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B. G. BJORNSON

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TRANSMISSION CONTROL IN TWO-WAY SIGNAL TRANSMISSION SYSTEMS

Filed Dec. 1, 1931

2 Sheets-Sheet 1

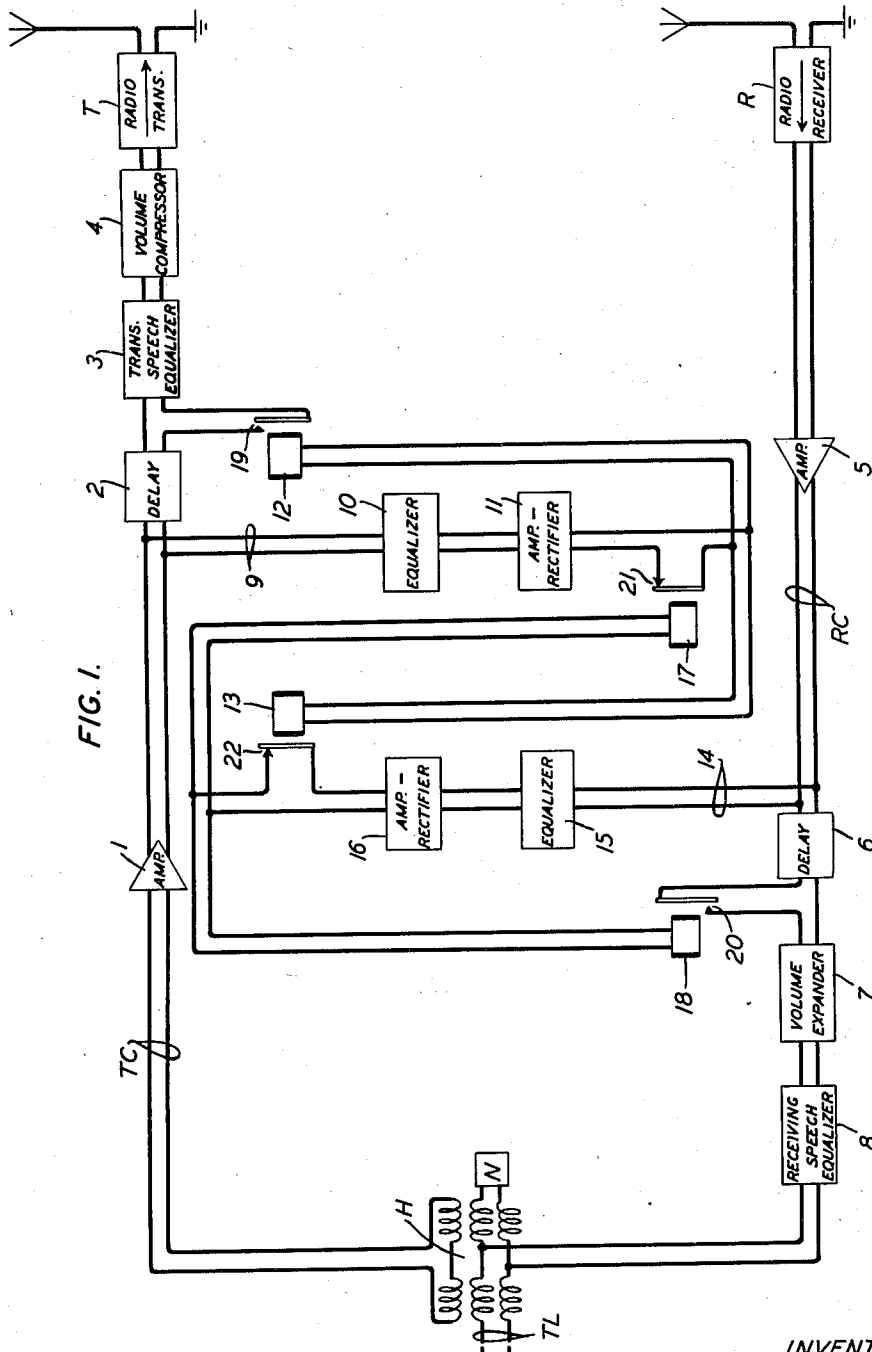


FIG. 1.

