Dec. 15, 1925. 1,565,544

R. BOWN

RADIO TRANSMISSION SYSTEM

Filed Sept. 18, 1924 2 Sheets-Sheet 1

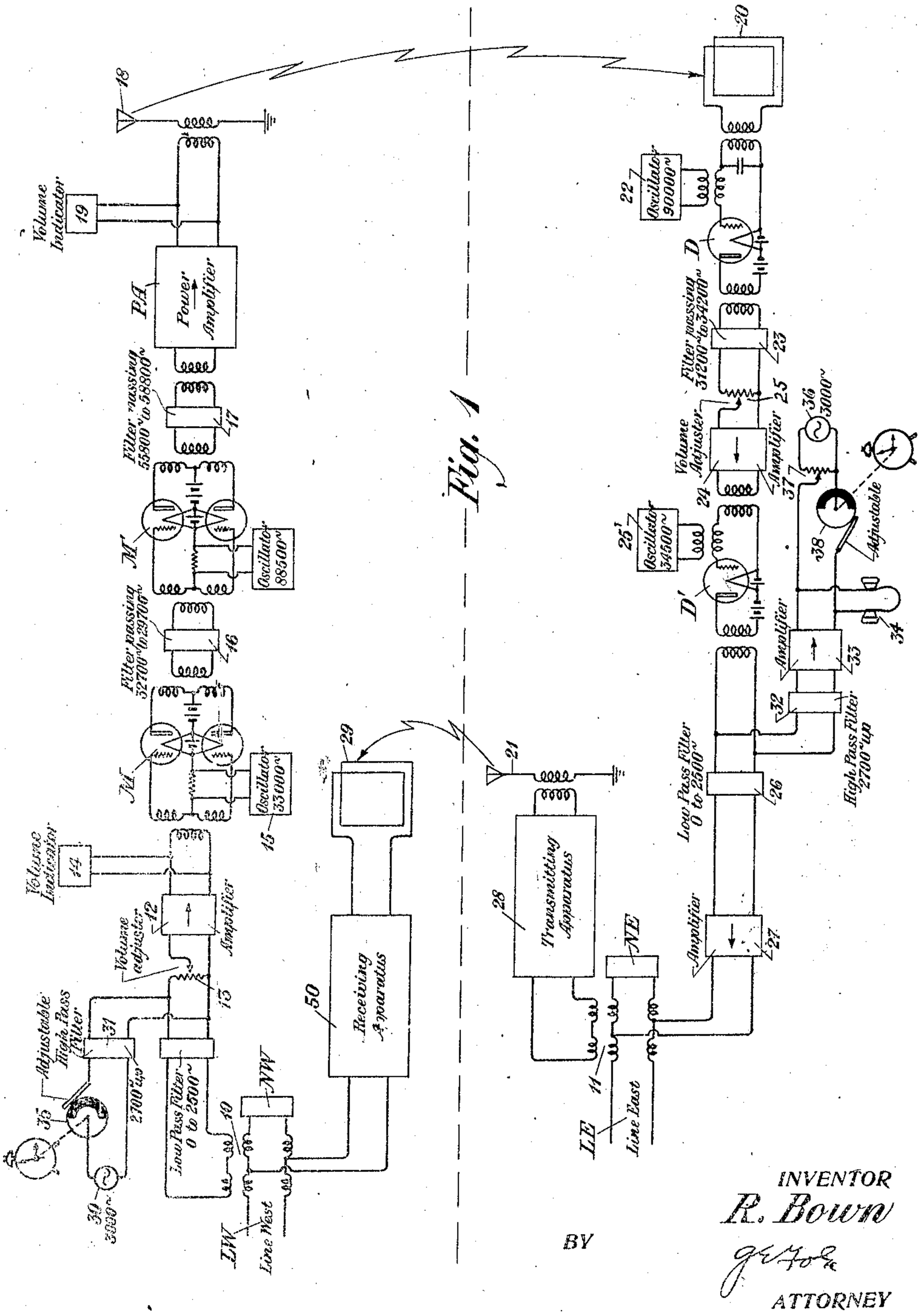

