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TRANSMISSION SYSTEM

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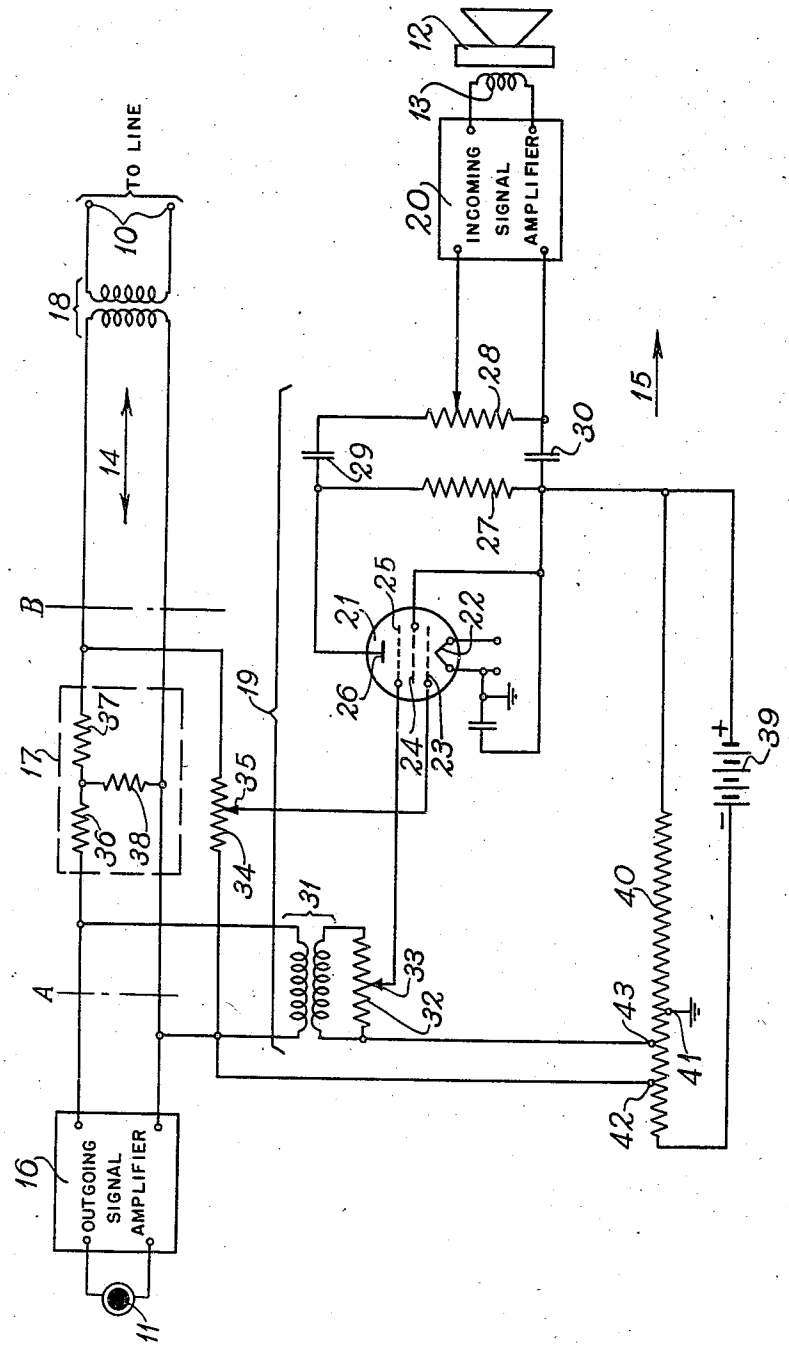

INVENTOR.
ROSWELL H. HERRICK
BY Davis, Hinkley, Smith & Shontz
ATTORNEYS

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TRANSMISSION SYSTEM

Roswell H. Herrick, Oak Park, Ill., assignor to Associated Electric Laboratories, Inc., Chicago, Ill., a corporation of Delaware

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The present invention relates generally to improvements in signal current transmission systems of the type in which signal controlled switching circuits are provided for blocking, under certain conditions, certain of the signal current channels included therein and, more particularly, to improvements in telephone substation circuits having incorporated therein coupled signal current channels for the transmission of incoming and outgoing signal currents.

