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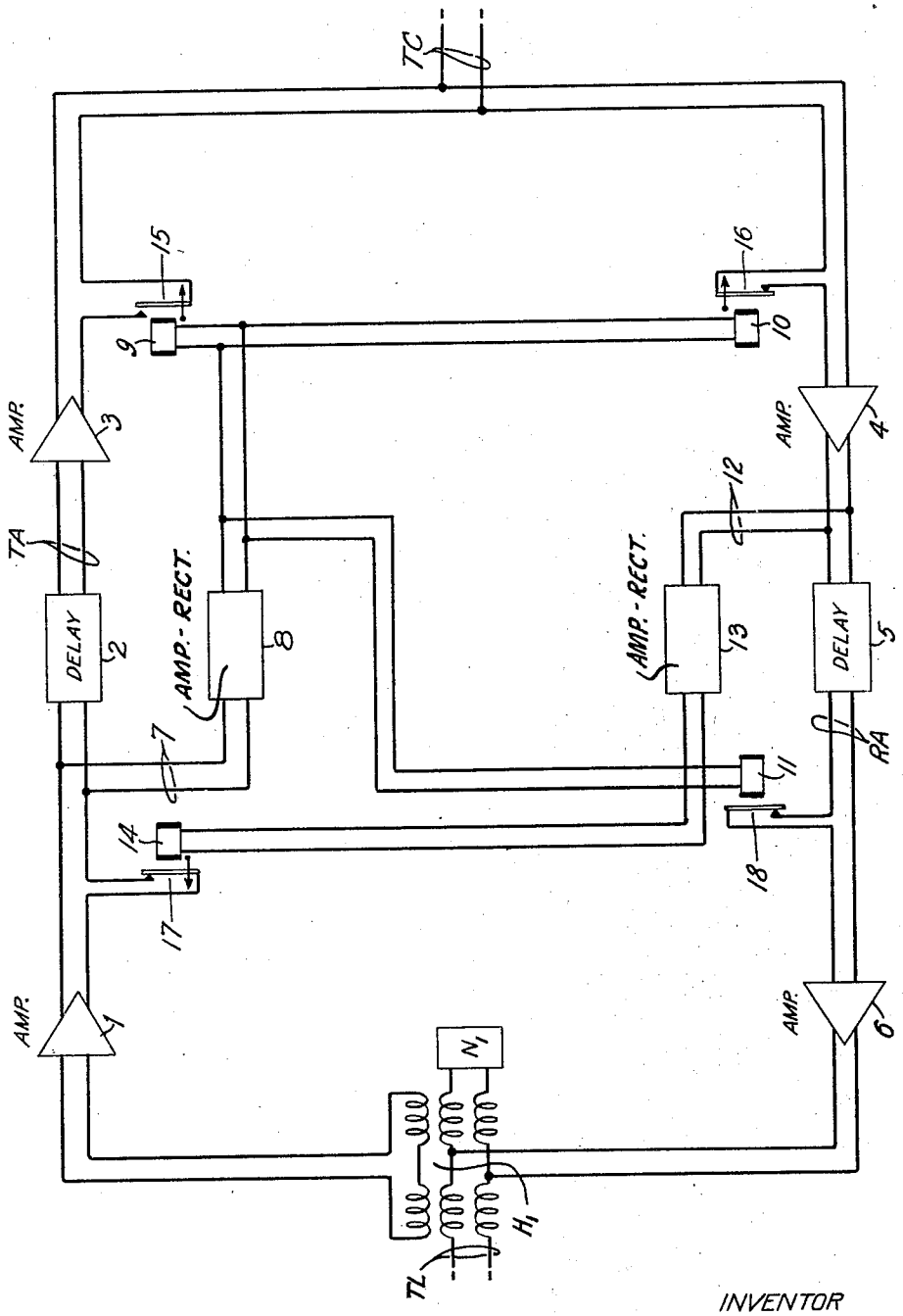

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TWO-WAY SIGNALING SYSTEM

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This invention relates to the transmission of signal waves, and its object is to produce improvements in the two-way transmission of such waves, for example, in the two-way repeating of telephonic currents.

