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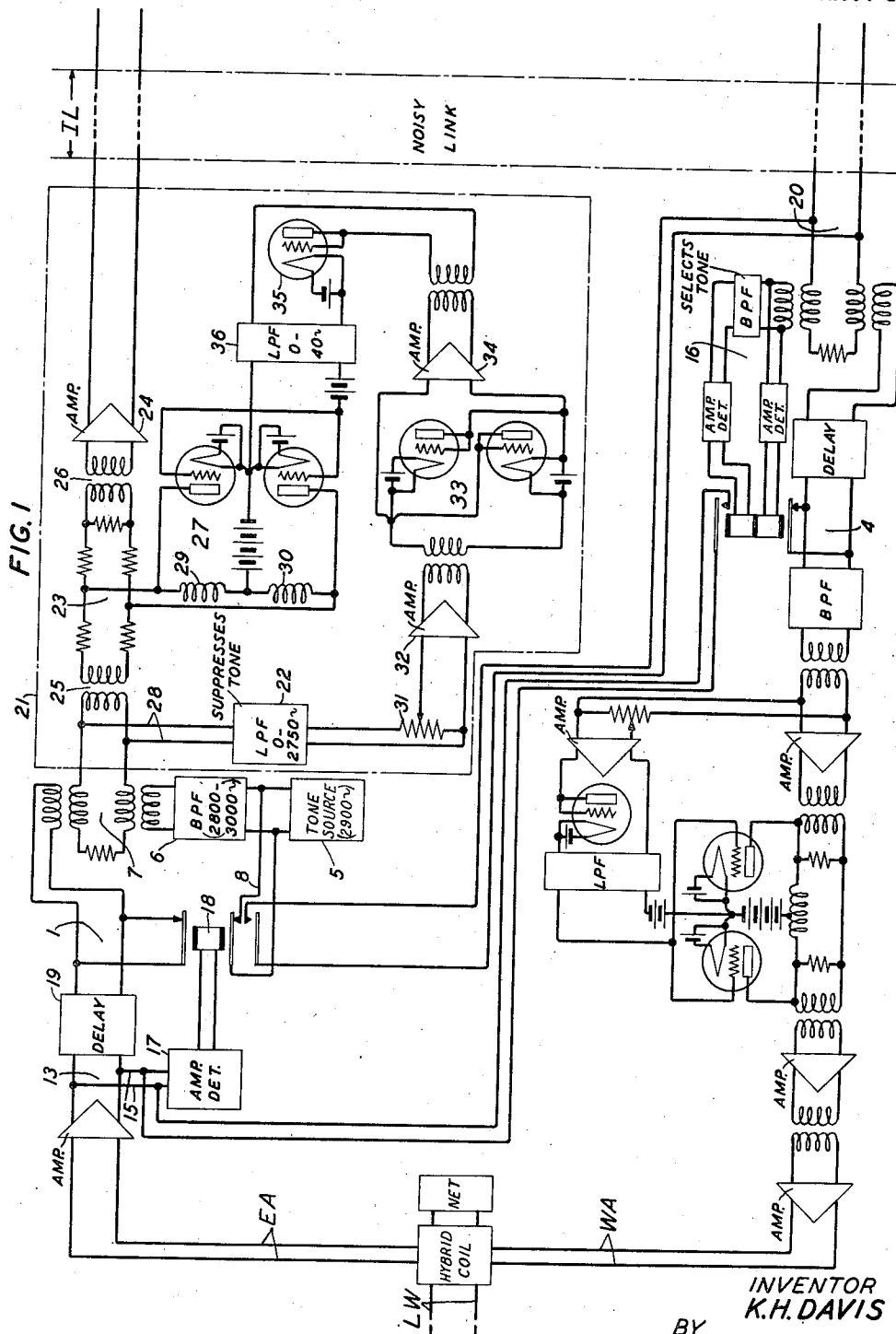
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2,206,080

