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TRANSMISSION LEVEL CONTROL SYSTEM

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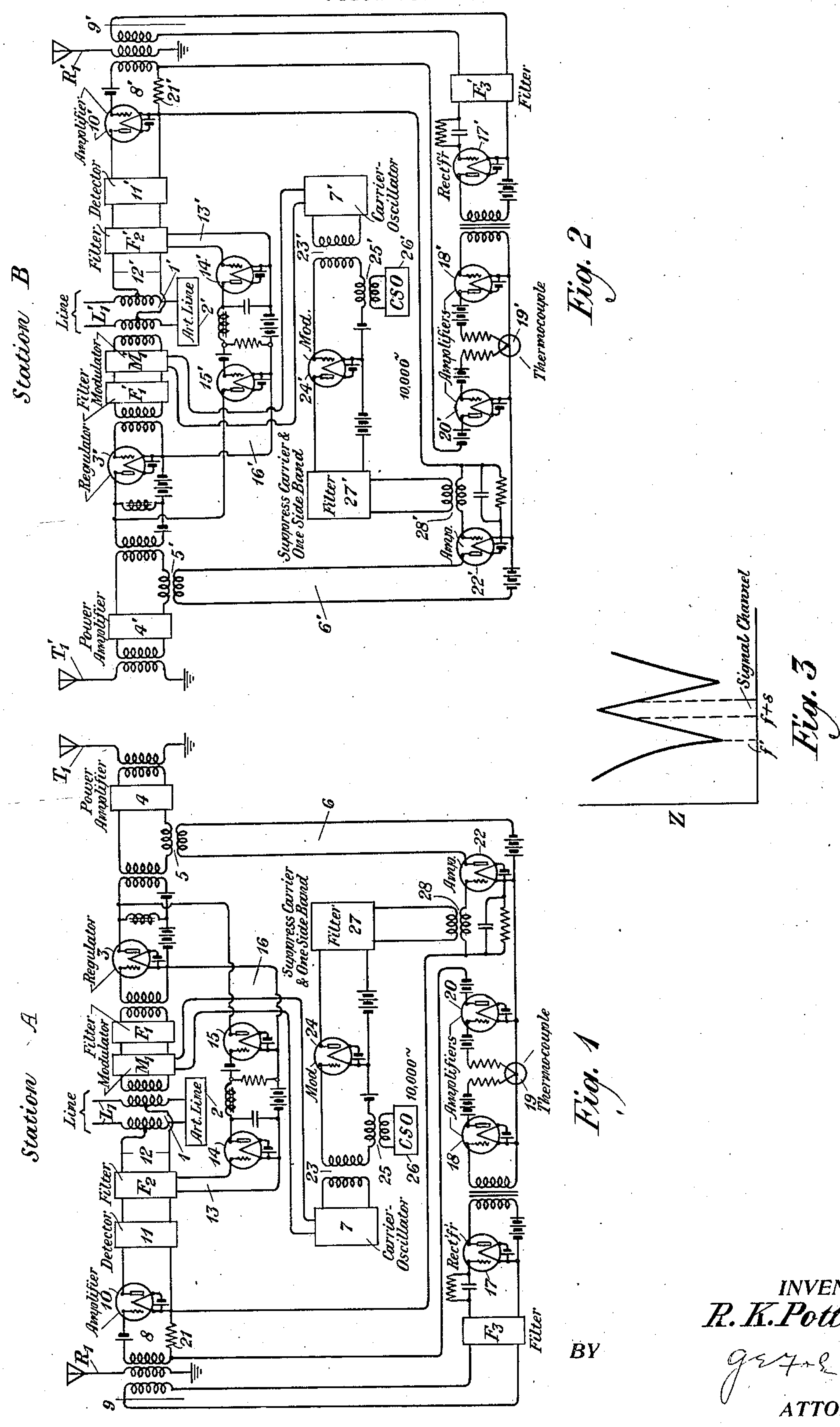


Fig. 1

Fig. 2

Fig. 3

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## TRANSMISSION-LEVEL-CONTROL SYSTEM.

