the source 3 of low frequency signaling current with the plate circuit of the oscillator 7 through the repeating coil 41. The plate battery 43 connects directly with the plate of the oscillator 7 over contacts of relay 42 when the signaling key is not operated, that is to say, when speech signals are being transmitted. When the key 16 is operated the plate battery 43 is connected to ground through the potentiometer 44 whereby the signal frequency, superimposed upon the voltage of the plate battery 43, will be impressed upon the plate circuit. The receiving circuit at station B is similar to that shown in connection with Fig. 1 except that the local source 38 of the beat frequency f_4 connected with the detector 37 is omitted because the carrier frequency of the signal waves is transmitted with the signal side bands, and such local source is unnecessary.

In transmitting speech over the circuit of Fig. 2 between stations A and B, the voice currents produced by the transmitter 1 will be impressed by the transformer 5 upon the modulator which is of the type described in the said patent of Carson which is characterized by the suppression of the carrier frequency. Simultaneous with the application of the voice frequency to this modulator the carrier frequency f of, for example, 50,000 cycles created by the oscillator 7 will be applied thereto across the impedance 18. It should be noted that in creating the carrier oscillations for the voice frequency the plate battery 43 is connected through contact 45 of relay 42 with the plate of the oscillator 7 so that the full voltage of 43 is applied thereto. The frequency f generated by the oscillator will depend upon the constants of the inductance 10 and 11 and the condensers 12, 13 and 14. The side bands $f \pm v$ produced by the modulator will be impressed upon the winding 20 of transformer 19, and one of these side bands say $f-v$ will be selected by the filter 21 and after amplification impressed upon the transmitting antenna 23. Let it be assumed that this side band $f-v$ represents the frequencies between 48,000 and 49,800 cycles. This band of frequencies will be received by the antenna 24 at station B and will be impressed by the tuned circuit 26 upon the demodulator 27 wherein it will be beaten with locally generated oscillations of the frequency f_2, say of 20,000 cycles created by the source 28. One of the resultant bands of frequencies, namely $f_2-(f-v)$, which upon the assumed values if 28,000 and 29,800 will be selected by the band filter 29 and after amplification will be impressed upon the demodulator 32 within the frequencies represented by this band will be beaten with the frequency f_3 viz, 30,000 cycles generated by the local source 33. One of the resultant bands of frequencies, $f_3-(f_2-(f-v))$, that is to say, 200 to 2,000 cycles, will be conveyed by the conductors 34 to the speech receiving device 35.

Having in mind the operation of the system for the transmission of speech, the transmission of signals will be clearly understood from the following description: Subscriber A will depress the key 16 thereby operating relays 15, 40 and 42. Relay 15 disconnects condenser 14 from the oscillating circuit which changes the tuning thereof, creating a frequency f_1 lying within the range of frequency transmitted by the band filter 21, the purpose of doing which was made clear in connection with the description of Fig. 1. The operation of relay 40 connects the 135 cycle generator 3 with one winding of the repeating coil 41 thereby serving to impress 135 cycle current upon the other winding of the said coil. The operation of relay 42 disconnects the plate battery 43 from the plate of the oscillator 7 and connects it through contact 46 with the grounded potentiometer 44. The operation of relay 42 also closes contact 47 which connects the plate of the oscillator 7 with the winding 48 of repeating coil 41 which is connected with the potentiometer 44. It will accordingly be seen that after relay 42 operates current will flow from battery 43 through contact 46 and through potentiometer 44 to ground. The plate of the oscillator 7 will be connected through contact 47 with the winding 48 of repeating coil 41 which is variably connected with the potentiometer 44 so that only a definite portion of the voltage to ground produced by the plate battery 43 may be applied to the plate of the oscillator 7. The repeating coil 41 serves to superimpose upon this portion of the direct current voltage the voltage of the 135 cycle current produced by generator 3. It will be seen that the oscillator 7 will produce a carrier current whose frequency is determined by the constants of inductances 10 and 11 and of condensers 12 and 13 modulated by the 135 cycle current from the source 3. Accordingly, there will be set up in the winding 17, which is inductively connected with windings 10 and 11 currents of the signal carrier frequency f_1, say, of the order of 49,000 cycles, and also the side bands thereof, that is to say, 48,865 and 49,135 cycles. These frequencies will pass directly to the band filter 21 over the inner contacts of relays 49 and 50 (since these relays have been operated by a signaling key 16 and do not have to pass through the modulator). Since these frequencies lie within the band of frequencies that the band filter 21 is adapted to pass, they will be impressed upon the antenna 23 and transmitted to the antenna 24 at station B. By beating with 20,000 cycles in the demodulator 27, there will be produced the frequencies 29,000, 28,865 and 29,135 cycles. These frequencies will be amplified by 31 and will be impressed upon the demodulator 32 wherein they will be beaten with the frequency of 30,000 cycles producing frequencies of 1,000, 1,135 and 865 cycles. These frequencies will be conveyed by the circuits 34 and 36 to the detector 37 wherein the signal frequency of 135 cycles will be detected by the presence of the 1,000 cycle component of the unmodulated signal carrier frequency.