Fig. 1

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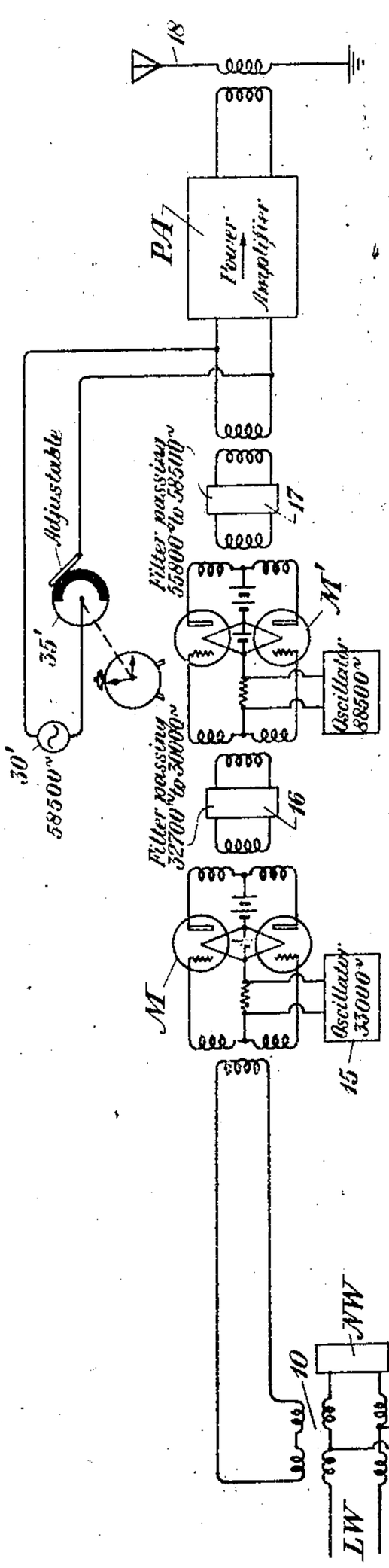