INVENTOR

B. G. BJORNSON

BY

H. A. Burgess

ATTORNEY

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2 Sheets-Sheet 2

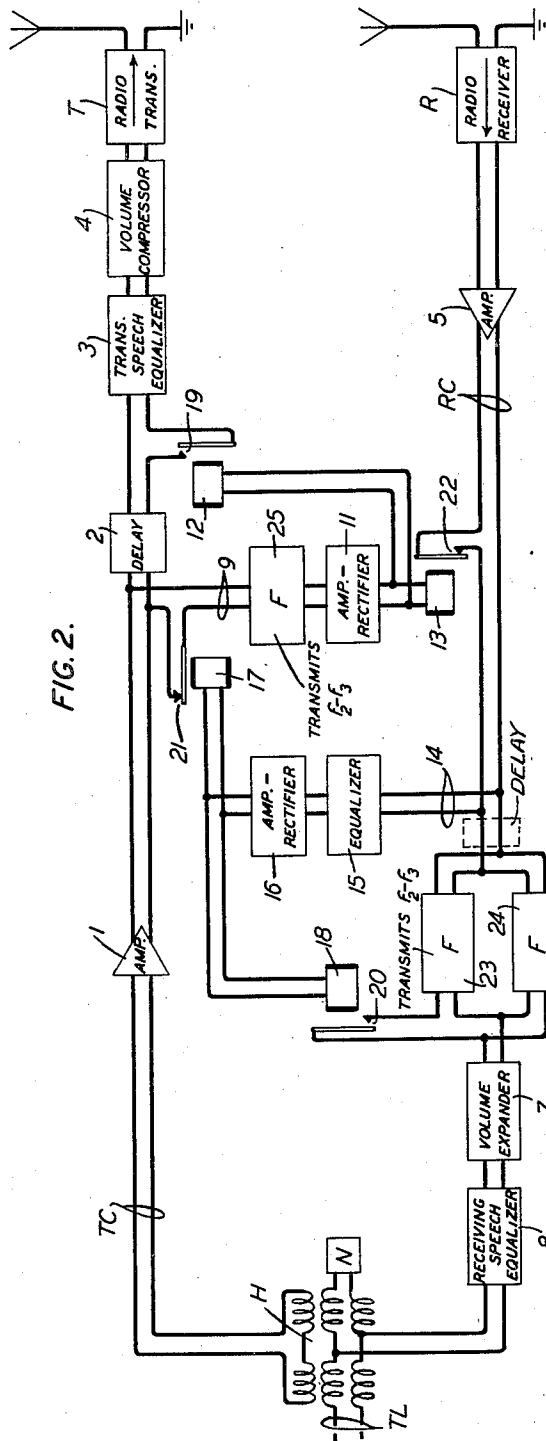


FIG. 2.

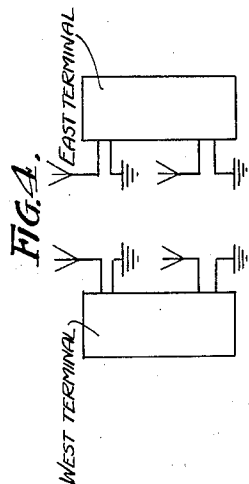


FIG. 4.

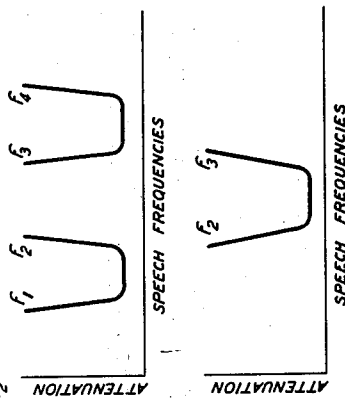


FIG. 3.

INVENTOR
B.G. BJORNSON
BY *H.A. Burgess*
ATTORNEY

UNITED STATES PATENT OFFICE

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TRANSMISSION CONTROL IN TWO-WAY
SIGNAL TRANSMISSION SYSTEMSBjorn G. Bjornson, Brooklyn, N. Y., assignor to
Bell Telephone Laboratories, Incorporated, New
York, N. Y., a corporation of New York

Application December 1, 1931, Serial No. 578,249

6 Claims. (Cl. 179—170)

This invention relates to transmission control in a telephone or other signaling system, particularly in a two-way signal transmission system comprising an intermediate noisy link, such as the radio part of a radio telephone system or a submarine cable in a submarine telephone cable system.