TRANSMISSION CONTROL AND SIGNALING SYSTEM

Filed April 27, 1939

2 Sheets-Sheet 1



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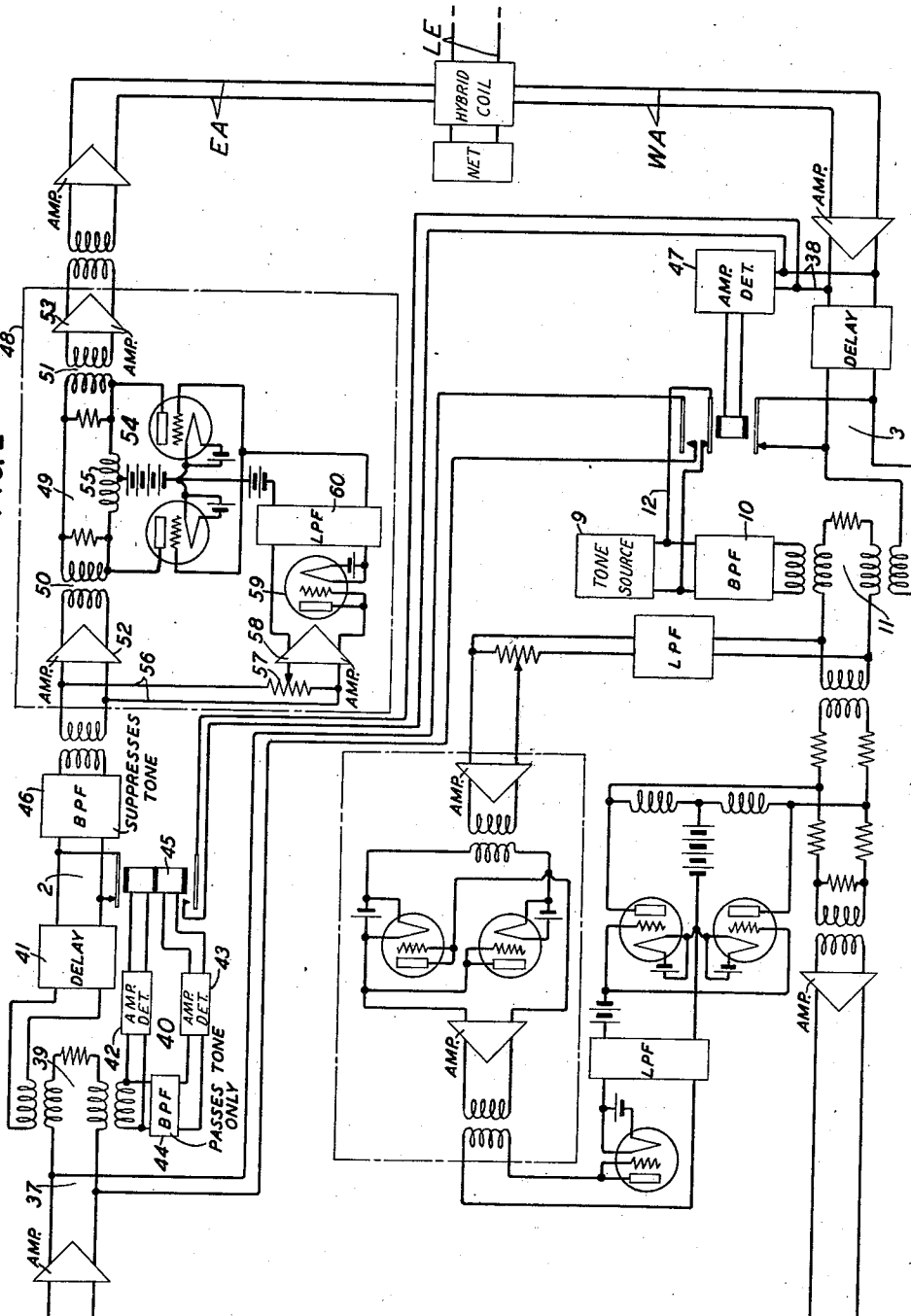
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FIG. 2



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TRANSMISSION CONTROL AND SIGNALING SYSTEM

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7 Claims. (Cl. 179—170)

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

It is an object of the present invention to improve transmission over a signal transmission system subject to interfering waves.