Fig. 2

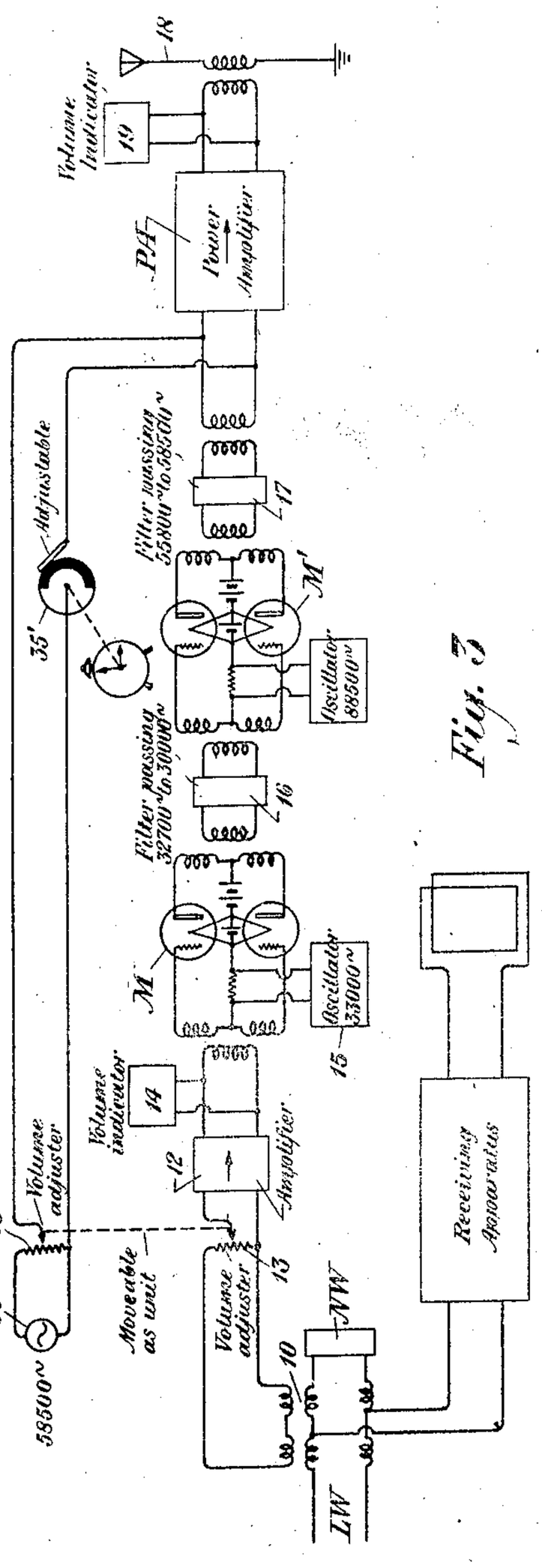

Fig. 3

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UNITED STATES PATENT OFFICE.

RALPH BOWN, OF WYOMING, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

RADIO TRANSMISSION SYSTEM.

Application filed September 18, 1924. Serial No. 738,511.

To all whom it may concern:

Be it known that I, RALPH BOWN, residing at Wyoming, in the county of Essex and State of New Jersey, have invented certain Improvements in Radio Transmission Systems, of which the following is a specification.

This invention relates to signaling systems, and more particularly to arrangements for controlling transmission in systems of radio communication. In telephone transmission and in other kinds of signaling as well, it is often desirable to transmit sounds which have a considerable range of volume. It is also necessary that the minimum volume transmitted be maintained above the noise level of the transmission medium and that the maximum volume transmitted through the medium shall not be sufficiently great to overload vacuum tubes used in the system. In the case of a radio telephone system the noise level is determined to a considerable extent by static disturbances and interference due to other signaling stations so that the minimum signal volume transmitted must be maintained fairly high. In the case of a long distance radio telephone system, such, for example, as a trans-Atlantic system, the situation is further complicated by the wide variation of the over-all transmission equivalent of the medium during the different periods of the day.

It is therefore desirable that some means be provided to compensate for the changes in the transmission equivalent due to the periodical variation of the medium, or, in other words, to maintain the transmission equivalent constant. In addition, it is desirable that some arrangement be made whereby the volume range may be compressed during transmission through the medium and again expanded to its original range at the receiving station. Accordingly it is proposed by the present invention to provide a controlling or pilot frequency which may be transmitted along with the signal, the variations in the amplitude of the received pilot frequency serving to indicate at the receiving station the variations of the equivalent of the transmission medium from normal. By making suitable adjustments in the amplifier or other apparatus at the receiving station from time to time in accordance with the received indication, the over-all transmission equivalent of the communication system may be maintained substantially constant.

It is also proposed to provide equipment at the sending station for adjusting the volume of the transmitted signal from time to time to keep the range of volume of the transmitted signal within the limits imposed by the noise level and distortion resulting from overloading the apparatus. In fact, from the standpoint of efficiency, it is desirable that the full power of the transmitter be controlled by the speaker's voice at all times so that the volume actually transmitted would in such case involve very small variation. This result may be obtained by adjusting some transmission element in the signaling circuit at the transmitting station as the signaling volume varies from normal so that the power impressed upon the modulator will be substantially constant. It is, of course, necessary, when such adjustments are made, that a compensating adjustment be made at the receiving station so that if the signal at the transmitting station is reduced it will be correspondingly augmented at the receiving station, and vice versa. It is therefore proposed that when any adjustment in the signal volume is made at the transmitting station a corresponding adjustment be made of the amplitude of the pilot or controlling frequency. When this is done it is possible, by adjusting the transmission element at the receiving station, to induce a compensating increase in volume whenever the amplitude of the received pilot frequency falls below normal and to induce a compensating decrease in volume when the received pilot frequency attains a value above normal. By making these adjustments at the receiving station in accordance with the indication of the pilot frequency, not only will the over-all transmission equivalent of the system be maintained substantially constant, but the received signal will be given the same range of variation of volume as

obtained in the case of the original signal before the range was narrowed for transmission over the medium.