The invention has special reference to "full neutral" type four-wire telephone circuits, such as are used at the terminals of a long two-way transmission link in a two-way telephone transmission system. A "full neutral" terminal circuit may be defined as one which between periods of transmission is not in condition to transmit efficiently in either direction, but initiation of signal currents in either direction automatically controls apparatus to condition the terminal circuits for efficient transmission in that direction. Such circuits are particularly advantageous in radio telephone or submarine cable telephone systems in that their use simplifies the problem of automatic volume control, and separates the problems of protecting the signal-controlled switching circuits against land noise and static, which because of their substantially different characteristics require different treatments.

It is an object of the present invention to improve transmission over a two-way signal transmission system subject to interfering noise.

In accordance with the present invention, properly designed signal-distorting transmission elements are used in the one-way transmission paths at the terminals of a two-way transmission medium in a two-way signal transmission system, for example, at the terminals of the radio or cable link in a two-way radio or submarine cable telephone system, for so reducing the effects of noise on the signal-controlled switching circuits as to enable substantially full neutral operation of the system to be used. This is accomplished in part in one embodiment by making the signal-controlled, switching circuit associated with the transmitting circuit at each terminal selectively responsive to a band of frequencies in which the amount of line noise is ordinarily low so as to prevent false operation by noise, and by utilizing mutually exclusive filters in the receiving path at each terminal to prevent false operation of the transmitting control circuit by energy received from the radio link or cable. A distortion transmission element in the transmitting path operating to raise the signal-to-noise ratio is utilized to improve the operation of the signal-controlled, receiving control at the distant terminal.

The exact nature and advantages of the invention will be better understood from the following detailed description thereof when read in connection with the accompanying drawings, in which:

Figs. 1 and 2 show schematic diagrams of a radio terminal for a two-way radio telephone transmission system such as shown diagrammatically in Fig. 4, embodying different modifications of the invention; and

Fig. 3 shows the attenuation-frequency characteristics of the filters in the transmission paths of the terminal of Fig. 2.

For convenience the invention will be described as applied to systems for the two-way transmission of speech waves, but it is apparent that the principles thereof apply equally well to systems for the transmission of signal waves in general comprising frequencies within or outside the speech frequency range, such as waves representing speech, entertainment program comprising music, as well as speech, etc.

The terminal systems of the invention are particularly suitable for use in a two-way radio telephone system such as shown diagrammatically in Fig. 1. In such a system, the terminal circuits at the west and east terminals would preferably be identical, that is, the system would comprise at both terminals the circuit arrangement of the invention as shown in Fig. 1, or alternatively at both terminals the circuit arrangement of the invention such as shown in Fig. 2.

The terminal shown in Fig. 1 comprises a four-wire circuit connecting a telephone line to a radio transmitter and a radio receiver which may be of any well known type or construction. The four-wire circuit comprises a transmitting circuit TC leading to the radio transmitter T and a receiving circuit RC leading from the radio receiver R. The input of the transmitting circuit TC and the output of the receiving circuit RC are connected in energy transmission relation with the telephone line TL and in substantially conjugate relation with each other by means of the three winding transformer or hybrid coil H and balancing network N in well known manner. The transmitting circuit TC comprises between the hybrid coil H and the radio transmitter T, in order the one-way amplifying device 1, the delay circuit 2, the transmitting speech equalizer 3 and the volume compressor 4. The receiving circuit RC comprises in order between the hybrid coil H and the radio receiver R, the one-way amplifier 5, the delay circuit 6, the volume expander 7 and the receiving speech equalizer 8.

Connected across the transmitting circuit TC between the output of the amplifying device 1 and the delay circuit 2 is the input of a control path 9 comprising an equalizer 10, the signal-controlled, relay-controlling device 11, which may be a vacuum tube amplifier-rectifier of well known type, and the windings of mechanical relays 12 and 13 connected in parallel with the output of the device 11. Connected across the receiving circuit RC between the output of the amplifying device 5 and the delay circuit 6, is the input of a control path 14 comprising the equalizer 15, the signal-controlled, relay-controlling device 16, similar to the device 9, and the windings of mechanical relays 17 and 18 connected in parallel with the output of the device 16.

