Oct. 7, 1924. 1,510,985

L. ESPENSCHIED

TRANSMISSION REGULATION

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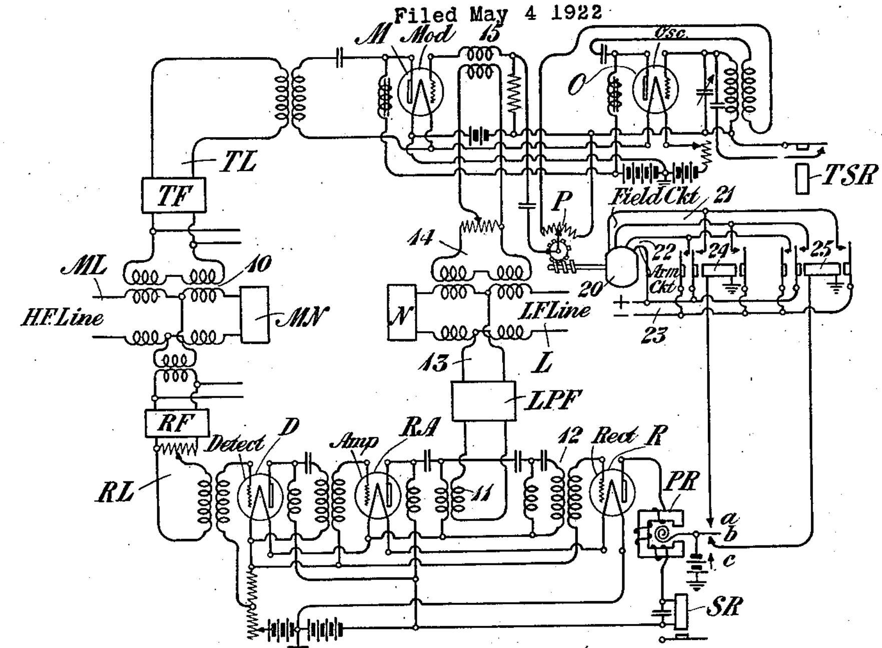
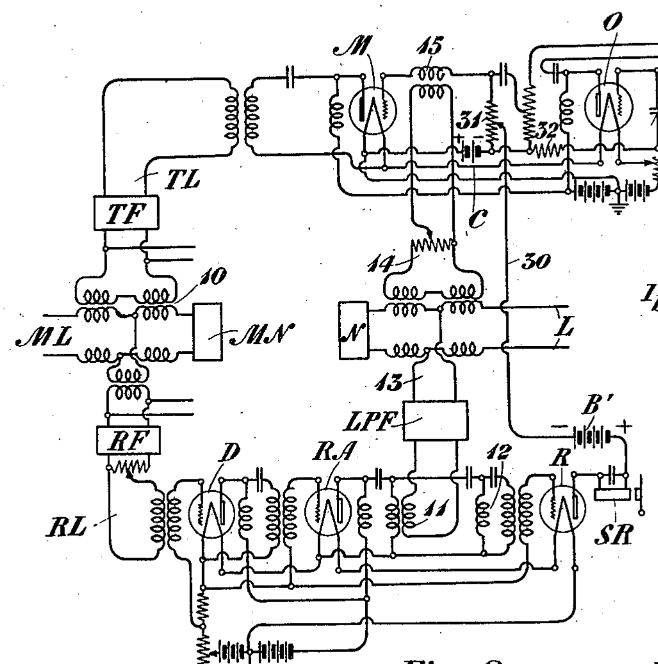


Fig. 1



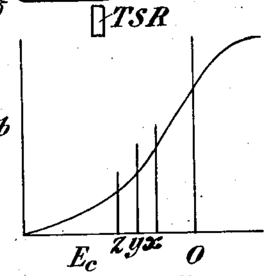


Fig. 3

Fig. 2

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UNITED STATES PATENT OFFICE.

LLOYD ESPENSCHIED, OF HOLLIS, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

TRANSMISSION REGULATION.