The invention will now be more fully understood from the following description when read in connection with the accompanying drawing, Fig. 1 of which illustrates schematically the arrangement of apparatus in a long distance radio telephone system whereby the volume range transmitted may be compressed and the over-all transmission equivalent at the same time be maintained substantially constant. Fig. 2 illustrates schematically the apparatus of a transmitting station equipped to obtain the latter result only, while Fig. 3 shows a modified form of the invention whereby both compression of the volume range and uniformity of transmission equivalent may be obtained.

Referring to Fig. 1 LW designates an ordinary telephone transmission line connected to a suitable two-way radio equipment at one station, and LE designates another telephone transmission line similarly associated with co-operating two-way radio equipment at a distant station. The line LW is associated with the transmitting and receiving channels of the radio apparatus by means of a hybrid coil 10, a suitable balancing network NW being provided to render the transmitting and receiving channels of the radio system substantially conjugate. Similarly the line LE is connected by means of a hybrid coil 11 with the transmitting and receiving channels of the radio apparatus at the distant station, a balancing network NE being provided at the distant station to render the transmitting and receiving channels substantially conjugate. Only the apparatus of the transmitting channel associated with the line LW is illustrated in detail, the corresponding transmitting apparatus being merely indicated symbolically.

The transmitting channel associated with the line LW includes a low frequency amplifier 12 having a potentiometer 13 for adjusting the volume of the transmitted signal. A volume indicator 14 of any well known type is bridged across the circuit upon the output side of the amplifier 12 to indicate the volume of the signal impressed upon the modulator M. The modulator may be of any well known type but is illustrated as being a balanced vacuum tube modulator supplied with a carrier current from a 33,000 cycle oscillator 15. Upon the output side of the modulator M a band filter 16 is provided for passing the lower side band resulting from modulation while suppressing the other side band. The carrier frequency supplied to the source 15 will be substantially suppressed by the balanced arrangement of the modulator M, but the filter 16 also serves to suppress the carrier frequency as well as one side band. On the assumption that the signal band ranges from 300 cycles to, say 2500 cycles, it would only be necessary for the filter 16 to pass a band from 32,700 cycles to 30,500. The lower limit of the filter 16 may have to be set at about 29,700 cycles for the purpose of passing a component corresponding to the 3,000 cycle controlling or pilot frequency to be referred to hereinafter.

A second modulator M′ is also provided in the circuit beyond the filter 16. This modulator may likewise be of the balanced type to suppress the supplied carrier which is illustrated as being obtained from an oscillator generating a frequency of 88,500 cycles. A band filter 17 is provided in the circuit upon the output side of the modulator M′ for suppressing the upper side band and supplementing the balanced arrangement of the modulator in the suppression of the carrier wave. A power amplifier PA is introduced between the filter 17 and the transmitting antenna 18 for the purpose of amplifying the transmitted energy to the desired point. An indicating instrument, such as a volume indicator 19 of a well known type, may also be provided on the output side of the power amplifier so that an attendant may be apprised whenever the power impressed upon the antenna exceeds or falls below the desired value.

The apparatus at the corresponding receiving channel associated with the line LE comprises a receiving antenna 20 which may be of the directive loop type so as to receive a maximum wave from the transmitting antenna 18 at the described sending station while receiving minimum energy from the local transmitting antenna 21 of the transmitting apparatus associated with the line LE. In the receiving channel beyond the antenna 20 is a vacuum tube detector D supplied with a beating frequency of 90,000 cycles from an oscillator 22. A band filter 23 is provided on the output side of the detector D for selecting the lower side band resulting from this step of demodulation. An intermediate frequency amplifier 24 is included in the circuit beyond the filter 23, this amplifier being provided with the potentiometer 25 for adjusting the volume of the received signal. A second detector D′ is included in the circuit beyond the amplifier 24, said detector being supplied with a beating frequency of 34,500 cycles from an oscillator 25′. A low-pass filter 26 is included in the receiving channel beyond the detector D′. This filter serves to suppress the upper side band resulting from the second step of demodulation together with the carrier frequency, while passing a portion of the lower side band which corresponds to the original signal band.