In the usual telephone substation circuit, a hybrid system or antiside tone network is provided for preventing signal currents developed during operation of the transmitter from being transmitted to the receiver and for preventing signal currents incoming over the line extending to the substation from being transmitted to the transmitter. In this type of arrangement one of the factors which determines the efficiency of the side tone suppression is the impedance of the talking circuit established by way of the two connected subscribers' lines. This impedance is not the same for different connections between different subscribers' substations. Accordingly, the hybrid system of each substation is usually balanced to provide maximum side tone suppression efficiency for average line conditions. In installations wherein amplification of the incoming and outgoing signal currents is required, the conditions of unbalance introduced into the substation circuit by the impedances of the lines over which an established talking circuit extends may become intolerable. This is particularly true in substation installations provided in an exchange area where the subscribers' lines are of widely different lengths. As an alternative to the type of system just described, an arrangement may be employed wherein separate signal current transmission channels are provided for transmitting outgoing and incoming signal currents between the associated transmitting and receiving means and the line extending to the substation circuit. In such an arrangement the channels must necessarily be electrically coupled at one end thereof and are usually acoustically coupled at the other end thereof. Due to the coupling between the channels it is necessary to provide some form of channel blocking means for rendering partially or completely inactive the channel over which signal currents are normally transmitted to the receiving means during those intervals when the transmitter is in use, thereby to prevent the locally generated signal currents from being reproduced by the receiving means, and vice versa. Moreover, if amplification is used in either or both of the two channels and the coupling between the transmitting and receiving means is of substantial magnitude, channel blocking is necessary for the further purpose of preventing the circuit from oscillating to produce interference commonly known as singing.

It is an object of the present invention, therefore, to provide telephone substation apparatus of the character described wherein the blocking of the signal current receiving channel when the outgoing signal current transmission channel is in use is accomplished in a positive and reliable manner without the use of movable circuit controlling devices and with a minimum of circuit apparatus.

It is a further object of the invention to provide an improved transmission system particularly suited for use in telephone substation circuits of the character described wherein the blocking of one of the signal current channels included therein is controlled in a simple, positive and reliable manner in accordance with the direction of signal current flow through the system.

In the illustrated embodiment of the invention there is provided a telephone substation circuit which is adapted to be connected to an associated line and comprises the usual transmitting and receiving means. A transmission system is provided which includes a first channel for transmitting signal currents from the transmitting means to the line and a second channel for transmitting incoming signal currents to the receiving means. This second channel includes a repeater which comprises an electron discharge tube having a first control electrode adapted to cause a relatively large change in the electron stream of the tube in response to a given change in the potential thereon and a second control electrode adapted to cause a relatively small change in the electron stream of the tube in response to said given potential change. The repeater further comprises an input circuit which is coupled to the first or outgoing signal current transmission channel and is operative to impress signal voltages of substantially opposite phase upon the two control electrodes when signal currents traverse this channel. Apparatus comprising a voltage transforming circuit included in the first or outgoing signal current channel is provided for changing the relative magnitudes of the voltages impressed upon the two control electrodes in accordance with the direction of signal current flow through the first

channel so that only signal currents incoming to the substation apparatus are transmitted from the first channel through the repeater to the second channel. More particularly, the electron discharge tube is so constructed and arranged that the first and second control electrodes thereof are adapted to cause changes in the electron stream of the tube in response to a given change in the potential impressed thereon which bear a predetermined relatively large ratio to each other. In order to utilize this relationship, the input circuit to the tube and, more particularly, the voltage transforming circuit mentioned above is so connected and arranged and the circuit elements thereof are so proportioned that the ratio of the magnitude of the signal voltages impressed upon the two control electrodes of the tube is substantially the inverse of the predetermined ratio mentioned above when signal currents flow from the transmitting means over the first channel to the line and is substantially greater than the inverse ratio just mentioned when signal currents flow from the line over the first channel to the input circuit of the repeater.

The novel features believed to be characteristic of the invention are set forth with particularity in the appended claims. The invention, both as to its organization and method of operation, together with further objects and advantages thereof will best be understood by reference to the specification taken in connection with the accompanying drawing the single figure of which illustrates a telephone substation circuit having incorporated therein the features of the invention as briefly outlined above.