Application filed May 4, 1922. Serial No. 558,479.

To all whom it may concern:

Be it known that I, LLOYD ESPENSCHIED, residing at Hollis, in the county of Queens and State of New York, have invented certain Improvements in Transmission Regulations, of which the following is a specification.

This invention relates to multiplex signaling circuits, and more particularly to methods and arrangements for controlling the transmission over such circuits.

In a wire carrier or radio telephone system, the fluctuations in attenuation of the transmission medium or line produce corresponding variations in the over-all transmission equivalent of the voice circuit. In one well known type of carrier system, the carrier frequency itself is suppressed at the modulator end in connection with each channel and a fundamental frequency, which is relatively low, is transmitted to the receiving end of the circuit and by harmonic regeneration is caused to produce a synchronous carrier supply for the respective demodulators. The carrier supply in this case is transmitted at a frequency which is substantially independent of ordinary line attenuation fluctuations and the variations in line attenuation at the side band frequency causes a directly proportional variation in the over-all equivalent, there being substantially no fluctuation of the equivalent of the circuit due to the carrier component itself.

With the type of carrier system, however, in which the carrier frequency is transmitted along with the side band of each individual channel, the transmission fluctuations may be even more serious since in demodulation the resultant voice output may be, for normal operation of the demodulator, proportional to the product of the carrier and modulated side band. If, therefore, the attenuation of the intervening line or other transmission medium varies, approximately the same variation will take place for both the carrier and the modulater side band, and the resultant voice circuit variation, being proportional to the product of these factors, will be approximately double that of the line attenuation itself.

In accordance with the present invention, it is proposed to overcome the difficulties encountered in connection with the transmission fluctuations in the type of circuit in which the carrier frequency is transmitted along with the side band, by controlling some element of the transmission channel or circuit to vary the transmission of such element in accordance with the amplitude of the received carrier frequency. While the variation in the amplitude of the carrier, in response to different transmission conditions, may be utilized to adjust circuit conditions in either the transmitting or receiving portion of a given two-way channel, as the invention is herein specifically disclosed, the adjustment is made in the transmitting portion of the channel, so that the change in transmission conditions for transmission in one direction is made to regulate the conditions for transmission in the opposite direction. As similar operations will take place at both ends of the circuit, the adjustment will, of course, be made for transmission both ways. This adjustment or control may be exercised either electrically or mechanically in accordance with the present invention.

The invention may now be more fully understood by reference to the following description, when read in connection with the accompanying drawings, Figures 1 and 2 of which illustrate two circuit arrangements embodying the principles of the invention, and Fig. 3 of which shows a curve indicating the electrical control exercised by the carrier over the transmitting channel of Fig. 2.

Referring to Fig. 1, ML designates a high frequency carrier transmission circuit which may be either a wire line or a radio antenna. The circuit ML is balanced by the usual form of balancing network MN and is provided with a hybrid coil 10 for associating it with a transmitting channel TL and a receiving channel RL in such a manner that the transmitting and receiving channels will be substantially conjugate with respect to each other. Additional transmitting and receiving channels for multiplex operation may be provided if desired, but as the invention is only concerned with the operation of one pair of channels at a time, such additional channels have not been illustrated.

The receiving channel RL includes a band filter RF for selecting the desired side band and the corresponding carrier frequency. A demodulator or detector D is also provided for detecting the low frequency signal from the side band. This detector may be of any well known type but is illustrated as being a vacuum tube detector. A receiving amplifier RA is also provided in the receiving channel. While this amplifier is shown as a vacuum tube amplifier, any well known type of amplifying device may be used. The output circuit of this amplifier includes a transformer 11 through which the detected voice currents may be transmitted to the low frequency line L through a low-pass filter LPF. A rectifier R is associated with the output circuit of the amplifier RA through a filtering device 12, which is arranged to be highly selective to the carrier frequency employed, so that the unmodulated carrier component appearing in the output circuit of the detector D and amplifier RA will be impressed upon the rectifier R. This rectifier may be of any well known type, but is illustrated as being a vacuum tube rectifier. The rectifier includes in its output circuit a signalling relay SR for controlling the ringing signal at the receiving station and a polar relay PR for regulating the transmission of the transmitting channel in a manner to be described hereinafter.