The operation of the apparatus so far described is as follows:

A voice band incoming from the line LW passes into the transmitting channed through the low-pass filter 10, and after being amplified by the amplifier 12 is impressed upon the modulator M. The carrier frequency component resulting from the first step of modulation is suppressed by the balanced arrangement of the circuit, and the upper side band is suppressed by the filter 16, the lower side band being transmitted by the filter and impressed upon the modulator M'. This modulator, which is supplied with a carrier frequency of 88,500 cycles, again suppresses the carrier frequency and produces two side bands, the upper of which is suppressed by the filter 17, and the lower of which is transmitted through the filter. It will be noted that the lower side band now corresponds to the original signaling band, and the band having been inverted twice, the frequencies in the band transmitted by the filter 17 will be in their normal relation, that is, the lowest frequency of the band passed will correspond to the lowest frequency in the original signaling band, and the highest frequency in the band will similarly correspond to the highest frequency of the original signal band. Therefore, the result of stepping up the band by two steps of modulation with suppression of the other side band each time results in finally producing a band corresponding to the upper side band which would be produced as the result of modulating the signal upon a carrier frequency of 55,500 cycles.

The signal band thus finally produced is impressed upon the power amplifier PA, and upon being amplified by the amplifier is radiated by the antenna 18 to the receiving antenna 20 at the distant station. The band received is then impressed upon a detector D at the distant station where it beats with the frequency of 90,000 cycles supplied by the oscillator. The filter 23 on the output side of the detector selects the lower side band ranging from 31,200 cycles to 34,200 cycles and impresses the selected band upon the intermediate frequency amplifier 24. The amplified band is then impressed upon the final detector D' where it beats with the frequency of 34,500 cycles supplied by the oscillator 25'. The lower side band resulting from this step of detection now corresponds to the original signal and is selected by the low-pass filter 26 and transmitted through the low frequency amplifier 27 to the line LE.

It will thus be seen that the original signal band incoming from the line LW is stepped up in the frequency spectrum by two steps of modulation and is transmitted as a single side band to the receiving station where it is in turn stepped by two steps of demodulation to its original position in the frequency spectrum. In a similar manner a signal band incoming from the line LE will be stepped up by the transmitting apparatus symbolically indicated at 28 and radiated by the transmitting antenna 21 to the receiving antenna 29 to be in turn stepped down by the apparatus symbolically indicated at 30 and then impressed upon the line LW. Thus a two-way conversation may take place between the lines LW and LE through the medium of the radio channels.

The foregoing description sets forth a type of radio telephone system to which the apparatus may be applied for compressing the volume range transmitted and for maintaining the transmission equivalent of the system constant in accordance with the present invention. For these purposes a source of current having a frequency just outside the voice range, for example, 3,000 cycles, is connected through a high-pass filter 31 to the potentiometer 13 associated with the amplifier 12 of the transmitting channel connected to the line LW. This frequency will be amplified by the amplifier 12 and subjected to any change in volume due to the adjustment of the potentiometer 13 whenever it is adjusted to change the volume of the signal transmitted. This controlling or pilot frequency will be applied to the various modulators and radiated in a manner similar to the signal band already described. At the receiving channel associated with the line LE a high-pass filter 32 similar to the filter 31 is bridged across the channel of the output side of the last detector D' for the purpose of selecting the controlling or pilot frequency. An amplifier 33 is provided for amplifying the pilot frequency to any desired value before impressing it upon the indicating device. In order to produce an indication upon a direct indicating device by means of the pilot frequency, it would be necessary for the pilot frequency to be transmitted with considerable energy. Therefore, of the total energy radiated, a considerable portion would have to be assigned to the pilot channel, thus decreasing the amount of energy available for the transmission of the signal. Accordingly it is proposed by the present invention to transmit the pilot frequency at a relatively low volume and use an aural receiving device such as a telephone receiver 34 connected to the output of the amplifier 33 for indicating the pilot frequency. As the telephone receiver will not give a direct indication of the amplitude of the pilot frequency, a time controlled interrupter 35 is provided in circuit with the source 30 so that the pilot frequency will be applied for, say a few seconds and then interrupted for a few seconds. At the receiving point a source of alternating current

36 having the same frequency as the pilot channel is connected through an adjustable potentiometer 37 to the terminals of the receiver 34. A time operated interrupter 38 similar to the interrupter 35 is included in circuit with the source 36, and this interrupter will be so timed as to apply the frequency from the source 36 to the receiver 34 during the interval that the interrupter 35 cuts off the source 30.