Application filed December 2, 1925. Serial No. 72,841.

This invention relates to transmission level control systems, and particularly to a system of that type in which the signal-to-noise ratio in transmission between stations is automatically maintained substantially constant.

A two-way radio transmission system in which the terminal stations are connected to wire circuits is equivalent to a four-wire repeater in which the connection to the wire circuits is established by hybrid coils. In such a radio system, it is desirable at times to raise the transmission level at the station which is transmitting, at any instant, in order that it will be sufficiently above the noise level of the transmission path, so that the signal may be clearly detected at the receiving end. Since such a radio system is equivalent to a four-wire repeater circuit, it is, of course, necessary to make a corresponding reduction in the amplification at the receiving end in order to prevent singing over the circuit. In systems heretofore proposed, this control of the transmitting and receiving signal levels has been effected manually, that is to say, by adjustment of the apparatus by an attendant at the transmitting and receiving stations.

It is the object of the present invention to automatically control the transmitting and receiving levels of a two-way radio system.

Other objects of this invention will be apparent from the following description when read in connection with the attached drawing, of which Figure 1 represents one of the stations of a system embodying the invention; Fig. 2, which is a duplication of Fig. 1, represents another station of the said system; and Fig. 3 shows the characteristic of a filter used in the system.

In Fig. 1, which will be designated station A of the system, the wire line $L_1$ represents a circuit by means of which signaling apparatus, such as a subscriber's telephone or telegraph apparatus, may be connected. This line is connected with the radio transmitting and receiving circuits of station A by means of the hybrid coil 1. Connected with the winding of this coil, to which the line $L_1$ is connected, is an artificial line 2 simulating electrically the line $L_1$. A third winding of the coil 1 is connected with the modulator $M_1$ of the transmitting branch of the radio circuit. While this modulator may be of any well-known type, a preferable form is that disclosed in the copending application of Potter, Serial No. 70,405, filed November 20, 1925, in which the carrier oscillations are suppressed. The output of the modulator is connected with the filter $F_1$, which is of a type adapted to transmit only one of the side bands resulting from modulation. The output side of the filter $F_1$ is connected with a regulator, namely, the vacuum tube 3, the function of which is to control the amplitude of the side band impressed thereon for transmission from the station. This regulator is coupled to the power amplifier 4, to the input side of which is also connected, by means of a transformer 5, a circuit 6 over which a control signal is transmitted. The nature of this control signal and its method of production and transmission will be described hereinafter. The output side of the power amplifier is connected with the antenna $T_1$ by means of which the signals transmitted from station A are sent to the other stations of the system. Thus, for example, the signals sent from the transmitter $T_1$ will be received by the receiving antenna $R_1'$ of station B shown in Fig. 2, which will be later described in detail. The carrier oscillations which are modulated in the device $M_1$ are supplied thereto by means of the oscillator 7.