The low frequency line L is balanced by the usual artificial line or network N and is provided with a hybrid coil for associating the low frequency line with the transmitting channel TL through the circuit 14. The connection is so arranged, in a manner well understood in the art, that the circuit 14 will be substantially conjugate with respect to the circuit 13 leading from the amplifying and detecting circuit. The circuit 14 is connected through a transformer 15 with the input circuit of a modulator M in the transmitting channel TL, said modulator being of any well known type, such for example, as a vacuum tube modulator. The carrier frequency is supplied to the modulator by means of an oscillator O, which may be of any well known type, but is illustrated as being a vacuum tube oscillator with the usual form of feed-back circuit. The circuit of the oscillator O is so tuned that it will oscillate at a desired frequency, but under the control of a signaling relay TSR the constants of the circuit may be so changed that oscillations will cease. In this manner ringing signals may be transmitted by the relay TSR by interrupting the carrier frequency which is normally generated by the oscillator O and transmitted to the modulator M over the line ML. The transmitting channel TL includes a suitable band filter TF designed to freely transmit the carrier frequency and one side band while suppressing frequencies corresponding to other channels.

The oscillator O is associated with the input circuit of the modulator M through an adjustable potentiometer P by means of which the amplitude of the oscillations from the oscillator O may be adjusted before being impressed upon the modulator M. This potentiometer may be adjusted by means of some mechanical device under the control of the polar relay PR in the receiving channel. As illustrative of a type of mechanical device which may be employed for this purpose, a motor 20 is illustrated, having a field circuit 21 and an armature circuit 22 supplied from common power leads 23. The relays 24 and 25 are provided for controlling the connections from the power leads to the armature circuit and field circuit, respectively, of the motor 20. Either relay closes the armature circuit and relay 24 connects the field winding for energization in one direction, while relay 25 connects the field winding for energization in the opposite direction. Depending upon which of these two relays is operated, therefore, the motor may be caused to rotate in either of two directions to adjust the setting of the potentiometer P. The circuits of relays 24 and 25 are controlled by the armature of the polar relay PR, which is so biased that, if a current of proper amplitude is flowing in the output circuit of the rectifier R, the armature will be held in its neutral position. If, however, the output current of the rectifier R is increased or decreased, one of the relays 24 or 25 is actuated to cause a corresponding operation of the motor 20.

The operation is as follows: Normally, when the circuit is not being used for the transmission of talking currents, the carrier will be transmitted over the line ML from the distant station and into the receiving channel RL, passing through the detector D, amplifier RA and being selected by the selecting device 12, and then passing into the input circuit of the rectifier R. A steady direct current will, therefore, flow in the output circuit of the rectifier R through the winding of the polar relay PR and the winding of the signal relay SR. When the carrier is interrupted to transmit a ringing signal, the direct current flowing through the relay SR will be interrupted and the armature of the relay SR will fall off to give a ringing signal at the receiving station in a well known manner.