In the transmitting circuit TC between the radio transmitter T and the delay circuit 2 are the normally open switch contacts 19 adapted to be closed by operation of the relay 12. In the receiving circuit RC between the hybrid coil H and the delay circuit 6 are the normally open switch contacts 20 adapted to be closed by operation of the relay 18. In the control path 9 between the output of the control device 11 and the windings of mechanical relays 12 and 13 are the normally closed switch contacts 21 adapted to be opened by operation of relay 17. In the control path 14 between the output of the control device 16 and the windings of relays 17 and 18 are the normally closed switch contacts 22 adapted to be opened by operation of the relay 13.

It will be noted that the radio terminal station which has just been described is of the type known in the art as "full neutral", that is, both the transmitting circuit and the receiving circuit are normally inoperative to transmit, but are respectively responsive to signals impressed on their inputs to make them operative to transmit said signals efficiently to the radio transmitter T and telephone line TL, respectively.

The transmitting speech equalizer 3 and the corresponding speech equalizer in the transmitting path at the distant radio terminal of the system (not shown) are networks designed to so distort the signal energy in transmission there-through as to compensate for or neutralize the effects of distortion inherent in the transmission paths, for example, static in the radio link of the system, or distortion produced by the operation of the transmission apparatus in the wire paths of the system. These distortion networks may be similar to those disclosed for a similar purpose in the patent to Hartley, No. 1,737,843, issued December 3, 1929, the patent to Affel No. 1,819,054, issued August 18, 1931 or in the patent to H. W. Dudley, No. 1,832,366 issued November 17, 1931 and the patent to Mathes et al, No. 1,844,422 issued February 9, 1932. They operate in general to improve the signal-to-noise ratio by distorting the speech wave so that its energy distribution brings the various separate frequency components in the distorted speech waves on the average to higher energy levels than the corresponding noise components.

The distortion characteristic of the transmitting equalizers may be made of any desired shape depending on the distortion factors to be corrected in a particular system. In a particular case, for example, it may be desired to compensate for the inefficiency of the ordinary telephone transmitter at the low and high frequencies, in which case the transmitting equalizer would be designed so as to boost the low and high frequencies in the transmitted signals while leaving

the amplitude level of the intermediate frequency components unchanged. In general, the transmitting equalizer should be designed to give the most satisfactory operation of the signal-controlled circuit at the distant terminal when the circuit is operated "full neutral" as shown in Fig. 1. The particular location of the transmitting equalizer in the transmitting path is of no importance. It may be located in front of the transmitting control circuit 9 as shown, in back of the transmitting control, or partly in front and partly in back of the transmitting control. It may, and generally will be, advantageous to make part of the correction for the distortion produced by the system at the receiving end as well as at the transmitting end, as by the use of the receiving speech equalizer 6 in the output of receiving path as shown in Fig. 1. In some cases, it may be desirable to give the transmitting speech equalizers and the receiving speech equalizer complementary characteristics. The circuits of the transmitting and receiving speech equalizers may be of any suitable design but are preferably of the constant resistance network type as disclosed in the patent to Zobel No. 1,603,305, issued October 19, 1926 and as more fully dealt with in the article by Zobel published in the Bell System Technical Journal for July, 1928, pages 438 to 534 inclusive.

The equalizer 15 in the receiving control circuit 14 is especially designed with respect to the transmitting speech equalizer at the distant terminal so that the receiving control will be most sensitive over the whole range of received speech frequencies when the distant terminal is transmitting. The equalizer in the transmitting control circuit 9 is designed so that the transmitting control will be most sensitive for the whole range of speech frequencies transmitted to the radio transmitter T while being inoperative by the line noise impressed upon its input. These equalizers may be designed in accordance with the principles disclosed in the Zobel patent and the Zobel article referred to above.

The volume compressor 4 in the transmitting circuit TC and the corresponding volume compressor in the transmitting circuit at the distant terminal are utilized to increase the ability of the receiving control circuit at the opposite terminal to operate the associated switching relays. They accomplish this by compressing the volume of the speech energy before it is supplied to the radio transmitter for transmission to the distant station, in such manner as to raise the level of the speech of low amplitude above the level of the static which will be encountered in the radio link of the system. The volume expander 7 in the receiving circuit RC at the terminal shown in Fig. 1 and the corresponding volume expander in the receiving circuit at the distant terminal are designed to expand the volume range of the speech waves impressed on their inputs to bring these waves to the normal amplitude level which they had at the transmitting terminal. These volume compressors and expanders may be of any of the types disclosed in R. C. Mathes Patent 1,757,729 issued May 6, 1930, Crissom Patent 1,737,830, issued December 3, 1929, or in the corresponding application of N. C. Norman filed January 27, 1931.