The operation of the volume compressing and transmission regulating apparatus is as follows:

When the signal band incoming from the line LW is decreased in volume below the volume necessary to produce a full modulation, the decrease in volume will be indicated upon the volume indicator 14. The volume adjusting potentiometer 13 will then be adjusted to increase the volume of the signal to the value necessary to produce a complete modulation. The pilot frequency from the source 30 will also be increased in volume by the setting of the potentiometer and will modulate the carrier frequency of 33,000 cycles applied to the modulator M. This modulator will appear as a 30,000 cycle component transmitted through the filter 16 which is then applied to the modulator M′ to modulate the carrier frequency of 88,500 cycles. This modulation in turn appears as a 58,500 cycle component transmitted through the filter 17 and impressed upon the power amplifier PA. This component after being amplified is radiated by the antenna 18 and received by the antenna 20. It is then impressed upon the detector D and by beating with the 90,000 cycle frequency from the source 22 produces a component having the frequency of 31,500 cycles which is passed through the filter 23 and amplified by the amplifier 24. The component is then impressed upon the detector D′ to beat with the 34,500 cycle frequency from the source 25′ thereby producing a component of 3,000 cycles which is passed through a high pass filter 32, amplified by the amplifier 33 and impressed upon the telephone receiver 34.

The attendant listening in the receiver 34 will alternately hear the control frequency of 3,000 cycles from the source 30 and a corresponding frequency of 3,000 cycles from the source 36 which is adjusted to some predetermined amplitude which will give the system a desired transmission equivalent. Whenever the potentiometer 13 of the sending channel is adjusted to increase the volume of the signal, the attendant will observe that the volume of the pilot frequency from the source 30 is greater than the volume of the 3,000 cycle frequency from the source 36. The attendant will then adjust the potentiometer 25 of the amplifier 24 to reduce the volume of the pilot frequency from the source 30 until the effect produced in the receiver 34 from both sources is the same. A very accurate comparison can be made of the volume transmitted from the two sources by reason of the fact that the noise picked up by the antenna 20 will be heard in the receiver 34 both when the pilot frequency from the source 30 is being received and when the comparison frequency from the source 36 is being received. The adjustment of the potentiometer 25 to bring the two frequencies to the same volume results in an adjustment of the volume of the signal transmitted to the line LE which results in a decrease of the volume of the signal applied to the line LE which just compensates for the increase in volume due to the adjustment of the potentiometer 13 at the transmitting channel. The over-all transmission equivalent of the radio channel is therefore the same as before the adjustments were made, and the signal is impressed upon the line LE with the same volume it would have had in case no adjustment of transmission had been made at all. The transmission adjustments, however, result in the transmission of the signal at substantially its maximum value so that its transmission level during transmission through the ether will be well above the noise level.

Similarly, if the volume of the signal incoming from the line LW is so great as to overload the vacuum tubes of the system, the attendant by observing either the volume indicator 14 or the volume indicator 19 will be apprised of the fact that the volume of the signal is greater than that previously determined as the best volume for transmission purposes. The attendant will accordingly adjust the potentiometer 13 to bring the volume of the signal down to the proper value. This, of course, produces a corresponding reduction in the amplitude of the frequency from the pilot source 30. Accordingly, the pilot frequency, when impressed upon the receiver 34, will have a lesser volume than the comparison frequency from the source 36. The attendant at the receiving channel will accordingly adjust the potentiometer 25 so that the volume heard in the receiver from both sources will be the same. This result is an increase in the volume of the signal transmitted to the line LE, while the over-all transmisssion equivalent of the radio channel will be again restored to its normal value. The volume of the signal transmitted to the line LE will be as great as the volume would have been had there been no transmission adjustment at all. At the same time the actual signal volume transmitted to the various parts of the system will not have been greater than the capacity of the various pieces of apparatus involved. It will be clear, there-

fore, that the signal impressed upon the line LE will range in volume over the same range of variation as the signal incoming from the line LW, although the actual volume of the signal transmitted from the antenna 18 to the antenna 20 will be maintained fairly constant. The range of volume actually transmitted is therefore compressed to very narrow limits.