If, while the carrier frequency is being transmitted, the transmission of the line ML should change, the amplitude of the carrier would be changed correspondingly, and the direct current flowing through the polar relay PR would be increased or decreased, depending upon whether the transmission efficiency of the line ML is increased or decreased. If this direct current is decreased, the biasing spring of the armature of the polar relay PR will move it against one of the contacts, say the lower one, and the relay 25 will be energized. Relay 25 will close the armature circuit of the motor 20 over its extreme left-hand contact, and over its other contacts will close the circuit of the field winding of the motor in such a direction that the motor will rotate to adjust the potentiometer to increase the amplitude of the oscillations transmitted from the oscillator O through the modulator M and the filter TF to the main line ML. The corresponding receiving apparatus at the distant station will at the same time operate in response to the lowered transmission efficiency of the line ML for the carrier frequency transmitted in the opposite direction and will adjust the potentiometer corresponding to P at the distant station to increase the amplitude of the carrier frequency transmitted through the distant modulator to the main line ML. The two potentiometers at the two stations will be operating in unison and the carrier frequency supplied by the oscillators at both stations will be increased in amplitude to such a point that the direct current flowing through the polar relay PR at the station illustrated, and the direct current flowing through the similar relay at the distant station, will be increased sufficiently to bring the armatures of the polar relays to neutral position. The adjustment will then cease and normal transmission conditions will obtain.

If the change in the transmission efficiency of the line was of such character as to increase the amplitude of the carrier current transmitted therethrough, the contact of the polar relay would be shifted to its upper contact to close the circuit of the relay 24. thereby causing the motor to adjust the potentiometer in the opposite direction to decrease the amplitude of the carrier current transmitted from the oscillator O to the distant station. A similar process would take place at the distant station and the adjustment would continue until the carrier frequencies transmitted in both directions were decreased in amplitude sufficiently to permit of the armatures of the polar relays, such as PR, again assuming their neutral position, when the adjustment would again cease. The interruption of the carrier frequency, in response to a ringing signal, would, by causing the direct current in the output circuit of the rectifier R to cease flowing, permit the armature of the polar relay PR to be shifted from its neutral position and thereby cause a false adjustment of the potentiometer P to take place, even though the transmission conditions be normal. This would be of no consequence, however, as the relay PR would cause an adjustment in the opposite direction as soon as the carrier frequency is again transmitted, owing to the increased carrier current flowing, by reason of the false adjustment of the circuit. The circuit would, therefore, be restored to normal immediately upon the cessation of the ringing signal. This difficulty may be eliminated, however, by employing a polar relay having three contacts, as shown at *a*, *b* and *c*. In the no-current condition of the output circuit of the rectifier, the armature of the polar relay would merely wipe over the intermediate contact *b*, and rest against the contact *c* without causing an adjustment of the transmission regulating apparatus. When the amplitude of the carrier frequency is gradually decreased, however, the armature of the relay makes contact with the intermediate contact *b* to operate the regulating apparatus.

The operation of regulating the transmission may also take place while the circuit is being used for talking purposes. Under such conditions, the side band and carrier are transmitted together over the line ML through the filter RF to the detector D. The detector D detects the low frequency voice currents from the side band by beating with the carrier frequency. The output circuit of the detector also includes a component of the unmodulated carrier frequency and this component, together with the voice currents, is impressed upon the amplifier RA and amplified. The voice currents are transmitted through the transformer 11 and the low-pass filter LPF to the line L. The higher frequency carrier, however, is selected by the selecting device 12 and transmitted to the rectifier R to maintain the armature of the polar relay PR in its neutral position, provided the transmission conditions are normal.

If, however, the transmission efficiency of the circuit ML is decreased, the amplitude of the unmodulated carrier component transmitted to the rectifier R will be decreased and the polar relay PR will cause the adjustment of the potentiometer P in the manner previously described. A similar operation will take place simultaneously at the other end and the amplitude of the carrier at both ends will be increased to make up for the decreased transmission efficiency of the line ML. Consequently, the amplitude of the low frequency voice currents transmitted to the line L will be maintained normal. Similarly, if the transmission efficiency of the line ML is increased, the unmodulated carrier component transmitted from the detector D to the rectifier R will cause the polar relay PR to set into action the adjustment in the opposite direction to decrease the amplitude of the carrier supply.