The operation of the system of Fig. 1 will now be described. Speech waves received over the telephone line TL are impressed by the hybrid coil H upon the transmitting circuit TC and amplified therein by the amplifying device 1. The

amplified waves in the output of the amplifying device 1 are divided between the delay circuit 2 in the main transmission circuit TC and the input of the transmitting control circuit 9. The portion diverted into control circuit 9 will be transmitted through the equalizer 10 which operates in well known manner to equalize the energy level of the different speech frequency components impressed thereon so that the energy output of the device 10 will be substantially constant irrespective of the frequencies impressed on the input of the device 10. The waves in the output of the equalizer 10 will be impressed on the control device 11 causing its operation and thus the energization of the windings of mechanical relays 12 and 13 connected to the output of the device 9.

Relay 12 will then operate to close switch contacts 19 in transmitting circuit TC making that path operative to transmit from the output of the delay circuit 2 to the transmitting speech equalizer 3. Meanwhile, the main portion of the speech waves in the output of the amplifying device 1 in the transmission circuit TC is being transmitted through delay circuit 2. The delay circuit is designed to introduce sufficient delay in the transmission therethrough of the speech waves to prevent their arrival at the disabling point in the output of the delay circuit 2 before the switch contacts 19 have been closed by operation of relay 12, thus preventing loss of any part of the speech signals. Relay 13 operates simultaneously with relay 12 to open switch contacts 22 in the output of the receiving control circuit 14, thus preventing subsequent operation of the control device 16 in response to waves in the receiving circuit RC from causing false operation of relays 17 and 18. The transmitting speech equalizer 3 in the main transmission circuit TC operates in the manner described above to distort the waves received from the output of the delay circuit 2 so as to compensate for the distortion inherent in the transmission path or the transmission apparatus therein. The distorted waves are impressed on the input of the volume compressor 4 which operates in the manner described in the patents and applications referred to above to raise the speech waves of low amplitude above the level of the static which will be encountered in the radio link of the system. The distorted waves are then radiated by the radio transmitter T to the distant radio terminal.

The operation of the system at the east radio terminal in response to the waves radiated from the west terminal shown in the drawings, will be clear from a description of the operation of the corresponding receiving apparatus at the west terminal.

The energy radiated from the distant radio terminal will be received by the radio receiver R and the speech signals detected therefrom in the usual manner. The detected speech signals will be amplified by the receiving amplifying device 5, and the amplified signals in the output of the device 5 will be divided between the delay circuit 6 in the main receiving circuit RC and the input of the receiving control circuit 14.

The portion of the amplified speech signals diverted into the control circuit 14 will be transmitted through the equalizer 15 which operates in well known manner to equalize the energy level of the different speech frequency components impressed thereon so that the energy out-

put of the device 15 will be substantially constant irrespective of the frequencies impressed on its input. The waves in the output of the equalizer 15 will be impressed upon the control device 16 causing its operation and thus the energization of the windings of relays 17 and 18 connected to its output.

Relay 17 will then operate to open normally closed switch contacts 21 in the output of the transmitting control circuit 9 thereby preventing subsequent operation of the control device 11 in that circuit in response to waves from the transmitting circuit TC from causing false operation of relays 12 and 13.

Relay 18 will operate simultaneously with relay 17 to close normally open switch contacts 20 in receiving circuit RC thereby making that circuit operative to transmit from the output of the delay circuit 6 to the volume expander 7. Meanwhile, the main portion of the speech waves in the output of the amplifying device 5 in the receiving circuit RC is being transmitted through delay circuit 6. The delay circuit 6 is designed to introduce sufficient delay in the transmission therethrough of the speech waves to prevent their arrival at the disabling point in the output of the delay circuit 6 before the switch contacts 20 thereat have been closed by operation of relay 18, thus preventing loss of any part of the signal in transmission to the volume expander 7.