Referring to the drawing, the substation circuit there illustrated is adapted to be connected to a line terminating at the terminals 10 and comprises a transmitter or microphone 11 and receiving means in the form of a loud speaker 12. The line connected to the terminals 10 may, for example, form a part of a conventional automatic or manual telephone system in which case it will terminate at its distant end in a line circuit, the character of which is determined by the character of the terminating exchange. Preferably, the loud speaker 12 is of the well-known moving coil type having embodied therein a voice or signal current coil 13 which is adapted to be energized by incoming signal currents. For the purpose of coupling the transmitter 11 and the loud speaker 12 to the line extending to the terminals 10, there is provided a transmission system which includes a first channel 14 and a second channel 15. The signal transmission channel 14 is utilized for the purpose of transmitting signal currents developed through operation of the transmitter 11 to the line connected to the terminals 10 and is coupled to the channel 15 so that signal currents incoming over the associated line may be transmitted therethrough to the second channel. Briefly described, the signal transmission channel 14 comprises a vacuum tube amplifier 16 for increasing the level of signal currents developed through operation of the transmitter 11, a voltage transforming network 17 and a coupling transformer 18 which functions to isolate line currents from the signal current channels. The incoming signal current transmission channel 15 comprises a repeater generally indicated at 19 which functions as the driver stage for a power amplifier 20, the output circuit of which is coupled to the voice coil 13 of the loud speaker 12 in the manner illustrated. More particularly, the repeater 19 conprises an electron discharge tube 21 of the well-known pentode type which includes a filamentary cathode 22, a first control electrode 23, a screen grid 24, a suppressor grid 25 and an anode 26. The output electrodes 22 and 26 of the tube 21 are coupled to the input circuit of the power amplifier 20 through a resistance capacitance coupling network which comprises a load resistor 27, a voltage dividing resistor 28 and a pair of signal current coupling condensers 29 and 30.

The electron discharge tube 21 is of the type wherein the suppressor grid 25 is electrically isolated from the other electrodes of the tube and is connected to a receptacle plug extending through the base of the tube so that connections may be made thereto. As thus connected, this grid may be utilized as a second control electrode for determining the electron flow from the cathode 22 to the anode 26. More particularly, this tube is so constructed and arranged that if a biasing potential is impressed upon the suppressor grid 25 and the potential is changed by a given amount, only a small change occurs in the electron stream or the number of electrons transmitted from the cathode 22 to the anode 26. In other words, the amplification factor of the tube as measured by control of the electron stream exercised through changes in the potential of the grid 25 is relatively small. On the other hand, the amplification factor of the tube is measured by control of the electron stream exercised through changes in the potential of the grid 23 is quite large. That is, a given change in the potential impressed upon the grid 23 causes a large change in the magnitude of the electron stream flowing from the cathode 22 to the anode 26. Tubes, such, for example, as the type 1AG are commercially available having characteristics such that a given potential in the potentials impressed upon two of the control electrodes thereof will produce changes in the electron stream having a magnitude ratio substantially greater than unity, this ratio being as much as ten to one in certain tubes.

The differential in the gains through the tube 21 as achieved through control of the electron stream by changing the potentials of the grids 25 and 23, respectively, is utilized to block the second signal current channel 15 when signal currents traverse the first channel 14 in a predetermined direction. To this end, the control electrode 25 is coupled to the channel 14 at a point A, intermediate the amplifier 16 and the voltage transforming circuit 17, over a path which includes a voltage phase reversing transformer 31 and a potentiometer resistor 32, the latter element having an adjustable tap 33 connected directly to the grid 25. The grid or control electrode 23, on the other hand, is coupled to the channel 14 at a point B, intermediate the voltage transforming circuit 17 and the coupling transformer 18, over a coupling path which has included therein a potentiometer resistor 34 having an adjustable tap 35 directly connected to the grid 23.