Instead of producing the regulation of the transmission under the control of the unmodulated carrier component by a mechanical means, as described in connection with Fig. 1, the same result may be accomplished electrically by means of the circuit illustrated in Fig. 2. The general arrangement of the circuit is similar to that of Fig. 1

and need not be described in detail. The plate circuit of the rectifier R, however, is connected through the signal relay SR, source B′ and over the conductor 30 to a point on resistance 31, which is in circuit with the grid of the modulator M. The normal grid potential of the modulator M and the oscillator O is derived from a battery C, one terminal of which is connected to the filament of the modulator M and the other terminal of which is connected to the common terminal of the resistances 31 and 32. The normal potential of the grid of the oscillator O will be determined by the drop through the resistance 32 and the normal potential of the grid of the modulator M will likewise be determined by the drop through the resistance 31. The plate circuit of the rectifier R may be traced from the grounded filament of the rectifier through the evacuated space of the tube to the plate, and then through the winding of the relay SR through battery B′ over the conductors 30 to a point along the resistance 31, and then through the lower part of the resistance 31 and through the battery C to the grounded filament of the modulator M. The battery C will usually be so poled as to make the grid of the modulator negative with respect to the filament. The battery B′ also tends to make the grid negative with respect to the filament.

Under normal transmission conditions of the line ML, with a carrier frequency of normal amplitude incoming over the line, a rectified direct current will flow in the circuit 30. The value of this rectified current will be such that the potential of the grid of the modulator M, due to the combined effect of the battery C and the rectified current flowing in the conductor 30, will give the desired operating characteristic for the vacuum tube M as a modulator.

Referring to the curve of Fig. 3, for example, which is a characteristic curve for the output of the modulator M plotted between grid potential and space current, it will be seen that the point of greatest curvature of the characteristic curve occurs at *x*, which corresponds to a condition in which the grid is a given number of volts negative. The point *x* is, therefore, the point in the characteristic curve at which the modulator M should be worked when the transmission conditions over the line ML are worst. The point *z* of the characteristic curve is a point at which some modulation will still occur, but the modulation efficiency of the tube will not be nearly so great as at the point *x*, because very little curvature occurs at this point. This point corresponds to a lesser negative potential of the grid of the tube and may be considered the point at which the modulator M should be worked when the transmission conditions of the line are best. The intermediate point *y* of the characteristic curve corresponds to what may be considered the average modulating efficiency of the tube M. The modulating tube should, therefore, be worked at this point when transmission conditions on the line ML are normal.

With a carrier frequency of normal amplitude in coming over the line ML, the rectified current flowing in the circuit 30, together with the potential from the battery C, should bring the grid of the modulating tube to the point in its characteristic corresponding to *y*. This may be accomplished by suitable adjustments of the potential of the batteries B′ and C and by a proper adjustment of the connection of the conductor 30 to the resistance 31. If the transmission efficiency of the line ML should be decreased, the amplitude of the carrier frequency incoming over the line will be decreased and the rectified direct current flowing in the circuit 30 will also be decreased, thereby rendering the grid of the modulator M less negative, so that the point of operation of the tube M will be shifted along its characteristic towards the point *x*. This will increase the modulating efficiency of the modulator M sufficiently to compensate for the decreased transmission of the line ML so far as transmission in the opposite direction is concerned. At the distant station, a similar operation will take place in connection with the transmitting and receiving channels at that station, so that the modulator at the distant station will have its efficiency increased sufficiently to compensate for the change in transmission in the direction toward the station illustrated. The detected low frequency voice currents will, therefore, remain at substantially the same amplitude, regardless of changes in the transmission over the circuit ML.

If the transmission efficiency of the line ML should be increased, the rectified direct current flowing in the circuit 30 will be increased, thereby rendering the grid of the modulator more negative, so that its operating point is shifted along the characteristic toward the point *z*. The modulating efficiency of the modulator will, therefore, be decreased sufficiently to compensate for the change in transmission over the circuit ML. A similar operation will take place at the distant station for transmission in the opposite direction.