The volume expander 7 operates in the manner described in the patents and application referred to above to expand the volume range of the received signals to bring them back to the normal amplitude levels which they had at the input of the volume compressor in the transmitting circuit at the distant terminal. The receiving equalizer 8 then operates on the expanded waves in a manner similar to that of the transmitting equalizers 3 in the transmitter circuit TC, to correct for any part of the distortion introduced in the signal waves in transmission over the system, which has not been corrected by the transmitting speech equalizer in the transmitting circle at the distant terminal.

The corrected speech waves in the output of the receiving speech equalizer 8 are then impressed by the hybrid coil H on the telephone line TL over which they are transmitted to the listening subscriber.

Fig. 2 shows one radio terminal of a two-way radio telephone system embodying a modification of the invention. The circuits of that terminal station differ from those in the terminal station shown in Fig. 1 in the following particulars.

Connected in the receiving circuit RC between the point of connection of the receiving control circuit 14 thereto and the input of the volume expander 5 are the mutually exclusive band-pass filters 23 and 24. The input of band-pass filter 24 is connected to the output of the amplifying device 5 in the receiving circuit RC beyond the point of connection of the control circuit 14 thereto, and its output is connected directly to the input of the volume expander 7. Thus, the filter 24 is at all times in condition to transmit the waves within its transmission frequency range from the output of the amplifying device 5 to the volume expander 7 in the output of the receiving circuit RC. The input of the band-pass filter 23 is connected to the receiving circuit RC in parallel with the input of band-pass filter 24, beyond the point of connection of the input of control circuit 14 thereto, but its output is normally disconnected from the input of the volume

expander 7 by means of the open switch contacts 20. The contacts 20 are adapted to be closed in response to operation of relay 18 to connect the output of the filter 23 to the input of volume expander 7.

As indicated by its attenuation-frequency characteristic shown in the upper portion of Fig. 3, the filter 24 is adapted to transmit with little attenuation a band of frequencies in the lower portion of the speech frequency range, ranging from a low frequency f_1 to a higher frequency f_2 , and a band of frequencies in the upper part of the speech frequency range, ranging from a frequency f_3 to a higher frequency f_4 , and to effectively suppress the intermediate frequency band ranging from the frequency f_2 to the frequency f_3 . As indicated by its attenuation-frequency characteristic shown in the lower portion of Fig. 3, the band-pass filter 23 is designed to transmit with little attenuation the frequency band f_2 — f_3 and to substantially suppress from transmission the frequency bands f_1 — f_2 and f_3 — f_4 . In the circuit of Fig. 2, the band-pass filter 25 is used in the transmitting control circuit 9 in place of the equalizer 10 shown in Fig. 1. The band-pass filter 25, as in the case of the filter 23 in the receiving circuit RC, is designed to transmit with little attenuation the frequency band f_2 — f_3 and to substantially suppress from transmission the frequency bands f_1 — f_2 and f_3 — f_4 .

In the circuit of Fig. 2, the normally closed switch contacts 22 adapted to be opened by operation of relay 13 connected to the output of the control device 11 in the transmitting control circuit 9 are located in the receiving circuit RC between the point of connection of the receiving control circuit 14 thereto and the output of the amplifying device 5, instead of being located in the output of the receiving control circuit 14 in the output of the control device 16 as in the circuit of Fig. 1.

In the circuit of Fig. 2, the normally closed switch contacts 21 adapted to be opened by operation of relay 17 are located in the input of the transmitting control circuit 9 instead of in the output of that circuit as in Fig. 1.

If the filter 23 in the receiving circuit RC does not produce sufficient delay in the transmission of the frequency band f_2 — f_3 therethrough in response to speech waves received from the output of the radio receiver R when the distant terminal is transmitting, to prevent any portion of that band reaching the disabling point in the output of filter 23 before the switch contacts 20 have been closed in response to the operation of relay 18, it may be necessary to utilize an additional delay circuit in receiving circuit RC, as indicated by the dotted box, for that purpose.

The frequencies within the band f_2 — f_3 transmitted by filters 23 and 25 and suppressed by filter 24 may be any frequencies within the speech frequency range which in line noise contains very little energy.