It will be seen from the foregoing that by means of the arrangements shown in Figs. 1 and 2 it is practicable to use low frequency signaling in a system characterized by the transmission of a single speech side band, the result being attained by using a different carrier frequency for the transmission of signals from that used for the transmission of speech, the signal carrier frequency lying within the band of the speech frequency. The arrangement shown in Fig. 2 possesses an advantage over that shown in Fig. 1 in that the carrier frequency upon which the signal frequency is superimposed is transmitted to the distant receiving station and therein serves to demodulate the signal frequency thus avoiding the necessity of supplying locally the other frequency f_4.

It is desired to point out that the signaling key 16 may be replaced by other forms of signal transmitting devices, such, for example, as the device shown in the co-pending application of Demarest and Almquist, Serial No. 646,903, filed June 21, 1923, which is intended to transmit a series of signaling impulses, each impulse being a high frequency wave modulated by a low frequency signaling current, which series of impulses are arranged to operate a selective device of the character described in the said co-pending application. It is furthermore desired to point out that the frequency transmitted through the band filter 21 at station A of either of the figures may again be translated to a different frequency and amplified, if necessary, before transmission by the antenna 23. In that event the local source of oscillations 28 at station B of the system would be preferably designed to beat down the received frequency to the frequency transmitted by the band filter 21, so that the frequency impressed upon the amplifier 31 would be of a lower order for which the amplifier would give better results.

While this invention is disclosed as embodied in particular forms, 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 with a modulator of a source of carrier current, separate sources of current to modulate the said carrier current, and means operated by the connection of one of said modulating sources with the said source of carrier current to change the frequency of the said carrier current.

2. In a signaling system, the combination with a modulator of a band filter connected with the output side of the said modulator, a source of carrier current, separate sources of current to modulate the said carrier current, and means operated by the connection of one of the said modulating sources with the said source of carrier current to change the frequency of the said carrier current, the magnitude of the change being such that the carrier will lie within the band of frequencies transmitted by the said filter.

3. In a signaling system, the combination with a modulator having a source of carrier frequency connected therewith, of a source of voice frequency, and a signaling circuit having means connected with the said source of carrier frequency to cause it to produce another carrier frequency of different order of magnitude, and a source of signaling frequency to modulate the said different carrier frequency.

4. In a signaling system, the combination with a modulator having a source of carrier frequency connected therewith, the modulator being characterized by the suppression of the carrier frequency, of a source of voice frequency, a source of signaling frequency, and means to connect to the said modulator either the said source of voice frequency or the source of signaling frequency, and means controlled by the connection of the said source of signaling frequency to the said modulator to cause said source of carrier frequency to produce another carrier frequency of different magnitude whenever the source of signaling frequency is connected to the said modulator.