Connected with the receiving antenna $R_1$ of the system are two circuits designated 8 and 9. Circuit 8 is connected with the input side of the amplifier 10, which has its output side connected with the detector 11, which detector may be of any well-known type. The output side of the detector is connected with the filter $F_2$ which is of a type adapted to pass into the circuit 12 the side band representing the communication signal. Circuit 12 is bridged across the midpoints of the line windings of the hybrid coil 1, by virtue of which the communication signal passes to the said line for transmission thereover to the distant subscriber. The filter $F_2$ is also adapted to impress upon the circuit 13 a control signal. This circuit has connected therewith a rectifier comprising the tubes 14 and 15, by means of which the control signal is rectified, and, by virtue of its connection with the regulator 3 over the circuit 16, serves to control the amplitude of the communication signal passing from the modulator $M_1$ through the said regulator. The branch receiving circuit 9 is connected with a filter $F_3$ which has the characteristic shown in Fig. 3. As will be seen from this characteristic, the filter is adapted to offer a high impedance to the communication signal represented by the band $f+s$, but to permit the passage therethrough of frequencies lying on each side of the communication signal frequencies. Thus, for example, disturbing frequencies which are present in the path traversed by the communication signal, and which are sufficiently close thereto in the frequency spectrum in order to interfere with the proper reception of the communication signal, are transmitted through the filter $F_3$, in order to control, in a manner which will now be made clear, the relative level of the communication signal to the noise level in the path traversed by the communication signal. The output side of the filter $F_3$ is connected with a rectifier 17 which is coupled with the amplifier 18. In the output circuit of this amplifier is a thermocouple 19 which is of the well-known type, which impresses a direct current potential upon the grid of the amplifier 20 proportional to the current flowing through the heating element of the thermocouple 19. The output circuit of the amplifier 20 is connected with the input side of the amplifier 10, being bridged across the resistance 21, and it is also connected with the input side of the amplifier 22. The connection of the amplifier 20 with the amplifiers 10 and 22 is made in such way that the action of the amplifier 20 will tend to simultaneously increase or simultaneously decrease the amplification of the amplifiers 10 and 22. The oscillator 7 which, as stated, is connected to the modulator $M_1$ is also coupled by the transformer 23 with the modulator 24, to the input circuit of which is also connected, by means of the transformer 25, a source of oscillations 26, known as the control signal oscillator. The frequency of the oscillations produced by this oscillator would preferably be such as to lie outside the band of frequencies constituting the communication signal. As shown on the drawing, it may be of the order of 10,000 cycles but this, of course, is purely illustrative. The output of the modulator 24 is connected with the filter 27 which is of a type intended to suppress the carrier frequency and one of the side bands, and the output side of this filter is connected by the transformer 28 with the input side of the amplifier 22. The output side of the amplifier 22 is connected by the circuit 6 with the input side of the power amplifier in the communication-transmission branch of the terminal circuit.

The other station designated B of the system, which is shown in Fig. 2, is preferably similar to station A. In Fig. 2, the same reference characters have been used as in Fig. 1, except that prime marks have been used to distinguish the similar parts in the latter figure.

The invention will be clearly understood by first tracing the paths traversed in transmitting a signal from the line $L_1$ to the line $L_1'$ of Fig. 2, and in tracing the reception by the line $L_1$ of Fig. 1 of a communication signal transmitted from the line $L_1'$ of Fig. 2. Then the method of generating and transmitting and receiving the control signal will be fully described, and finally, the manner in which the control signal circuit operates to automatically maintain constant the ratio between the signal level and the noise level throughout a system such as represented by stations A and B.

When a communication signal which, for sake of brevity, will be referred to as a speech signal, is impressed upon the line $L_1$ by a telephone connected therewith, the current resulting therefrom will flow over the line $L_1$ and through the hybrid coil windings, and will be impressed upon the modulator $M_1$ in the transmitting branch of station A. This speech band will modulate carrier oscillations from the source 7. One of the bands resulting from such modulation will be selected by the filter $F_1$ and will be impressed upon the regulator 3. This regulator, which is controlled through the rectifier-amplifier tubes 14—15, would normally be adjusted so as to permit therethrough a side band having a fixed amplitude. This side band would pass to the power amplifier 4, and after having given the required degree of amplification, would be radiated from the antenna $T_1$ to the receiving antenna $R_1'$ at station B. The speech band will pass into the receiving circuit 8′ and upon being amplified by 10′, would be detected by 11′. The detected speech band would then pass through the filter $F_2'$ into the circuit 12′, and thence would be transmitted over the line $L_1'$ to the subscriber at the distant end of that line.

While this speech band is being transmitted from station A to station B, a control signal is being transmitted simultaneously from station B to station A. This control signal is produced by modulating the carrier frequency from the source 7′ by a control signal of a different frequency, for example, of 10,000 cycles produced by the source 26′. This modulation is effected by the modulator 24′, and after one of the side bands and the carrier have been suppressed by the filter 27′, the resultant side band is impressed by the transformer 28′ upon the amplifier 22′. The amplification of this control signal depends upon attenuation and interference in the transmitting path between station B and station A, of which further will be said hereinafter. The control signal as amplified by 22′ is conducted over the circuit 6′ to the input side of the power amplifier 4′, and is radiated from the transmitter $T_1'$ to the receiving antenna $R_1$ of station A. This control signal passes into the circuit 8 and is amplified by 10 and the 10,000 cycle component is detected by 11. The filter $F_2$ passes this control signal into the circuit 13 wherein it is rectified by the rectifier 14—15 and controls the output of the regulator 3, that is to say, the amplitude of the speech wave being transmitted by the antenna $T_1$.