The voltage transforming circuit 17 is provided for the purpose of creating a difference in the magnitudes of the voltages appearing across the channel 14 at the points A and B when signal currents traverse this channel. As will be pointed out more particularly hereinafter, one of the requirements of this circuit is that no phase shift occur therein. In other words, the

signal voltage appearing across the channel 14 at the point A when signal currents traverse the channel should be in phase coincidence with the signal voltages appearing across the channel at the point B. For this reason, the circuit is comprised solely of resistance elements, the two resistors 36 and 37 being serially included in the channel and the resistor 38 being connected between the junction point of the two resistors 36 and 37 and the opposite side of the channel. As thus connected, signal currents delivered to the circuit 17 from the amplifier 16 traverse the resistor 36 in series with a parallel network which includes as one branch the resistor 38 and as the other branch the primary winding of the transformer 18 and the resistor 37. Accordingly, the magnitude of the signal voltage appearing across the channel 14 at the point B therealong is less in magnitude than the voltage across the channel at the point A. In a similar manner when signal currents are delivered to the circuit 17 through the transformer 18, the voltage across the channel at the point A differs from and is less than that appearing across the channel at the point B. Preferably, the constants of the circuit 17 are proportioned to provide a drop of approximately ten decibels in the signal level between the points A and B in each direction.

For the purpose of supplying positive anode potential to the anode 26 of the tube 21 and of providing appropriate biasing potentials for the grids 25 and 23, there is provided a direct current source 39 which is shunted by a voltage dividing resistor 40. More particularly, the resistor 40, which is connected across the terminals of the source 39, is provided with a grounded midtap 41 through which connection is made to the grounded cathode 22 of the tube 21 and with two additional taps 42 and 43 by way of which negative biasing potentials of appropriate values are respectively impressed upon the control electrodes 23 and 25.

Referring now more particularly to the operation of the apparatus, when sound waves impinge upon the diaphragm of the microphone 11 the generated signal currents are amplified by the amplifier 16 and are transmitted through the voltage transforming circuit 17 and the coupling transformer 18 to the line terminating at the terminals 10. During such signal current transmission the signal voltage developed across the channel 14 at the point A is reversed in phase by the transformer 31 and impressed across the terminals of the potentiometer resistor 32. The portion of this voltage represented by the drop across the adjustable portion of the potentiometer resistor 32 is impressed between the cathode 22 and the suppressor grid 25 over a path including the adjustable tap 33. Similarly, the signal voltage developed across the channel 14 at the point B during signal current transmission of the character described is impressed across the potentiometer resistor 34 and the portion of this voltage appearing across the adjustable portion of the resistor 34 is impressed between the cathode 22 and the control grid 23 over a path including the adjustable tap 35. Due to the presence of the transformer 31 in the first coupling path described above, the voltages respectively impressed upon the control electrodes 23 and 25 are in opposed phase relation. This is true for the reason that no phase shift occurs in the resistive voltage transforming circuit 17. Accordingly, the control influences exerted by these two voltages upon the electron stream flowing from the cathode 22 to the anode 26 tend to cancel each other. As explained previously, due to the relatively high amplification factor of the grid 23 as compared with that of the grid 25, greater changes in the electron flow occur in response to a given change in potential upon the grid 23 than in response to the same change in the potential impressed upon the grid 25. With the arrangement described, however, the signal voltage of large amplitude is impressed upon the grid 25 while the signal voltage of small amplitude is impressed upon the grid 23. More particularly, the resistance values of the elements 36, 37 and 38, forming the voltage transforming circuit 17, are so proportioned that the ratio of the signal voltages respectively impressed upon the grids 25 and 23 when signal currents flow from the microphone 11 over the channel 14 to the line connected to the terminals 10 is the inverse of the ratio of the changes produced in the electron stream in response to a given change in the potentials impressed upon the grids 25 and 23. Thus, the net control effect exerted on the electron stream flowing from the cathode 22 to the anode 26 is substantially zero. In order further to obtain an exact canceling of the control influences respectively exerted on the electron stream by the potentials on the grids 25 and 23, the adjustable taps 33 and 35 may be adjusted as required in order to obtain the necessary signal voltage ratio. Due to the opposing effects exerted by the two control grids, no substantial change occurs in the output current of the repeater 19 which traverses the load resistor 27. Accordingly, the signal currents are not transmitted through the channel 15 to the loud speaker 12 during operation of the transmitter 11, this channel being effectively blocked during such signal current transmission.