The invention is especially applicable to a system in which two-way transmission of electrical energy is required over wire circuits for long distances, such as a communication system comprising the combination of telephone subscribers' circuits with a long two-way telephone cable of high attenuation, e. g. a deep sea submarine telephone cable. The high attenuation of the two-way cable in such a system necessitates the use of amplifying means for the signaling currents at the cable terminals. In such a system also, signal-controlled circuit-control apparatus is commonly used in connection with the oppositely directed amplifying paths at the cable terminals to insure that the system is operative to transmit in only one direction at a time, so as to suppress effectively echoes or singing, or both. This is usually accomplished by making the circuit-control apparatus responsive to transmission of signaling energy over the system in one direction to render the system operative in that direction, and to effectively disable the system for transmission in the opposite direction.

In such a system as has been described the transmitting and receiving amplifiers in the one-way transmitting and receiving paths respectively at each terminal of the cable are usually associated with one end of the cable through coupling means such as a hybrid coil or a Y-connection. Because of the inseparable connection of the transmitting and receiving amplifiers, a considerable amount of energy from the transmitting amplifier in the transmitting circuit at each terminal may be transferred through the coupling means to the receiving amplifier in the receiving circuit. In spite of the best cable balance, some noise from the output of the transmitting amplifier, when it is not transmitting, will get into the receiving branch and interfere with reception therein. Also during transmission, the receiving amplifier may be badly overloaded by unbalance energy transmitted through the coupling means from the transmitting amplifier.

In accordance with the present invention this interference with reception or the overloading of the receiving amplifiers in such a system is prevented by arranging the circuits at each terminal of the cable so that during reception, the transmitting branch will be disabled in the output of the transmitting amplifier therein, while the receiving branch is normally operative, or is made operative by the incoming signaling energy, and during transmission, in response to the transmitted energy the transmitting branch will be made operative, and the receiving branch will be disabled in the input of the receiving amplifier.

For convenience the invention will be described as applied to a system 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 programs comprising music as well as speech, etc. Also the frequency band need not be continuous, but may consist of superposed narrow bands, as in the case of multiplex carrier transmission.

In the following description of the invention reference will be made to the accompanying drawing, the single figure of which shows a schematic circuit diagram of a cable terminal embodying the invention.

The terminal station of the drawing is shown as connecting a two-way line TL, such as a land telephone line, to the west end of a two-way cable TC of high attenuation, such as a deep sea submarine telephone cable. This west terminal station comprises a transmitting circuit TA for repeating waves from the line TL into the cable TC, and a receiving circuit RA for repeating waves received from the cable TC into the line TL.

The output of the transmitting circuit TA and the input of the receiving circuit RA are shown connected directly to each other and to the cable by an ordinary Y-connection,

but may be connected to each other and the cable by means of a hybrid coil bridge circuit or any other type of coupling means. The input of the transmitting circuit TA and the output of the receiving circuit RA are shown connected to each other and to the line TL by means of a three-winding transformer or hybrid coil H_1 and a balancing network N_1, but may be connected to each other and the line in any other suitable manner.

Connected in the transmitting circuit TA between the hybrid coil H_1 and the cable TC is a one-way amplifier 1, a delay circuit 2 and a one-way amplifier 3. Connected in the receiving circuit RA between the cable TC and the hybrid coil H_1 is a one-way amplifier 4, a delay circuit 5 and a one-way amplifier 6.

Connected to the transmitting circuit TA between the hybrid coil H_1 and the input of the delay circuit 2 is a control path 7 comprising the signal-controlled, relay controlling device 8, and the windings of relays 9, 10 and 11 connected in parallel to the output of the device 8. Similarly, connected to the receiving circuit RA between the output of amplifier 4 and the input of delay circuit 5 is a control path 12 comprising a signal-controlled, relay controlling device 13, and the winding of a relay 14 connected to the output of device 13.

In the transmitting circuit TA between the output of amplifier 3 and the cable TC is a normally open switch 15 adapted to be closed by the operation of relay 9. In the receiving circuit RA between the cable TC and the input of amplifier 4 is a normally closed switch 16 adapted to be opened by operation of relay 10. In transmitting circuit TA between the point of connection of the control circuit 7 thereto and the output of amplifier 1 is a normally closed switch 17 adapted to be opened by operation of relay 14. In the receiving circuit RA between the output of delay circuit 5 and the input of amplifier 6 is a normally closed switch 18 adapted to be opened by operation of relay 11.

It is seen that the west cable terminal circuit which has just been described is of the form which is known in the art as semi-biased, i. e., the circuit is normally operative to transmit waves between the line TL and the cable TC in one direction, and transmission in the opposite direction depends on a switching operation.