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

What is claimed is:

1. The method of controlling transmis-

sion in a carrier system in which the carrier is transmitted along with the side band, which consists in transmitting the carrier and side band over a medium whose transmission is variable under different conditions, combining the carrier together with the side band by detection to produce the low frequency signaling wave represented by the side band together with an unmodulated carrier component, selecting the unmodulated carrier component thus produced, producing from the selected carrier a current having characteristics depending upon the transmission conditions to which the carrier has been subjected, and controlling the electrical characteristics of the transmission circuit in accordance with the characteristics of the current thus produced to compensate for the change in efficiency of the transmitting medium in at least one direction.

2. The method of controlling transmission in a carrier system in which the carrier is transmitted along with the side band, which consists in transmitting the carrier and side band over a medium whose transmission is variable under different conditions, combining the carrier together with the side band by detection to produce the low frequency signaling wave represented by the side band together with an unmodulated carrier component, selecting the unmodulated carrier component thus produced, producing from the selected carrier a direct current whose amplitude depends upon the transmission conditions to which the carrier has been subjected, and controlling the electrical characteristics of the transmission circuit in accordance with the amplitude of the direct current thus produced to compensate for the change in efficiency of the transmitting medium in at least one direction.

3. The method of controlling transmission in a carrier system in which the carrier is transmitted along with the side band, which consists in transmitting the carrier and side band over a medium whose transmission is variable under different conditions, selecting the carrier, rectifying the selected carrier to produce a direct current whose amplitude depends upon the transmission conditions to which the carrier has been subjected, and controlling the electrical characteristics of the transmitting medium by means of the rectified carrier current to compensate for the change in efficiency of the transmitting medium in at least one direction.

4. The method of controlling transmission in a two-way carrier transmission system in which a transmitting and receiving channel is provided at each of two intercommunicating stations and in which the carrier is transmitted along with the side band, which consists in transmitting the carrier and side band over a medium whose transmission is variable under different conditions, selecting the carrier in a receiving channel, producing from the selected carrier a current having characteristics depending upon the transmission conditions to which the carrier has been subjected, and controlling the electrical characteristics of the transmitting channel in accordance with the characteristics of the current produced from the carrier to compensate for changes in the efficiency of the transmitting medium with respect to transmission in the opposite direction.

5. The method of controlling transmission in a two-way carrier transmission system in which a transmitting and receiving channel is provided at each of two intercommunicating stations and in which the carrier is transmitted along with the side band, which consists in transmitting the carrier and side band over a medium whose transmission is variable under different conditions, selecting the carrier into a receiving channel, producing from the selected carrier a direct current whose amplitude depends upon the transmission conditions to which the carrier has been subjected, and controlling the electrical characteristics of the transmitting channel in accordance with the amplitude of said direct current to compensate for changes in the efficiency of the transmitting medium with respect to transmission in the opposite direction.

6. The method of controlling transmission in a two-way carrier transmission system in which a transmitting and receiving channel is provided at each of two intercommunicating stations and in which the carrier is transmitted along with the side band, which consists in transmitting the carrier and side band over a medium whose transmission is variable under different conditions, combining the carrier together with the side band by detection to produce low frequency signaling currents represented by the side band together with an unmodulated carrier component, selecting the unmodulated carrier component thus produced, producing from the selected carrier component a direct current whose amplitude varies in accordance with the transmission conditions to which the carrier has been subjected, and controlling the electrical characteristics of the transmitting channel in accordance with the amplitude of said direct current to compensate for changes in the efficiency of the transmitting medium with respect to transmission in the opposite direction.

7. In a system for controlling transmission, a transmitting medium over which the carrier is transmitted together with the side band, the transmission efficiency of said medium being variable under different conditions, a detector upon which the side band and carrier may be simultaneously impressed

to detect the low frequency signaling currents represented by the side band, means to select from the output of the detector the unmodulated carrier frequency component, means to produce from the selected carrier component a current having characteristics depending upon the transmission conditions to which the carrier has been subjected, a circuit element, and means for controlling said circuit element in accordance with the characteristics of the current thus produced to compensate for the change in efficiency of the transmitting medium in at least one direction.