If we are transmitting speech signals from station A to station B, and, of course, receiving a control signal simultaneously from station B at station A, it is necessary to adjust the regulator 3 at the outset in order to give the required signal level for what may be termed the normal noise level in the path traversed both by the speech signal and the control signal. It will, of course, be apparent that since both the speech signal and the control signal traverse the same path, they will be affected to substantially the same extent, and therefore, the variation in the intensity of one is in a measure the variation in the intensity of the other. Accordingly, while speech signals are transmitted from the line $L_1$ through the modulator $M_1$, the regulator 3, the amplifier 4 and the antenna $T_1$ to the antenna $R_1'$, thence over the receiving circuit of station B, including the amplifier 10′, the detector 11′, the filter $F_2'$, to the line $L_1'$, the regulator 3 at station A is adjusted in order to give the required degree of amplification to the speech signal, which adjustment is effected by the regulation of the rectifier 14—15 at station A, and also by adjustment of the amplifier 22′ at station B. After this adjustment has been effected, and assuming that the interference level and attenuation over the transmission path remain the same between the two stations, the incoming control signal at station A, which is impressed upon the circuit 13 by the filter $F_2$, will not change the amplitude of the outgoing control signal. If the attenuation of the communication signal between stations A and B is increased, the attenuation of the control signal between B and A will likewise be increased, so that a weaker control signal is received by station A. This control signal when rectified by 14 and impressed on 15 will cause the regulator 3 to increase the amplitude of the outgoing communication signal to station B, which insures the receipt of a strong signal at station B. If, on the other hand, the attenuation of the communication signal would be less than normal between A and B, so that the speech signal would be too strong, the control signal between B and A would likewise be too strong when received at A and it would reduce the amplitude of the communication signal by its action on the regulator 3.

The control of the communication signal is also dependent upon the noise level in the vicinity of the receiving station. Thus an interfering frequency such as $f$ in Fig. 3 which is close to the speech band $f+s$, will be received by the antenna $R_1'$ and impressed upon the circuit 9′. This frequency will pass through the filter $F_3'$, and when rectified by 17′ and amplified by 18′, will set up a voltage across the potential terminals of the thermocouple 19′, which voltage affects the amplifier 20′. The effect of this amplifier is to increase or decrease the gain of the amplifiers 10′ and 22′, affecting both amplifiers in the same way. Let it be assumed that the noise level as represented by $f$ is higher than normal. This would require an increase in the communication signal sent from A. To effect this result it is necessary to reduce the control signal sent from B. The control signal being produced at station B and passing through the amplifier 22′ will have smaller amplitude than normal due to rectified noise, and consequently this wave will be weaker than normal when received at station A. This situation is similar to the receipt of a control signal having greater attenuation than normal. The rectified voltage of this control signal produced by the rectifier 14 at station A will be similarly decreased. The effect of this when impressed on the amplifier 15 is to increase the amplitude of the speech band passing through the regulator 3 to the antenna $T_1$ and thence to the distant station B. At station B, the amplifier 10′ has, as noted above, been adjusted to decrease the amplification so as to keep the overall equivalent of the transmission circuit constant and prevent singing. The result of the action of the interfering frequency that passes through the filter $F_3$ into what may be termed a supplemental control circuit is to raise the transmission level of the signal radiated by the antenna $T_1$ so that it will be above the increased noise level in the path between stations A and B. Interfering impulses taken from either side of the signal channel are thereby directed into the rectifying tube, which might actually be sensitized by the additional application of a constant level local oscillation. The disturbances in the output of this tube are then impressed upon a circuit which responds slowly to changes in the magnitude of input voltage variations. As shown in the circuit, the device employed is a thermocouple with heater element in series with the plate circuit of one tube and the voltage generator, so as to place a biasing voltage on the grid of the subsequent vacuum tube. When properly adjusted, the ratio of the signal level to the noise level may be maintained constant between the stations of the system.