Signal currents incoming to the substation apparatus over the line connected to the terminals 10 are transmitted through the coupling transformer 18 and the voltage transforming circuit 17 to the output circuit of the signal amplifier 16. Since this amplifier is inherently a unidirectional transmitting device, the signal currents are prevented from flowing therethrough to the transmitter 11. When, however, signal currents traverse the channel 14 in this direction the voltage appearing across the channel at the point B is substantially greater than that appearing across the channel at the point A due to the voltage reducing action of the circuit 17. Accordingly, the signal voltage which is impressed upon the control grid 23 having the high amplification factor is substantially greater than that impressed upon the grid 25 having the lower amplification factor. As a result, the control effect exerted on the electron stream through changes in the potential of the grid 25 is substantially negligible as compared with the electron stream changes resulting from the signal voltage impressed upon the grid 23. In effect, therefore, the grid 23 functions substantially to alone control the currents traversing the output circuit of the repeater 19. Thus, the incoming signal currents are repeated through the repeater 19 and by way of the resistance capacitance coupling network included in the output circuit thereof to the input circuit of the amplifier 20. Following amplification in the amplifier 20, these signal currents are delivered to the loud speaker 12 for reproduction in the usual manner.

From the foregoing explanation it will be apparent that a substantial drop in signal level

is realized through the action of the circuit 17. In order to minimize this drop while maintaining the required ratio between the signal voltages impressed upon the control electrodes 23 and 25 an amplifier may be inserted in the coupling path over which the channel 14 is coupled to the control electrode 25. In such case, the phase reversing transformer 31 could be omitted or the input or output circuit of the amplifier could include a phase correcting network suitably designed to maintain the signal voltages impressed upon the two electrodes 23 and 25 in phase opposition.

While there has been described what is at present considered to be the preferred embodiment of the invention, it will be understood that various modifications may be made therein, and it is contemplated to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

I claim:

1. In a transmission system, a first two-way signal transmission channel, a second signal transmission channel, a repeater included in said second channel, said repeater including an electron discharge tube having a first control electrode adapted to cause a large change in the electron stream of the tube in response to a given change in the potential impressed thereon and a second control electrode adapted to cause a relatively small change in the electron stream of the tube in response to said given change in the potential impressed thereon, an input circuit coupled to said first channel at two different points and including means for impressing signal voltages of substantially opposite phase upon said control electrodes when signal currents traverse said first channel, and means comprising a two-direction transmission network included in said first channel between said points for changing the relative magnitudes of said voltages in accordance with the direction of signal current flow through said first channel so that signal currents are transmitted from said first channel through said second channel only when signal currents traverse said first channel in a predetermined direction.

2. In a transmission system, a first signal transmission channel, a second signal transmission channel, a repeater included in said second channel, said repeater including an electron discharge tube having first and second control electrodes adapted to cause changes in the electron stream of the tube in response to a given change in the potentials impressed thereon having a ratio to each other which is greater than unity, an input circuit for impressing signal voltages of substantially opposite phase upon said control electrodes when signal currents traverse said first channel, and means for controlling said voltages in accordance with the direction of signal current flow through said first channel so that the ratio of the magnitudes thereof is substantially the inverse of said predetermined ratio when signal currents traverse said first channel in one direction and is substantially greater than said inverse ratio when signal currents traverse said first channel in the opposite direction.

3. In a transmission system, a first signal transmission channel, a second signal transmission channel, a repeater included in said second channel, said repeater including an electron discharge tube having first and second control electrodes adapted to cause changes in the electron stream of the tube in response to a given change in the potentials impressed thereon having a ratio to each other which is greater than unity, an input circuit for impressing signal voltages of substantially opposite phase upon said control electrodes when signal currents traverse said first channel, and means comprising a voltage reducing circuit included in said first channel for controlling said voltages in accordance with the direction of signal current flow through said first channel so that the ratio of the magnitudes thereof is substantially the inverse of said predetermined ratio when signal currents traverse said first channel in one direction and is substantially greater than said inverse ratio when signal currents traverse said first channel in the opposite direction.