5. In a signaling system, the combination with a modulator having a source of carrier frequency connected therewith, the modulator being characterized by the suppression of a carrier frequency, of a source of voice frequency, a source of signaling frequency, a band filter connected with the output side of the said modulator adjusted to pass only one band of the voice modulated carrier, and means to control the connection of the said modulator to the said voice frequency or the said signaling frequency source, the said controlling means also including means for causing the said carrier frequency to produce a carrier frequency of different magnitude when the said signaling frequency is applied thereto, the different carrier frequency being within the range of the said filter.

6. In a signaling system, the combination with a modulator having a source of carrier frequency connected therewith, the modulator being characterized by the suppression of the carrier frequency, of a source of voice frequency, a source of signaling frequency, a band filter connected with the output side of the modulator adjusted to pass only one band of the voice modulated carrier, and means controlled by the connection of the said signaling source to the said source of carrier frequency to cause the said carrier frequency source to produce another carrier frequency, the magnitude of which lies within the range of frequencies that the said filter is capable of passing.

7. In a signaling system, the combination with an oscillator normally producing a carrier frequency f of a modulator having a source of frequency v to modulate the said frequency f, a filter adapted to pass either but not both of the side bands $f+v$ and $f-v$, means for causing said oscillator to produce a carrier frequency f_1, the magnitude of which is such as to pass through the said filter, signaling means to modulate the carrier frequency f_1, and means to disconnect the said modulator from the said filter and to connect the said oscillator directly thereto whenever the frequency f_1 is being generated.

8. In a signaling system, the combination with a transmitting station comprising an oscillator producing a carrier current of a definite frequency, a modulator, means to modulate the said carrier frequency oscillations by another frequency, a filter adapted to pass one of the side bands of modulation, a transmitting circuit to transmit the band of frequencies passed by the said filter, signal controlling means to cause the said oscillator to produce a second and different carrier frequency modulated by a signaling frequency, the said second carrier frequency as modulated being within the range of frequencies passed by the said filter, switching means controlled by the said signal controlling means to disconnect the said modulator from the said filter and to connect the said oscillator directly thereto whenever the said oscillator is producing the said different carrier frequency, and a receiving station comprising means to receive the

transmitted bands, means to detect the said second frequency and also the said signaling frequency, and indicating means responsive to each of the latter frequencies.

9. In a signaling system, the combination with a filter adapted to pass a particular range of frequencies of a modulator having a source of carrier current and a source of modulating current connected therewith adapted to produce a band of frequencies that will pass through the said filter, and signal controlling means comprising means to cause the said oscillator to produce a second modulated carrier current, the magnitude of which is within the range passed by the said filter, and means to disconnect the said modulator from the said filter and to connect the said oscillator to the said filter during the period in which the second modulated carrier current is being created.

10. In a signaling system, the combination with a transmission circuit, of a modulator, a source of carrier oscillations normally of a fixed frequency, a source of voice frequencies, a source of signaling frequency, a filter connected with the output side of said modulator and adjusted to pass only one side band of the carrier oscillations of normal frequency modulated by the voice frequencies, and means responsive to the effective connection of the said source of signaling frequency with the said transmission circuit to change the frequency of the carrier oscillations whenever the said source is so connected.

11. In a signaling system, the combination with a transmission circuit of a source of current of definite frequency representing a message signal, a source of current of frequency differing from that of said first source representing a calling signal, a source of carrier oscillations of a predetermined normal frequency to be modulated by the message signal frequency for impression upon the said transmission circuit, and means controlled by the transmission of the said calling signal to change the frequency of the said carrier oscillations to be modulated by the said calling signal frequency.

In testimony whereof, I have signed my name to this specification this 27th day of May, 1924.

WILLIAM H. T. HOLDEN.