When speech signals are transmitted from station B to station A, a control signal passes from station A to station B, and serves to control the amplitude of the speech signal sent out by the antenna $T_1'$ in the same manner as described above. It is important to point out that in the form in which this invention is disclosed, the control signal is being radiated from both stations at all times, although only that control signal is employed which is passing in a direction opposite to that in which the speech signal is going. An arrangement for suppressing the transmission of the control signal from the same station from which at the same instant a speech signal is passing, is disclosed in my copending application, Serial No. 72,842, filed December 2, 1925, and renewed November 13, 1926.

While this invention has been disclosed as embodied in a particular form, it is obviously 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 system for controlling the transmission level between stations of a signaling system, the method for automatically regulating the signal-to-noise ratio which consists in transmitting a communication signal from one station to a second station of the system, simultaneously transmitting from the second to the first station a control signal whose frequency is outside the range of the communication signal, the said signal traversing substantially the same path so as to be subject to the same interfering sources, and automatically controlling the amplitude of the communication signal transmitted by the said first station by the control signal received at the said first station.

2. In a system for controlling the transmission level between stations of a signaling system, the method for automatically regulating the signal-to-noise ratio which consists in transmitting a communication signal from one station to a second station of the system, simultaneously transmitting a control signal from the said second station to the said first station, the frequency of the said control signal differing from that of the said communication signal, rectifying the said control signal at the said first station, and automatically controlling the amplitde of the communication signal being transmitted from the said first station by the rectified control signal.

3. In a system for controlling the transmission level between stations of a signaling system, the method for automatically regulating the signal-to-noise ratio which consists in transmitting a communication signal from one station to a second station of the system, simultaneously transmitting a control signal from the said second station to the said first station, the frequency of the said control signal differing from that of the said communication signal, simultaneously receiving at the said second station an interfering frequency or band of frequencies lying outside the range of frequencies constituting the communication signal, varying the amplitude of the control signal produced at the second station in accordance with the magnitude of the interfering frequency or band of frequencies, rectifying the said control frequency at the said first station, and controlling the amplitude of the communication signal being transmitted from the said first station by and in accordance with the magnitude of the rectified control signal.

4. In a system for controlling the transmission level between stations of a signaling system, the method for automatically regulating the signal-to-noise ratio which consists in transmitting a communication signal from one station to a second station of the system, simultaneously transmitting a control signal from the said second station to the said first station, the frequency of the said control signal differing from that of the said communication signal, varying the amplitude of the transmitted control signal by and in accordance with the magnitude of the interference existing at the receiving station, and controlling the amplitude of the communication signal transmitted from the said first station by the instantaneous amplitude of the control signal.

5. In a system for controlling the transmission level between stations of a signaling system, the method for automatically regulating the signal-to-noise ratio which consists in transmitting a communication signal from one station to a second station of the system, simultaneously transmitting a control signal from the said second station to the said first station, the frequency of the said control signal differing from that of the said communication signal, varying the amplitude of the transmitted control signal by and in accordance with the magnitude of the interference existing at or near the said second station, receiving at the first station the control signal as thus varied at the said second station, rectifying the received control signal and controlling the amplitude of the communication signal by and in accordance with the instantaneous amplitude of the rectified control signal.

6. In a system for controlling the transmission level between stations of a signaling system, the method for automatically regulating the signal-to-noise ratio, which consists in transmitting a communication wave from one station of the system, receiv-

ing at a second station the said communication wave and also an interfering wave, separating by frequency selection the communication wave from the interfering wave, transmitting from the second station to the first station a control wave, the frequency of which lies outside the band of the communication wave, and governing the amplitude of the control wave by the strength of the interfering wave.