4. In a transmission system, a first two-way signal transmission channel including a voltage transforming circuit, a second signal transmission channel, a repeater including an electron discharge tube having a first control electrode adapted to cause a large change in the electron stream of the tube in response to a given change in the potential impressed thereon and a second control electrode adapted to cause a relatively small change in the electron stream of said tube in response to said given change in the potential impressed thereon, a path for coupling said first control electrode to said first channel at a point on one side of said voltage transforming circuit, a path including a voltage phase reversing device for coupling said second control electrode to said first channel at a point on the other side of said voltage transforming circuit, and means including said voltage transforming circuit for controlling the relative magnitudes of the signal voltages impressed on said control electrodes over said paths so that signal currents are transmitted from said first channel to said second channel only when they traverse said first channel in a predetermined direction.

5. In a transmission system, a first signal transmission channel including a voltage transforming circuit, a second signal transmission channel, a repeater including an electron discharge tube having first and second electrodes adapted to cause changes in the electron stream of the tube in response to a given change in the potentials impressed thereon having ratio to each other which is greater than unity, a path for coupling said first electrode to said first channel at a point on one side of said voltage transforming circuit, and a path including a voltage phase reversing device for coupling said second control electrode to said first channel at a point on the other side of said voltage transforming circuit, the impedances of the circuit elements included in said paths and said voltage transforming circuit being so proportioned that the ratio of the magnitudes of the signal voltages impressed on said control electrodes over said paths is substantially the inverse of said predetermined ratio when signal currents traverse said first channel in one direction and is substantially greater than said inverse ratio when signal currents traverse said first channel in the opposite direction.

6. In a transmission system a first signal transmission channel including a voltage transforming circuit consisting solely of resistance elements, whereby substantially no phase shift occurs during the transmission of signal currents through said circuit, a second signal transmission channel, a repeater including an electron discharge tube having a first control electrode adapted to

cause a large change in the electron stream of the tube in response to a given change in the potential impressed thereon and a second control electrode adapted to cause a relatively small change in the electron stream of said tube in response to said given change in the potential impressed thereon, a path for coupling said first control electrode to said first channel at a point on one side of said voltage transforming circuit, a path including a voltage phase reversing device for coupling said second control electrode to said first channel at a point on the other side of said voltage transforming circuit, and means including said voltage transforming circuit for controlling the relative magnitudes of the signal voltages impressed on said control electrodes over said paths so that signal currents are transmitted from said first channel to said second channel only when they traverse said first channel in a predetermined direction.

7. Telephone substation apparatus adapted to be connected to a line and comprising transmitting and receiving means, a first two-way channel for transmitting signal currents from said transmitting means to said line and for transmitting incoming signal currents to said receiving means, a second channel coupling said receiving means to said first channel, a repeater included in said second channel and comprising an electron discharge tube having a first control electrode adapted to cause a large change in the electron stream of the tube in response to a given change in the potential impressed thereon and a second control electrode adapted to cause a relatively small change in the electron stream of the tube in response to said given change in the potential impressed thereon, an input circuit coupled to said first channel at two different points and including means for impressing signal voltages of substantially opposite phase upon said control electrodes when signal currents traverse said first channel, and means comprising a two-direction transmission network included in said first channel between said points for controlling the relative magnitudes of said voltages in accordance with the direction of signal current flow through said first channel so that only signal currents incoming to said apparatus are transmitted from said first channel to said second channel.

8. Telephone substation apparatus adapted to be connected to a line and comprising transmitting and receiving means, a first channel for transmitting signal currents from said transmitting means to said line, a second channel for transmitting incoming signal currents to said receiving means, a repeater included in said second channel and comprising an electron discharge tube having first and second electrodes adapted to cause changes in the electron stream of the tube in response to a given change in the potentials impressed thereon having ratio to each other which is greater than unity, an input circuit coupled to said first channel and operative to impress signal voltages of substantially opposite phase upon said control electrodes when signal currents traverse said first channel, and means for controlling said voltages in accordance with the direction of signal current flow through said channel so that the ratio of the magnitudes thereof is substantially the inverse of said predetermined ratio when signal currents flow from said transmitting means through said first channel to said line and is substantially greater than said inverse ratio when signal currents flow from said line over said first channel to said input circuit.