As is well known, when radio signals are transmitted over long distances considerable change in the transmission efficiency of the medium occurs from hour to hour during the day. When any change occurs in the transmission efficiency of the ether in the system above described, this change will result in an increase or decrease in amplitude of the pilot frequency impressed upon the receiver 34 through the filter 32. The attendant will therefore adjust the potentiometer 25 to bring an equality in volume between the pilot frequency and the frequency from the source 36. This results in bringing the over-all transmission equivalent of the radio channel back to its normal value. It is therefore clear that by means of the arrangements above described, not only may the volume range of the signal actually transmitted be kept within very narrow limits, but the over-all transmission equivalent of the radio part of the system may be maintained substantially constant.

Fig. 2 illustrates a modification of the transmitting apparatus whereby the pilot frequency is introduced as a radio frequency without undergoing the several steps of modulation. In the case illustrated, the pilot frequency is generated by the source 30′ having a frequency of 58,500 cycles. This frequency is impressed upon the channel at a point beyond the modulators, as, for example, upon the input side of the power amplifier PA. This avoids the necessity of passing the pilot frequency through the filters 16 and 17, and the range of these filters may be correspondingly narrowed so that they will accommodate only a band having the same width as the signal itself. The pilot frequency is interrupted by the time controlled interrupter 35′ as in the case of Fig. 1. The apparatus of the corresponding receiving channel will be identical with that illustrated in Fig. 1.

In the arrangement of Fig. 2, it is assumed that the pilot frequency will be transmitted at a constant amplitude, and by beating with the local sources associated with the detectors D and D′ of the receiving channel it will be stepped down to 3,000 cycles for selection by the filter 32. This arrangement only permits of adjustments of volume in the receiving channel to compensate for changes in the transmission efficiency of the medium. It does not indicate any adjustments of the volume of the signal, however, for the reason that the pilot frequency is not subjected to such volume adjustments.

Fig. 3 shows an arrangement by which the pilot frequency may be applied to the transmitting channel at a point beyond the modulators and used to indicate change in volume at the transmitting channel as well as changes in the transmission efficiency of the medium. In this case the source 30′ generating a frequency of 58,500 cycles is connected to the transmitting channel at the same point as in Fig. 2. A potentiometer 13′, however, is interposed between the source 30′ and the power amplifier PA. This potentiometer is arranged to be adjusted in the same manner as the potentiometer 13 which controls the volume of the signal. For example, the two potentiometers may be made to move together as a unit by some well known mechanical connection. With this arrangement, when the potentiometer 13 is adjusted to bring the volume of the signal actually radiated by the antenna 18 to its desired normal value, the potentiometer 13 is given a corresponding adjustment so that the volume of the pilot frequency would be changed. The pilot frequency will therefore arrive at the receiving channel changed in volume so that the attendant observing the difference in volume as compared with the volume from the source 36 may adjust the potentiometer 25 of the receiving channel to compensate for the adjustment of the potentiometer 13 of the transmitting channel. Therefore, the apparatus of Fig. 3, co-operating with the apparatus of a receiving channel similar to that illustrated in Fig. 1, may be used not only to maintain the over-all transmission equivalent of the radio part of the system constant, but it may be used to keep the volume of the signal actually transmitted at or near a desired normal value, or, in other words, it may be used to compress the volume range transmitted.

It will be noted that the time control interrupters, such as 35 and 28, may be of any well known type common in the art, and no difficulty whatever need be encountered in maintaining the interrupters in proper synchronism. Since each interrupter applies the corresponding source to the circuit for a period of, say, several seconds, absolute synchronism is not necessary, and an interrupter controlled by an ordinary clock mechanism will maintain the interrupters at the two distant points in substantial synchronism for a considerable period of time without any adjustment whatever. Whenever it is apparent to the attendant at the receiving station that the interrupters are out of time, synchronism may be at once obtained by merely adjusting the brush of

the interrupter. This adjustment may, of course, be made at either the sending or transmitting channel, it is simpler to do it at the receiving point.