The one-way amplifiers 1, 3, 4 and 6 may be any of the types well known in the art. The amplifier 1 is adjusted so as to amplify the incoming signal waves received from the line TL at least to a level sufficient to cause operation of the signal controlled, relay controlling device 8 to operate relays 9, 10 and 11. The amplifier 4 is adjusted so as to amplify the received signal waves from the cable TC to a level sufficient to cause operation of the signal-controlled, relay controlling device 13 to operate relay 14. Amplifier 3 is adjusted so as to amplify the signal waves in the output of delay device 2 to a level sufficient to compensate, at least in part, for the attenuation which will be produced in transmission over the cable TC to the east terminal station. The amplifier 6 in the receiving circuit RA is adjusted so as to amplify the signal waves in the output of delay circuit 5 to a sufficient level to compensate, at least in part, for the attenuation which will be produced in them in transmission over the line TL to a receiving point.

The control devices 8 and 13 may be vacuum tube amplifier-rectifier devices of the type well known in the art, or any other devices which will respond to electrical waves impressed on their input circuit to control the operation of a relay or relays connected to their output circuits.

The delay circuits 2 and 5 may be of any type which will produce a delay of a required amount, which will be specified below, in electrical waves in transmission therethrough, as, for example, a low pass filter, such as disclosed in the United States patents to Campbell, 1,227,113 and 1,227,114, issued May 22, 1917, or a network such as disclosed for a similar purpose in Arnold Patent 1,565,302, issued December 15, 1925.

Since the terminal stations at both ends of the cable TC may be substantially identical in construction, except perhaps for the amplification factor of the amplifiers used, which will depend upon the characteristics of the circuits associated with the cable terminal, it has been deemed sufficient to illustrate only the terminal station at one end of the cable, the west end, and in the following description the method of operation of the system will be clear from reference to the single station shown. Also, as the system operates in similar manner when the direction of the signal waves is from west to east as when it is from east to west, the operation of the system in the former case need only be described.

When no currents are being received over the cable TC in the direction from east to west, or when the currents received thereover when amplified by amplifier 4 are still of insufficient level to cause the operation of control device 13 to energize the winding of relay 14, the switch 17 in the circuit TA is in the closed condition illustrated in the drawing. Similarly, when no currents are being received over the line TL in the direction from west to east, or the currents being received thereover when amplified by amplifier 1 are still of insufficient level to cause the operation of control device 8 to energize the windings of relays 9, 10 and 11, switches 18 and 16 are in the closed condition and switch

15 in the open condition shown in the drawing.

Now let it be assumed that speech waves to be transmitted from west to east are received at the west cable terminal station over the line TL. These waves will be impressed by hybrid coil H_1 on the transmitting circuit TA, transmitted thereover to amplifier 1 and amplified thereby. The amplified waves in the output of amplifier 1 will be divided between the input of delay circuit 2 and the input of control path 7. The main portion of the amplified waves in the output of amplifier 1 will be transmitted through delay circuit 2, being delayed in transmission therethrough for a certain period. The transmitted waves will then be amplified by amplifier 3.

A small portion of the amplified waves in the output of amplifier 1 will be diverted into the control path 7 and will operate the control device 8 therein causing the windings of relays 9, 10 and 11 to be energized. Relay 9 will operate to close the normally open switch 15 in the output of transmitting circuit TA to make that circuit operative to transmit from the output of amplifier 3 to the cable TC. Relays 10 and 11 are adjusted to operate substantially simultaneously with or before relay 9 to respectively open the normally closed switches 16 and 18 in receiving circuit RA. The opening of switch 16 will prevent any transmission of waves from the cable TC, or from the output of the transmitting circuit TA to the input of amplifier 4, and thus will prevent overloading of that amplifier.

Delay circuit 2 in the transmitting circuit TA is designed to produce sufficient delay in the speech waves transmitted therethrough to prevent their arrival at switch 15 in the output of amplifier 3 until after that switch has been closed by the operation of relay 9. The speech waves after amplification by amplifier 3 will therefore be transmitted from the output of amplifier 3 directly to the cable TC and will be transmitted thereover to the east terminal station.