9. Telephone substation apparatus adapted to be connected to a line and comprising transmitting and receiving means, a first channel for transmitting signal currents from said transmitting means to said line, a second channel for transmitting incoming signal currents to said receiving means, a repeater included in said second channel and comprising an electron discharge tube having first and second electrodes adapted to cause changes in the electron stream of the tube in response to a given change in the potentials impressed thereon having ratio to each other which is greater than unity, an input circuit coupled to said first channel for impressing signal voltages of substantially opposite phase upon said control electrodes when signal currents traverse said first channel, and means comprising a voltage transforming circuit included in said first channel for controlling said voltages in accordance with the direction of signal current flow through said channel so that the ratio of the magnitudes thereof is substantially the inverse of said predetermined ratio when signal currents flow from said transmitting means through said first channel to said line and is substantially greater than said inverse ratio when signal currents flow from said line over said first channel to said input circuit.

10. Telephone substation apparatus adapted to be connected to a line and comprising transmitting and receiving means, a first channel for transmitting signal currents from said transmitting means to said line, a voltage transforming circuit included in said first channel, a second channel for transmitting incoming signal currents from said line to said receiving means, a repeater included in said second channel and comprising a first control electrode adapted to cause a large change in the electron stream of the tube in response to a given change in the potential impressed thereon and a second control electrode adapted to cause a relatively small change in the electron stream of the tube in response to said given change in the potential impressed thereon, a path for coupling said first control electrode to said first channel at a point on one side of said voltage transforming circuit, a path including a voltage phase reversing device for coupling said second control electrode to said first channel at a point on the other side of said voltage transforming circuit, and means including said voltage transforming circuit for controlling the relative magnitudes of the signal voltages impressed on said control electrodes over said paths so that only signal currents incoming to said apparatus are transmitted from said first channel through said second channel.

11. In a transmission system, a bi-directional signal current transmission channel including a voltage transforming network operative to pass signal currents in either direction, a second signal current channel coupled to said bi-directional channel at points on either side of said network, and means controlled in accordance with the difference between the signal voltages across said channel at points on either side of said network for preventing signal currents transmitted over said bi-directional channel in one direction from traversing said second channel.

12. In a transmission system, a bi-directional signal current transmission channel including a voltage transforming network operative to pass

signal currents in either direction, a second signal current channel including an electron discharge device having a pair of control electrodes coupled to said bi-directional channel on either side of said network, and means including said network for controlling the voltages impressed upon said control electrodes so that said electrodes exert substantially equal and opposite effects on the electron stream of said device when signal currents traverse said bi-directional channel in one direction and exert substantially unequal but opposite effects on the electron stream of said device when signal currents are transmitted over said bi-directional channel in the opposite direction, whereby signal currents are transmitted from said bi-directional channel through said second channel only when they traverse said bi-directional channel in said other direction.

13. In a transmission system, a bi-directional signal current transmission channel, a coupling network including an output circuit and means for transmitting signal currents from said channel to said output circuit only when they traverse said channel in a predetermined direction, and a second signal current transmission channel electrically coupled to said bi-directional channel only through said network, whereby signal currents are only transmitted from said bi-directional channel through said network to said second channel when they traverse said bi-directional channel in said predetermined direction.

14. In a transmission system, a bi-directional signal current transmission channel including a voltage transforming network operative to pass signal currents in either direction, a coupling network coupled to said channel at points on either side of said voltage transforming network and including an output circuit and means controlled in accordance with the difference in the signal voltages across said channel at said points for transmitting signal currents from said channel to said output circuit only when the signal currents traverse said channel in a predetermined direction, and a second signal current transmission channel electrically coupled to said bi-directional channel only through said coupling network, whereby signal currents are only transmitted from said bi-directional channel through said network to said second channel when they traverse said bi-directional channel in said predetermined direction.

15. In a transmission system, a bi-directional signal current transmission channel including a voltage transforming network operative to pass signal currents in either direction, said network consisting of interconnected resistance elements exclusively, a coupling network coupled to said channel at points on either side of said voltage transforming network and including an output circuit and means controlled in accordance with the difference in the signal voltages across said channel at said points for transmitting signal currents from said channel to said output circuit only when the signal currents traverse said channel in a predetermined direction, and a second signal current transmission channel electrically coupled to said bi-directional channel only through said coupling network, whereby signal currents are only transmitted from said bi-directional channel through said network to said second channel when they traverse said bi-directional channel in said predetermined direction.

ROSWELL H. HERRICK.