7. In a system for controlling the transmission level between stations of a signaling system, the method for automatically regulating the signal-to-noise ratio, which consists in transmitting a communication wave from one station of the system, receiving at a second station the said communication wave and also an interfering wave, separating by frequency selection the communication wave from the interfering wave, amplifying the communication wave as thus selected, transmitting from the second station to the first station a control wave, the frequency of which lies outside the band of the communication wave, governing simultaneously the amplitude of the control wave and also the degree of amplification of the selected communication wave by and in accordance with the strength of the interfering wave.

8. In a system for controlling the transmission level between stations of a signaling system, the method for automatically regulating the signal-to-noise ratio, which consists in transmitting a communication wave from one station of the system, receiving at a second station the said communication wave and also an interfering wave, separating by frequency selection the communication wave from the interfering wave, transmitting from the second station to the first station a control wave, the frequency of which lies outside the band of the communication wave, governing the amplitude of the control wave by the strength of the interfering wave, receiving and rectifying the said control wave at the first mentioned station and regulating the amplitude of the communication wave to be transmitted inversely with changes in the rectified control wave.

9. In a system for controlling the transmission level between stations of a signaling system, the method for automatically regulating the signal-to-noise ratio, which consists in generating at one station of the system a carrier frequency, modulating the said carrier frequency by a signal frequency and transmitting the signal modulated carrier, receiving at another station the said signal modulated carrier, generating at the said other station a carrier frequency, modulating said carrier by a control frequency lying outside the range of the signal frequency, transmitting the said control modulated carrier from the second station to the first station, detecting the said control frequency and regulating by the detected frequency the amplitude of the signal modulated carrier to be transmitted.

10. In a system for controlling the transmission level between stations of a signaling system, the combination with a transmitting circuit at one station of the system having a source of carrier frequency, a source of signal frequency, a modulator connected with both sources, a regulator to govern the amplitude of the signal modulated wave, and means to transmit the said signal modulated wave, of a receiving circuit at a second station of the system having means to receive the said signal modulated wave, means to generate a control wave, means to transmit the said control wave, and a receiving circuit at the said first mentioned station including means to receive the said control wave, and means to effectively apply the said control wave to the said regulator to produce variations in amplitude of the signal modulated wave opposite in direction to the variations of the control wave.

11. In a system for controlling the transmission level between stations of a signaling system, the combination with a transmitting circuit at one station of the system having a source of carrier frequency, a source of signal frequency, a modulator connected with both sources, a regulator to govern the amplitude of the signal modulated wave, and means to transmit the said signal modulated wave, of a receiving circuit at a second station of the system including means to receive the said signal modulated wave, means to generate a control wave, means to transmit the said control wave, and a receiving circuit at the first mentioned station having means to receive the said control wave, means to rectify the control wave and means to effectively apply the rectified wave to the said regulator to produce variations in the amplitude of the signal modulated wave opposite in direction to the variations of the control wave.

12. In a system for controlling the transmission level between stations of a signaling system, the combination with a transmitting circuit at one station of the system having a source of signal modulated waves, a regulator to govern the amplitude of the said waves and means to transmit the said waves, of a receiving circuit at a second station of the system having means to receive the signal modulated waves and an interfering wave, means to separate by frequency selection the said signal modulated waves and said interfering wave, means to amplify the signal modulated waves, means to rectify the interfering wave, means also at the said second station to generate and transmit a control wave, means connected with

and responsive to the said rectifying means to govern the amplitude of the control wave as transmitted and also the degree of amplification produced by the said amplifier upon the received signal modulated waves, and a receiving circuit at the said first mentioned station having means to receive the said control wave and to effectively apply the said control wave to the said regulator to produce variations in the amplitude of the signal modulated wave opposite in direction to the variations of the control wave.

13. In a system for controlling the transmission level between stations of a signaling system, the combination with a transmitting circuit at one station of a system having a source of control waves, of a receiving circuit at the same station having means to receive signal waves and interfering waves, means to effectively separate said signal waves and said interfering waves by virtue of their frequency difference, and means to employ said interfering waves to vary the amplitude of the control wave as transmitted, the said variations being opposite in direction to the variations of the said interfering waves.

In testimony whereof, I have signed my name to this specification this 1st day of December, 1925.

RALPH K. POTTER.