8. In a system for controlling transmission, a transmitting medium over which the carrier is transmitted together with the side band, the transmission efficiency of said medium being variable under different conditions, a detector upon which the side band and carrier may be simultaneously impressed to detect the low frequency signaling currents represented by the side band, means to select from the output of the detector the unmodulated carrier frequency component, means to produce from the selected carrier component a direct current whose amplitude depends upon the transmission conditions to which the carrier has been subjected, a circuit element, and means for controlling said circuit element in accordance with the amplitude of said direct current to compensate for the change in efficiency of the transmitting medium in at least one direction.

9. In a system for controlling transmission, a transmitting medium over which the carrier is transmitted along with the side band, the transmission efficiency of said medium being variable under different conditions, means for selecting the carrier, a rectifying device to rectify the selected carrier to produce a direct current having an amplitude depending upon the transmission conditions to which the carrier has been subjected, a circuit element, and means for controlling said circuit element in accordance with the amplitude of the rectified current to compensate for the change in efficiency of the transmitting medium in at least one direction.

10. In a system for controlling transmission, a pair of intercommunicating stations, a transmitting medium over which the carrier is transmitted between said stations together with the side band, the transmission efficiency of said medium being variable under different conditions, a transmitting channel and a receiving channel at each station, means for selecting the carrier into the receiving channel after transmission, means to produce from the selected carrier a current having characteristics depending upon the transmission conditions to which the carrier has been subjected, a transmission element in the transmitting channel, and means to control said transmission element in accordance with the characteristics of the current produced in the receiving channel to compensate for changes in the transmission efficiency of the transmitting medium for transmission in the opposite direction.

11. In a system for controlling transmission, a pair of intercommunicating stations, a transmitting medium over which the carrier is transmitted between said stations together with the side band, the transmission efficiency of said medium being variable under different conditions, a transmitting channel and a receiving channel at each station, means for selecting the carrier into the receiving channel after transmission, means to produce from the selected carrier a direct current whose amplitude depends upon the transmission conditions to which the carrier has been subjected, a transmission element in said transmitting channel, and means to control said transmission element in accordance with the amplitude of said direct current to compensate for changes in the transmission efficiency of said transmitting medium with respect to transmission in the opposite direction.

12. In a system for controlling transmission, a pair of intercommunicating stations, a transmitting medium over which the carrier is transmitted between said stations together with the side band, the transmission efficiency of said medium being variable under different conditions, a transmitting channel and a receiving channel at each station, a detector in said receiving channel upon which said side band may be impressed together with the carrier to detect the low frequency signaling current represented by the side band, means to select the unmodulated carrier component from the output of said detector, means to produce from said selected carrier component a direct current whose amplitude depends upon the transmission conditions to which the carrier has been subjected, a transmission element in said transmitting channel, and means to control said transmission element in accordance with the amplitude of said direct current to compensate for the change in transmission efficiency of said transmitting medium with respect to transmission in the opposite direction.

13. In a system for controlling transmission, a pair of intercommunicating stations, a transmitting medium over which the carrier is transmitted between said stations together with the side band, the transmission efficiency of said medium being variable under different conditions, a transmitting channel and a receiving channel at each station, a detector in said receiving channel upon which the side band may be impressed together with the carrier for detecting the low frequency signaling currents represented by

the side band, means to select the unmodulated carrier component from the output of said detector, a rectifier for producing a rectified direct current from said selected carrier component, the amplitude of said rectified current depending upon the transmission conditions to which the carrier has been subjected, a modulator associated with said transmitting channel, a carrier source and a source of signaling currents associated with said modulator, and means to control an element of said transmitting channel in accordance with the amplitude of said rectified current to compensate for the transmission changes in said transmitting medium with regard to transmission in the opposite direction.

In testimony whereof, I have signed my name to this specification this 2nd day of May, 1922.

LLOYD ESPENSCHIED.