In the prior art, it is known to employ in a transmitting path at a terminal of a radio or wire telephone system, apparatus operating to compress the volume range of the transmitted signals before they are transmitted through an intermediate link in the system of limited volume range capacity and subject to noise, static or other interference, in such manner as to bring it within the useful transmission range of that link, and to raise the level of the signals of low amplitude above the level of the interfering waves, thus increasing the protection against false operation of the signal-controlled switching circuits employed at the receiving terminal for preventing singing and suppressing echoes, and in some cases also to employ in the receiving circuit at each terminal of the system beyond the point of connection of the switching apparatus thereto similar apparatus operating in inverse manner to expand the volume range of the received signals, to restore them to their original amplitude relations. Such volume range compressors and expanders so used are disclosed, for example, in Norman Patent No. 1,922,602, issued August 15, 1933, or Bjornson Patent No. 1,987,986, issued January 15, 1935.

It is also known in the prior art, as disclosed in Mitchel Patent 2,098,350, issued November 9, 1937, to employ in connection with a signaling system including a variable or noisy link, control energy of distinctive frequency, the magnitude of which is made to vary inversely with variation of the magnitude of the applied signal energy, transmitted over the system through the variable link along with the signals, to supplement the signal energy in controlling wave-responsive transmission control devices for preventing singing and suppressing echoes, on the receiving side of the variable link, in such manner that positive operation of these devices is attained whether the signal level is high or low and in the presence of interfering energy received from the variable link.

In accordance with the present invention, a system similar to that disclosed in the afore-

mentioned Mitchel patent is improved by utilizing a single compressor at the transmitting end of the system to compress the transmitted signals and to make the magnitude of the transmitted control energy vary inversely with the magnitude of the compressed signal energy, thereby providing increased protection against false operation of the transmission control devices by noise or other interfering energy with economy of apparatus.

The invention will be better understood from the following detailed description thereof when read in conjunction with the drawings in which:

Figs. 1 and 2 when placed side by side with Fig. 1 at the left show diagrammatically, and in part schematically, a long two-way telephone system embodying the invention.

In the system shown in Figs. 1 and 2, the west two-way line section LW and the east two-way line section LE are respectively coupled by the usual hybrid coils and associated balancing networks to the east and west terminals of a long four-wire telephone circuit comprising a west-to-east one-way repeating path EA and an east-to-west repeating path WA, each including a number of one-way amplifiers located at spaced intervals along the path, as indicated.

The four-wire circuit includes an intermediate two-way transmission link IL, the transmission characteristics of which may change from time to time (from external or internal causes) so as to result in the transmission of interfering energy over the system along with the signals, or more specifically, a link subject to noise, static, signal fading (in the case of radio transmission) or change of impedance. This intermediate link IL may comprise two long two-wire lines, respectively joining the west and east portions of the repeating paths EA and WA, as indicated by the dash lines, a two-way radio link including a two-way air portion and radio transmitting and receiving apparatus connected by two-wire lines with the outgoing and incoming portions of the paths EA and WA at the two terminals of the four-wire circuit, or a long two-wire line, such as a two-way submarine telephone cable, suitably coupled at its terminals to the outgoing and incoming portions of the paths EA and WA at the terminals of the four-wire circuit.

Associated with the paths EA and WA near the two terminals of the four-wire circuit are combined voice and tone-operated switching apparatus for preventing singing and suppressing echoes, circuits for applying tone energy to the

transmitting end of the path EA or WA, circuits for producing complementary compression of the transmitted signals and voice energy in accordance with the invention, and apparatus for expanding the received signal energy in the output of each repeating path, which will be described in connection with the following complete description of the operation of the whole system.

Normally, that is, in the absence of transmitted voice signals, the repeating path EA is disabled at a point 1 near its input and at a point 2 near its output, and the path WA is similarly disabled at the points 3 and 4 respectively in its input and output, as by short-circuit connections across these paths as indicated.

A source of control tone energy 5, such as an oscillator, of a distinctive frequency which may be inside or outside the signal frequency range (for example, 2900 cycles) is connected to the path EA near the west terminal on the outgoing side of the disabling point 1, through the band-pass filter 6 and the hybrid coil coupling 7, but, in the absence of signal transmission in the path EA, the tone energy is prevented from passing out over the path EA by a short-circuiting connection 8 directly across the output of the tone source 5. A similar source 9 of control tone energy is connected to the path WA near the east terminal of the four-wire circuit, on the outgoing side of the disabling point 3, through the band-pass filter 10 and the hybrid coil coupling 11, but, in the absence of signal transmission over the path WA, the tone energy is prevented from passing out over that path by the short-circuiting connection 12 across the output of tone source 9.