Relay 9 is designed so as to remain operated for a definite period of time after the input of speech energy to the control path 7 ceases, so as to prevent clipping of the speech, i. e., loss of the portion of the speech which has not reached the switching point in transmitting circuit TA (switch 15) at the time the control device 8 releases due to a fall in the level of the waves impressed on its input. Similarly, relay 10 is designed so that it will remain operated for a definite period of time after the control device 8 has released so as to insure that the switch 16 in path RA will remain open at least until all of the speech energy passing over the transmitting circuit TA has been sent into the cable TC. This will prevent false operation of the control device 13 in control path 12 connected to the receiving circuit RA. Relays 9 and 10 may be so designed by well known mechanical construction making them slow to release, or by the use of an electrical auxiliary hangover circuit in connection with the relays, such as disclosed, for example, in the copending application of J. Herman, Serial No. 144,848, filed October 28, 1926.

The operation of the circuits at the terminal station at the east end of the cable TC in response to the speech waves transmitted thereto will be made clear by describing the operation of the similar circuits at the west terminal station shown in the drawing, in response to waves received over the cable TC. The speech waves incoming over cable TC will be transmitted directly into the input of the receiving path RA at the west terminal, as the output of the transmitting circuit TA is disabled because of the normally open switch 15 therein. The normally open switch 15 in the output of transmitting circuit TA also prevents the transmission of any amplified energy which may be present in the output of amplifier 3 when speech waves are not being transmitted over the circuit TA, such as amplified noise, from the output of transmitting circuit TA to the input of receiving circuit RA through the coupling therebetween. If this amplified noise were transmitted into receiving circuit RA, it might, of course, seriously interfere with reception in that circuit.

The incoming speech waves from the cable TC will be amplified by amplifier 4 in receiving circuit RA. The amplified waves in the output of the amplifier 4 will be divided, the main portion being transmitted to the input of delay circuit 5 and a smaller portion being diverted into control path 12.

The portion of the speech waves diverted into control path 12 will operate control device 13 therein causing the winding of relay 14 in the output thereof to be energized. Relay 14 will operate to open the normally closed switch 17 in the input of the transmitting circuit TA. The circuit TA will, therefore, be rendered inoperative to transmit waves from the line TL, or unbalance energy from the output of the receiving circuit RA passing through the coupling H_1, thus preventing false operation of relays 9, 10 and 11. The main portion of the speech waves in the output of amplifier 4 in receiving circuit RA will be transmitted through delay circuit 5 and after being delayed therein for a certain period of time will be transmitted to the input of amplifier 6, amplified by that amplifier and impressed by the hybrid coil H_1 on the circuit TL over which it will be transmitted to a distant receiving circuit. The delay circuit 5 is designed so as to delay transmission of the speech waves therethrough for a sufficient

time interval to insure that switch 17 in the input of transmitting circuit TA is closed by relay 14 in sufficient time to prevent any unbalanced signaling energy from hybrid coil H_1 getting into the control circuit 7 to cause false operation of relays 9, 10 and 11.

The relay 14 may be designed to remain operated for the required length of time after the cessation of supply of speech energy to the input of control circuit 12 to prevent the closing of the switch 17 in the receiving circuit RA until after all of the east to west speech waves have been transmitted into the circuit TL from the output of the receiving circuit RA. The premature closing of switch 17 might result in false operation of the relays 9, 10 and 11 by unbalanced energy transmitted through the hybrid coil H_1. The relay 14 may be maintained operated for the required length of time by making it slow to release by well known methods of mechanical design, as indicated in the drawing or by associating with this relay an auxiliary hangover circuit such as disclosed in the copending application of J. Herman referred to above.

Although in the embodiment of the invention which has been illustrated and described, electromagnetic relays are employed for conditioning the amplifier paths by operating movable switches to close or open-circuit these paths, the invention is not limited to such conditioning means. For example, it is within the scope of the invention to disable the transmission paths by short-circuits or loss circuits, instead of open circuits, inserted in the paths controlled by current controlled relays. Stationary devices having no movable elements may be employed in place of the mechanical relays shown in the drawing, for example, vacuum tube relays, such as disclosed in Crisson Patent 1,647,212, issued November 1, 1927, or in an article by C. A. Beers and G. T. Evans, in the Institute of P. O. Electrical Engineers (London), Vol. 20, pp. 65 to 72 inclusive, published in 1920.