It will be seen that the circuit of Fig. 2 as described is what may be called a "semi-full neutral" circuit inasmuch as the transmitting circuit is normally inoperative to transmit waves of any frequencies, and the receiving circuit is normally inoperative for transmission of waves of certain frequencies within the speech frequency range; and each circuit is responsive to initiation of speech energy therein to become fully operative to transmit efficiently waves of all frequencies in the speech frequency range to the radio transmitter or to the telephone line TL, respectively, as will be

indicated by the following description of operation.

Let it be assumed that speech waves from a subscriber associated with the telephone line TL are being received at the west radio terminal station. These speech waves will be impressed by the hybrid coil H upon the transmitting circuit TC and amplified by the amplifying device 1 therein. The amplified waves in the output of the amplifying device 1 will be divided between the input of the delay circuit 2 in the transmitting circuit TC and the input of the transmitting control circuit 9. Of the portion diverted into the control circuit 9, those frequencies within the range f_2 — f_3 will be selected by the filter 25 and will cause the operation of the control device 11 to energize the windings of the relays 12 and 13. Relay 12 will operate to close its normally open switch contact 19 thereby making the transmitting circuit TC operative to transmit the main portion of the speech waves which has been delayed in transmission through the delay circuit 2, through the transmitting speech equalizer 3 and volume compressor 4 to the radio transmitter T for radiation to the distant radio terminal associated with the listening subscriber.

The relay 13 will operate simultaneously with relay 12 to open the normally closed switch contact 22 in the receiving circuit RC thereby making that circuit inoperative thereafter to transmit any waves which may be subsequently received from the radio receiver R, to the telephone line TL or to the input of the receiving control circuit 14, thus preventing interference or false switching.

Now let it be supposed that the west radio terminal station shown in the drawings is not transmitting and that a subscriber associated with the distant radio terminal starts to talk so that corresponding energy is transmitted by the distant radio transmitter. This energy will be received by the radio receiver R at the west terminal and the voice signals detected therefrom in the usual manner. The detected voice currents are amplified by the amplifying device 5 in the receiving circuit RC and the amplified waves divided between the inputs of the filters 23 and 24 and the input of the receiving control circuit 14. The portion diverted into receiving control circuit 14 after equalization by the equalizer 15 causes the operation of the control device 16 to energize the relays 17 and 18 connected to the output thereof. Relay 17 operates to open the normally closed switch contacts 21 in the input of the transmitting control circuit 9 thereby preventing false operation of that circuit by energy subsequently initiated in the transmitting circuit TC to render the output of the transmitting circuit operative and the input of receiving circuit RC inoperative, during the period of receiving signals.

Relay 18 operates simultaneously with relay 17 to close normally open switch contacts 20 in the output of the filter 23 in receiving circuit RC thereby connecting that filter to the input of the volume expander 5 so that the received signals within the frequency range f_2 — f_3 (the transmission range of filter 23) will be transmitted over the outgoing portion of the receiving circuit RC to the telephone line TL along with the received signals within the frequency ranges f_1 — f_2 and f_3 — f_4 which have been transmitted through the filter 24.

The transmitting speech equalizer 3, the volume compressor 4, the receiving speech equalizer 8 and the volume expander 7 have the same

functions in the system of Fig. 2 as in the system of Fig. 1 previously described.

It will be noted from the above description of Fig. 2 that the receiving circuit RC is never operative to transmit speech signals within the frequency band f_2 — f_3 when the transmitting control circuit 9, which is selective to that band, is operative, but that the receiving circuit RC is at all times operative to transmit the frequency bands f_1 — f_2 and f_3 — f_4 which will not operate the transmitting control circuit 9. Thus, any unbalance energy which might be transmitted from the receiving RC to the transmitting circuit TC through hybrid coil H can not cause false operation of the transmitting control. By making the filter 25 in the transmitting control circuit 7 selective only to a frequency band f_2 — f_3 in which the amount of line noise energy is ordinarily low, and preventing that frequency band from being transmitted over the output of the receiving circuit RC when the transmitting control circuit 9 is operative, it is apparent that the transmitting control may be set at maximum sensitivity without danger of false operation by any unbalance noise energy which might be transmitted from the receiving circuit RC to the transmitting circuit TC through the hybrid coil H.

It is to be understood that the invention is not limited to the particular circuits and details thereof which have been illustrated and described, which have been given by way of example only, as many modifications within the scope and spirit of the invention will be apparent to persons skilled in the art.