The operation of the system for signal transmission in the direction from west to east is as follows:

The signal waves received over the line section LW will divide in the hybrid coil, the useful portion of the signal energy passing into the input of the amplifying path EA and being transmitted out over that path toward the east. At the point 13 in the path EA, the voice signal energy will be divided, a portion passing through the delay circuit 19 and the other portion into the input of the transmitting vodas and control tone switching circuit 15 connected across the path EA at that point. The portion diverted into the switching circuit 15, if that circuit has not been previously blocked in its input by prior incoming voice signals or control tone in the receiving path WA at the terminal by operation of the switching circuit 16 connected to that path, will be amplified and detected in the amplifier-detector 17 and cause the operation of the electromagnetic switching relay 18 in its output.

Relay 18 operated, removes the disability at the point 1 in the path EA, allowing the west-to-east voice signals, which meanwhile have been delayed in delay circuit 19, to pass out over the path EA. Relay 18 operated, also simultaneously applies a suppressing disability at a point 20 in the incoming path WA at the terminal in front of the point of connection of the switching circuit 16 thereto, as by closing a short circuit across that path. Relay 18 operated, also simultaneously breaks the short-circuiting connection 8 across the output of oscillator 5 allowing the tone energy of distinctive frequency (2900 cycles) generated by that oscillator to be applied to the path EA through the band-pass filter 6 and hybrid coil

7, and to pass out over that path along with the voice signals.

The band filter 6 has the proper pass range, say 2800-3000 cycles, to eliminate interference which might fall within the transmission range of the signals passing over the path EA and in the channels which may be used for other switching purposes.

The voice signals and the superposed tone energy are then transmitted over the path EA to the compressor device shown within the dot-dash box 21. This device as illustrated, except for the addition of low-pass filter 22, is identical with the compressor device at the sending station A of the transmission system shown in Fig. 1 of the aforementioned Norman Patent 1,922,602, and for a detailed explanation of its construction and operation reference is made to the specification of that patent, only a brief description being given here.

The compressor comprises a section of line 23 of high impedance which may comprise a resistance network, connected in the path EA in front of amplifier 24 by the tandem transformers 25 and 26 as indicated, a variable impedance element 27 shunting the line section 23 at its mid-point, and a forward-acting control circuit 28 for controlling the impedance device 27 to adjust the loss inserted in the path EA.

The variable impedance device 27 comprises two three-electrode amplifying vacuum tubes having their cathode-anode circuits connected in push-pull and their control grid-cathode circuits connected in parallel. The retardation coils 29 and 30 in the individual portion of the cathode-anode circuits of the two tubes are bridged in series across the mid-point of line section 23, so that a loss corresponding to the sum of the plate impedances of the two tubes is thus effectively inserted in the path EA.

The value of the loss inserted in path EA by the variable impedance device 27 is controlled by varying the potential on the control grids of the two amplifier tubes in that device in the following manner.

The low-pass filter 22 in the input of control circuit 28 is designed to select from the superposed voice signal and tone waves impressed on that circuit only the lower voice frequencies, for example, a range extending from 0 to 2750 cycles, as indicated, and to suppress the higher tone frequency (2900 cycles).

The voice frequencies in the output of filter 22 are impressed across potentiometer 31 on the first stage 32 of an amplifier, and the amplified waves are then fed into the vacuum tube "rooter" device 33. The latter device is of the type illustrated and described in the U. S. Patent No. 1,737,830, issued December 3, 1929, to G. Crisson, and operates to produce in its output voltages proportional at any instant to the square root of the alternating current voltages impressed on its input. Its purpose is to enable a linear relation to be obtained between the range of signal volumes at the input to the compressor and the range of signal volumes in the output of the compressor regardless of whether the signal intensity at the input to the compressor is high or low or the intensity range being transmitted is large or small. The resulting "root" voltages are amplified in the amplifying stage 34, rectified in the linear vacuum tube rectifier 35 and impressed on the low-pass filter 36.