It will be obvious that the general principles herein disclosed may be embodied in many organizations widely different from those illustrated without departing from the spirit of the invention as defined in the following claims:

What is claimed is:

1. In a signaling system, a transmission medium, an adjustable transmission element at the transmitting end of said medium, means to apply signaling current to said transmission element, means to adjust said transmission element in accordance with the variations in volume of the signaling current, means to apply a control frequency to said medium, means to vary the volume of said control frequency in accordance with the adjustment of said transmission element, a compensating transmission element at the receiving station, means at said receiving station to receive said controlling frequency and indicate changes in the volume thereof, and means to adjust said compensating transmission element to compensate for the adjustment of the transmission element at the sending station in accordance with the indications produced by said control frequency.

2. In a signaling system, a transmission medium an amplifier at the transmitting end of said medium, means to impress signaling current upon said medium through said amplifier, means to adjust the gain of said amplifier in accordance with the variations in volume of said signaling current, means to impress controlling current upon said medium, means to vary the volume of said controlling current in accordance with the adjustment of the gain of said amplifier so that the controlling current will arrive at the receiving station with an amplitude determined by the change in the gain of the amplifier at the transmitting station, a compensating amplifier associated with said medium at the receiving station, means at the receiving station to receive said controlling current and indicate changes in the amplitude thereof, and means to adjust the gain of the compensating amplifier at the receiving station to compensate for changes in the gain of the amplifier at the transmitting station as indicated by the changes in the volume of the received controlling current.

3. In a signaling system, a transmission medium, an adjustable transmission element associated therewith at the transmitting station, means to impress signaling currents upon said medium through said element, means to adjust said element in accordance with the changes in volume of the signaling current, means to impress a controlling current upon said medium, means to adjust the volume of said controlling current in accordance with the adjustment of said transmission element whereby said controlling current will arrive at the receiving station with an amplitude determined by the adjustment of said element and by any change in the transmission equivalent of said medium, a compensating adjustable transmission element associated with said medium at the receiving station, means at the receiving station to receive said controlling current and indicate changes in the amplitude thereof, and means to adjust said compensating transmission element to compensate for the changes in volume indicated by said controlling current whereby the over-all transmission equivalent of the system will be maintained substantially constant and the volume of the received signal will be restored to its original value as compared with the pre-determined normal value.

4. In a signaling system, a transmission medium, an amplifier associated with said medium at the transmitting station, means to impress signaling currents upon said medium through said amplifier, means to adjust the gain of said amplifier in accordance with the volume of the signaling currents, means to impress a controlling current upon said medium, means to vary the volume of said controlling currents in accordance with the adjustment of said amplifier whereby said controlling current will be transmitted over the medium and arrive at the receiving station with an amplitude determined by the change in the gain of said amplifier and any change in the transmission equivalent of said medium, a compensating amplifier associated with said medium at the receiving station, means at the receiving station to receive said controlling current and indicate changes in the volume thereof, and means to adjust the gain of said compensating amplifier at the receiving station in accordance with the indicated changes in volume of the received controlling current whereby the over-all transmission equivalent of the system will be maintained substantially constant and the volume of the received signal will be restored to its original value as compared with the pre-determined normal value.

5. In a radio signaling system, means at the transmitting station to radiate a signal, means at said station to radiate a pilot frequency, means at the receiving station to receive and detect a radiated signal, an adjustable transmission element at the receiving station for adjusting the volume of the received signal, means to select said pilot frequency at the receiving station, a local source having the same frequency as

the pilot frequency at the receiving station, means to alternately impress the selected pilot frequency and the frequency from the local source upon the receiver to compare their volumes, and means to adjust said transmission element at the receiving station in accordance with the variations in volume of the pilot frequency as indicated by said comparison.

In testimony whereof, I have signed my name to this specification this 16th day of September, 1924.

RALPH BOWN.