What is claimed is:

1. A circuit for transmitting signal energy between a two-way signal line subject to noise and a two-way transmission medium, comprising one one-way path for transmitting from said line to said medium and another one-way path for transmitting from said medium to said line, control means responsive only to signal waves received from said line, of certain frequencies at which the noise level in said line is low, for disabling said other one-way path while allowing transmission between said line and said medium over said one one-way path, means in said other one-way path normally preventing transmission thereover between said medium and said line of waves of said certain frequencies, means responsive to waves received from said medium for disabling said control means, and for substantially simultaneously increasing the effective frequency transmission range of said other one-way path to include said certain frequencies.

2. A circuit for transmitting signal energy between a two-way signal line subject to noise and a two-way transmission medium also subject to noise, comprising one one-way path for transmitting from said line to said medium and another one-way path for transmitting from said medium to said line, control means responsive to signal waves from said line of frequencies at which the amplitude level of line noise is low, for disabling said other one-way path, while allowing transmission of waves from said line to said medium, means responsive to waves received by said other one-way path from said medium for disabling said control means, and for increasing the effective frequency transmission range of said other one-way path to include said certain frequencies, and means in said one one-way path for raising the amplitude level of all frequency components in the signals transmitted

to said medium above the amplitude level of the noise inherent therein.

3. The circuit of claim 1 and in which transmission of said certain frequencies over said other one-way path is prevented by a filter therein designed to effectively suppress said certain frequencies while passing other frequencies, and in which the effective frequency transmission range of said other one-way path is increased by means operating in response to waves received from said medium for connecting another filter in said other path in parallel to the first filter, said other filter being adapted to transmit waves of said certain frequencies.

4. A two-way telephone transmission system subject to line noise and comprising a two-way signal transmission medium, a terminal circuit therefor normally disabled from transmitting to said medium and normally operative to receive therefrom only waves of certain frequencies within the speech frequency range at which the line noise level is low, receiving control means responsive to speech waves incoming from said medium to render said receiving circuit completely operative to receive speech waves of all frequencies, a source of speech waves to be transmitted to said medium, transmitting control means selectively responsive to the speech waves from said source of frequencies other than said certain frequencies only to render said terminal circuit operative to transmit speech waves from said source to said medium, and to disable said receiving control means, and means also responsive to the speech waves incoming from said medium to disable said transmitting control means.

5. A two-way signal transmission system comprising a two-way signal transmission medium and a terminal circuit at each end of said medium comprising a normally disabled transmitting circuit, a normally disabled receiving circuit, an equalizing circuit in said transmitting circuit designed to correct for the distortion in said system at certain frequencies, control means connected to said transmitting circuit, control means connected to said receiving circuit, said control means connected to said transmitting circuit being responsive to signal transmission therein to render said transmitting circuit operative to transmit to said medium, and to disable said control means connected to said receiving circuit, said control means connected to said receiving circuit being responsive to signals from said medium to render said receiving circuit operative to receive the signals from said medium, and to disable the control means connected to said transmitting circuit, and equalizing means in the input of the receiving circuit control means designed with respect to the equalizing means in the transmitting circuit of the opposite end terminal circuit to make said receiving circuit control means responsive to received waves of substantially all frequencies in the voice frequency range.

6. A two-way signal transmission system comprising a two-way signal transmission medium subject to noise, a terminal circuit at each end of said medium comprising a normally disabled transmitting circuit, a receiving circuit at least partially disabled normally, control means connected to said transmitting circuit, and other control means connected to said receiving circuit, said control means connected to said transmitting circuit being responsive to signal waves therein to render that circuit operative to trans-

mit said waves to said medium, and to disable said other control means, said other control means connected to said receiving circuit being responsive to signal waves received thereby from
5 said medium to disable said control means connected to said transmitting circuit, and to render said receiving circuit completely operative to transmit the received signal waves, and means for improving the operation of said other control means, comprising means in the transmitting circuit of the opposite end terminal circuit for raising the amplitude level of the low amplitude signal waves therein above the level of the noise inherent in said medium, so as to allow said other control means to be set at maximum sensitivity to operation by signals while preventing its operation by noise. 5

BJORN G. BJORNSON.