The low-pass filter 36 is provided for the purpose of effectively suppressing from the rectified current transmitted therethrough any voice fre-

quency components which might result in distortion being produced in the path EA if they are applied to the grids of the tubes in variable impedance device 27. This low-pass filter is preferably designed to have a cut-off at about 40 cycles per second.

The low frequency rectified variations in the output of filter 35 are applied symmetrically in parallel to the control grid circuits of the two tubes in device 27 causing like variations in the grid voltages of these tubes and consequently equal variations in the plate impedances of these tubes. Thus a loss corresponding to the sum of the two plate impedances is inserted in the path EA at the mid-point of line section 23.

The push-pull arrangement of the plate circuits of the two tubes in device 27 provides that, while their impedances are responsive to changes in the applied control grid potentials, their combined impedance as seen from the path EA is substantially independent of the magnitude of the energy passing over that path.

The poling of the control grids of the tubes in variable impedance device 27 with respect to that of the rectifier 35 is selected so that the values of the output impedances of the tubes in device 27 will decrease with increase in the amplitude of and increase with decrease in the amplitude of the voice signals at the input to control circuit 28, and, therefore, the loss inserted in the path EA by the variable impedance device 27 will increase with increase in the voice signal input level and decrease with decrease in the signal input level.

As the compressor is placed in the circuit EA after the point where the control tone from oscillator 5 is introduced, and the control tone itself, due to the action of filter 22 in the control circuit 28, is prevented from adjusting the value of the loss inserted in the path EA by the compressor, the magnitude of the control tone energy transmitted over the path EA is made by the compressor to vary inversely with the magnitude of the signal energy. Thus, when the syllabic speech power of the signal transmitted over the path EA is at a minimum, the gain of the compressor is at a maximum and consequently the control tone is at a maximum. On the other hand, when the syllabic speech power is at a maximum, the gain of the compressor is at a minimum and consequently the control tone is at a minimum.

In other words, a single compressor device operates to make the signal wave and tone transmitted over the path EA complementary in amplitude, or the transmitted control current is made to vary in amplitude inversely as the syllabic variations of the compressed speech. Besides the obvious advantage in economy of equipment provided by employing a single device to perform both of these operations, there is an additional advantage in that its accomplishment is not dependent on making the adjustment of two similar pieces of apparatus identical.

The compressed voice or other signal waves and the inversely varying control energy, after amplification by amplifier 24 pass together over the "noisy link" IL to the east terminal of the four-wire circuit shown in Fig. 2. Unless the input of the path EA on the receiving side of the "noisy link" has been previously disabled at the point 37 in response to operation of the transmitting vodas circuit 38 connected to the input of the path WA, by transmission over that path in the direction from east to west, the received energy

will pass through to the hybrid coil 39 which divides it between the input of the receiving vodas control circuit 40, and the input of the delay circuit 41 in the main signaling path which is normally disabled at the point 2 in the output of the delay circuit 41 by a normal short circuit.

The control circuit 40 comprises two parallel amplifier-detector portions 42 and 43. Of the two amplifier-detectors shown, the upper one, 42, is tuned to respond to the signal (voice) waves only and is made to be comparatively insensitive so that it will operate only in response to comparatively strong signaling energy. The lower amplifier-detector 43, on the other hand, because of the band-pass filter 44 in its input designed to pass substantially only waves of the frequency of the transmitted control tone, will respond only to the received control tone and not to the signal waves, and it is adjusted to be comparatively sensitive so as to operate on substantially all magnitudes of the transmitted control energy except the very low magnitudes.

If, then, the received (compressed) voice energy is of high level, the amplifier-detector 42 will operate to energize the upper operating winding of the electromagnetic relay 45 causing the relay to operate to remove the disability in path EA at the point 2, and allowing the received signal and control energy which has meanwhile been delayed in the delay circuit 41 to pass on over the path EA to the band-pass filter 46 which is designed to suppress from the transmitted current the frequencies corresponding to those of the transmitted control tone while transmitting substantially all important frequencies in the voice band.