Although the cable terminal circuit which has been illustrated and described is normally disabled in the output of the transmitting amplifier and normally operative in the input of the receiving amplifier, it is within the scope of the invention to have both the output of the transmitting amplifier and the input of the receiving amplifier normally disabled, in which case the control path associated with the transmitting circuit need only be responsive to currents to be transmitted to render the transmitting circuit operative to transmit from the line TL to the cable TC, and an additional control path may be connected to the input of the receiving circuit and made responsive to signal waves received over the cable TC to render the receiving circuit operative between the cable TC and the receiving amplifier. Although in the terminal circuit illustrated and described, both the input of the transmitting circuit TA and the output of the receiving circuit have been shown as normally operative, it is within the scope of the invention to have either one or both of these circuits normally disabled in which case the control paths associated with these paths may be arranged to make the disabled circuit operative in response to currents to be transmitted thereover to the cable TC or to the circuit TL.

Although in the terminal circuit which has been illustrated and described, the receiving circuit and the transmitting circuit have been shown normally disabled or adapted to be disabled in two places, because of the high gain of the apparatus necessary in terminal circuits of this type, it may be desirable to have the transmitting and receiving circuits normally disabled, or adapted to be disabled in more than two places by means similar to those shown.

Certain deviations from the system which may be made within the scope of the invention have been mentioned above. Other alternatives or modifications will readily occur to one skilled in the art in connection with adapting the invention to different transmission requirements. The invention is not to be construed, therefore, as limited to the specific disclosure, but its scope is defined in the appended claims.

What is claimed is:

1. A terminal circuit for a two-way transmission line, said circuit comprising a source of waves to be transmitted over said line, a transmitting circuit and a receiving circuit each including amplifying means, coupling means connecting said transmitting circuit and said receiving circuit to said line, means normally disabling said transmitting circuit for transmitting waves from the output of the amplifying means therein to said coupling means, means under control of the waves received from said source for rendering said transmitting circuit operative to transmit said received waves to said line, and for substantially simultaneously disabling said receiving circuit for transmitting waves between said coupling means and the amplifying means in said receiving circuit, and means under control of the waves received by said receiving circuit from said line for effectively disabling said transmitting circuit in the input of the amplifying means therein.

2. A two-way transmission system comprising a section of two-way line, two oppositely directed one-way line sections each including amplifying means, means connecting the output of one and the input of the other of said one-way line sections to one end of said two-way section of line, means normally disabling said one one-way section of line in the output of the amplifying means therein, means responsive to transmission in said one

one-way section of line for rendering said one one-way section operative to transmit to said two-way line section, and for disabling said other one-way section in the input of the amplifying means therein, and means responsive to transmission from said two-way line section to said other one-way line section for disabling said one one-way line section in the input of the amplifying means therein.

3. A two-way transmission system comprising two two-way line sections, two oppositely directed one-way transmission circuits each including amplifying means, means coupling the input of one and the output of the other of said one-way circuits to one of said two-way line sections and the output of said one and the input of said other one-way circuit to the other of said two-way line sections, means normally disabling said one transmission circuit in the output of the amplifying means therein, means responsive to transmission from said one two-way line section to said one one-way transmission circuit to disable said other one-way line section in the input and in the output of the amplifying means therein, and to render operative said one one-way line section for transmission to said other two-way line section, and means responsive to transmission from said other two-way line section to said other one-way circuit for disabling said one one-way circuit in the input of the amplifying means therein.

4. The system of claim 3 and in which said one one-way transmission circuit includes transmission delay means connected between the normally disabling means therein and said means responsive to transmission from said one two-way line section, and in which said other one-way transmission circuit includes transmission delay means connected between the disabling point in the output of the amplifying means therein and said means responsive to transmission from said other two-way line section.

5. A two-way transmission system comprising two two-way line sections, two oppositely directed one-way transmission circuits, each including amplifying means, means coupling the input of one and the output of the other of said one-way circuits to one of said two-way line sections, means coupling the input of said other one-way circuit and the output of said one one-way circuit to the other of said two-way line sections, and means responsive to transmission from said one two-way line section to said one one-way circuit for effectively disabling the input and output of said other one-way circuit.

6. A two-way transmission system comprising two two-way line sections, two oppositely directed one-way transmission paths each including amplifying means, means coupling the input of one and the output of the other one-way path to one of said two-way line sections, means coupling the input of said other and the output of said one one-way path to the other of said two-way line sections, control means connected to said one one-way path and responsive to transmission therein to disable said other one-way path, control means connected to said other one-way path and responsive to transmission therein to disable the input and output of said one one-way path, and delay means connected in said one one-way path between the point of connection of the control means thereto and the disabling point in the output of said one one-way path.

In witness whereof, I hereunto subscribe my name this 2nd day of December, 1929.

ROBERT C. MATHES.