If, on the other hand, the level of the received signals is low, the relay 45 will not operate in response to the output of amplifier-detector 42, but will be operated due to the energization of its lower winding by the output of amplifier-detector 43 by the control energy passing through the band-pass filter 44, this control energy, due to the action of the compressor device at the transmitting end of the system, being of high level when the signal level is low.

The operation of relay 45 either by the compressed voice signals or by the complementary compressed tone, will simultaneously cause a disability, such as a short circuit, to be connected across the input of the amplifier-detector 47 in the transmitting vodas circuit 38 connected across the input of the path WA, thus preventing subsequent false operation of that device by subsequently received east-to-west voice energy or echoes of the received west-to-east voice signals.

The tone having been eliminated by filter 46, the compressed voice signals in the output of that filter then pass to the "expander" device shown within the dot-dash box 48, which is identical with and operates in the same manner as the expander device employed at the receiving station B of the system shown in Fig. 1 of the aforementioned Norman Patent 1,922,602. Briefly, this expander includes a section of line 49 connected by the transformers 50 and 51 between the output of amplifier 52 and the input of amplifier 53 in the path EA, this section of line by means of shunt resistances of suitable value being designed to have an impedance which is low in value compared to that of the variable impedance device 54 coupled in series with the line section 49 by its output coil 55. The variable impedance device 54 is similar to the device 27 employed in the compressor at the west terminal of the sys-

tem, comprising two three-electrode amplifying vacuum tubes having their anode-cathode circuits connected in push-pull relation and containing equal portions of the output coil 55, and their control grid-cathode circuits connected in parallel.

The main portion of the compressed signal waves in the output of the band-pass filter 46 is amplified by amplifier 52 in the signal path EA, and is transmitted through line section 49 encountering therein a series loss corresponding to the sum of the plate impedances of the two tubes in the variable impedance device 54. The value of this plate impedance and therefore the loss produced in the path EA, depends on the potential on the control grids of the tubes in the variable impedance device, which is varied by the compressed voice signals in the input of amplifier 52 through the forward-acting control circuit 53 in the following manner.

The portion of the compressed voice signals diverted into control circuit 56 is impressed by potentiometer 57 on the input of amplifier 58. The amplified voice signals in the output of amplifier 58 are rectified in the linear vacuum tube rectifier 59, and the rectified signals passing through the low-pass filter 60, similar to and provided for a similar purpose as the low-pass filter 36 in the compressor control circuit described above, apply a voltage varying in accordance with their amplitude level to the control grids of the tubes in the device 54. The poling of the control grids of these tubes with respect to that of the rectifier 59 is made such that the plate impedance of the former tubes with variation in the control grid potentials, will decrease with increase in, and increase with decrease in the amplitude of the voice signals impressed on the control circuit 56, and, therefore, the loss inserted in the signal path EA by the device 54 will decrease with increase in the amplitude of the signals and increase with decrease in the amplitude of the signal input.

This will have the effect of expanding the volume range of the signals transmitted over the path EA beyond the line portion 49. By proper choice of the values of the elements in the variable impedance device 54 and those in the line section 49, this expansion may be made such as to restore the signals to their original volume range at the transmitting end of path EA.

The loss introduced in the path EA by the variable impedance device 54, due to the compression produced by the compressor in the signals at the transmitting end of the system, will be such a function of the voltage impressed on control circuit 56 that no "roter" device is required in the latter circuit to restore the signals to their original volume range.

The expanded voice signals in the output of line section 49 are amplified by the amplifiers in the output of path EA to any desired level before they are impressed on the two-way line LE.

The operation of the system of Figs. 1 and 2 for signal transmission in the direction from east to west, is similar to that described above for transmission in the direction from west to east, the transmission control apparatus associated with the path WA being similar to that associated with the path EA, described above.

The application of the invention illustrated and described should be considered merely as typical and not as limiting, and various modifications which are within the spirit and scope of the invention will occur to persons skilled in the art.

Also, it is to be understood that the values specified above for the frequencies of the tone sources and the pass ranges of the various filters in the system described and illustrated are to be taken by way of example only and not as limiting the invention.

What is claimed is:

1. In a signaling system including a transmitting section, a receiving section with an associated wave-responsive transmission control device, and an intermediate variable transmission link, means responsive to the initiation of signal wave transmission in said transmitting section for causing a distinctive control wave to be transmitted over said system through said intermediate link along with the signal waves, means in said transmitting section for compressing the volume range of the transmitted signal waves, and for causing the magnitude of the transmitted control wave energy to vary inversely with the magnitude of the compressed signal wave energy, and means at the receiving end of said system for utilizing the received control wave energy to control said wave-responsive devices.

2. In a signaling system comprising a transmitting section, a receiving section, an intermediate variable transmission link, and a wave-responsive transmission control device connected to said receiving section, means responsive to the initiation of signal wave transmission in said transmitting section to cause a distinctive control wave to be applied to said intermediate link along with the signal waves, means connected to said transmitting section for compressing the volume range of the signal waves before they are applied to said intermediate link, and for making the amplitude of the control wave energy applied to said link vary inversely with the amplitude level of the compressed signal waves, and means to utilize the control wave energy received in said receiving section to control said wave-responsive devices when the received signal energy is weak.

3. In a signaling system including a transmitting section, a receiving section with an associated wave-responsive transmission control device, and an intermediate transmission link subject to variable interfering noise energy, means for producing positive operation of said wave-responsive device at all times during signal transmission in the presence of received noise energy, comprising means for compressing the volume range of the signal waves initiated in said transmitting section before applying them to said intermediate link, means responsive to said signal waves for applying to said intermediate link a control wave of distinctive frequency, the amplitude of which control wave varies inversely with the magnitude of the compressed signal wave energy applied thereto, and means selectively responsive to the signal waves of large amplitude or the received control wave energy received in said receiving section to operate said transmission control device.

4. In a signaling system comprising two stations connected by a variable transmission medium, and means responsive to the initiation of signal waves for transmission at one station to cause control current of distinctive frequency to be transmitted over said medium along with the signal waves to condition the other station for receiving the transmitted signal waves, means at said one station for compressing the volume ranges of the transmitted signal waves and the transmitted control current, and for causing the

amplitude of the transmitted control current to vary inversely with the amplitudes of the transmitted signal waves.

5 5. The system of claim 4 in which the same device is employed for compressing the volume ranges of the signal waves and control current, and for causing the amplitude of the transmitted control current to vary inversely with the amplitudes of the transmitted signal waves.

10 6. In a two-way telephone transmission system comprising two stations each having a transmitting and a receiving circuit, a two-way signal transmission medium subject to interfering noise energy connecting the two stations, and wave-
15 responsive means connected to the receiving circuit at each station for conditioning the station for receiving signals, means for improving the operation of said wave-responsive means in the presence of received noise energy comprising
20 means responsive to the initiation of telephone signal transmission in the transmitting path of a station for causing control energy of distinctive frequency to be applied to that path for transmission to said medium along with said signals, a volume range compressor in the transmitting path traversed both by said telephone signals and said control energy, means responsive
25 to applied telephone signals for causing the gain of said compressor to decrease in proportion to an increase in the level of the applied telephone signals and to increase in proportion to a decrease in the level of the applied telephone signals, means for preventing the gain of said compressor from being varied in response to the ap-

plied control energy, whereby the telephone signals and control energy transmitted through said compressor are made complementary in amplitude and means making the wave-operative transmission control devices connected to the
5 receiving circuit at each station to respond positively either to received telephone signal energy of high level or to the received control energy of substantially all levels.

7. In a signal wave transmission system including two stations connected by a variable transmission medium, means responsive to the initiation of signal wave transmission at one station to cause a control wave of a distinctive frequency to be transmitted along with the signal waves over said medium to the other station and a wave-responsive switching device at said other station, supplied with the received signal and control waves, operating to put said other station in proper receiving condition, means at said one station for compressing the volume ranges of the signal waves and the control wave before they are transmitted over said medium, and for causing the amplitude of the transmitted control wave to vary inversely with the amplitude of the transmitted signal waves, so as to provide positive
25 operation of said switching device at said other station either in response to the received control wave energy or the received signal wave energy, and means at said other station for expanding the received compressed signal waves to restore them to their original amplitude values.

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