

Oct. 24, 1944.

L. G. ABRAHAM

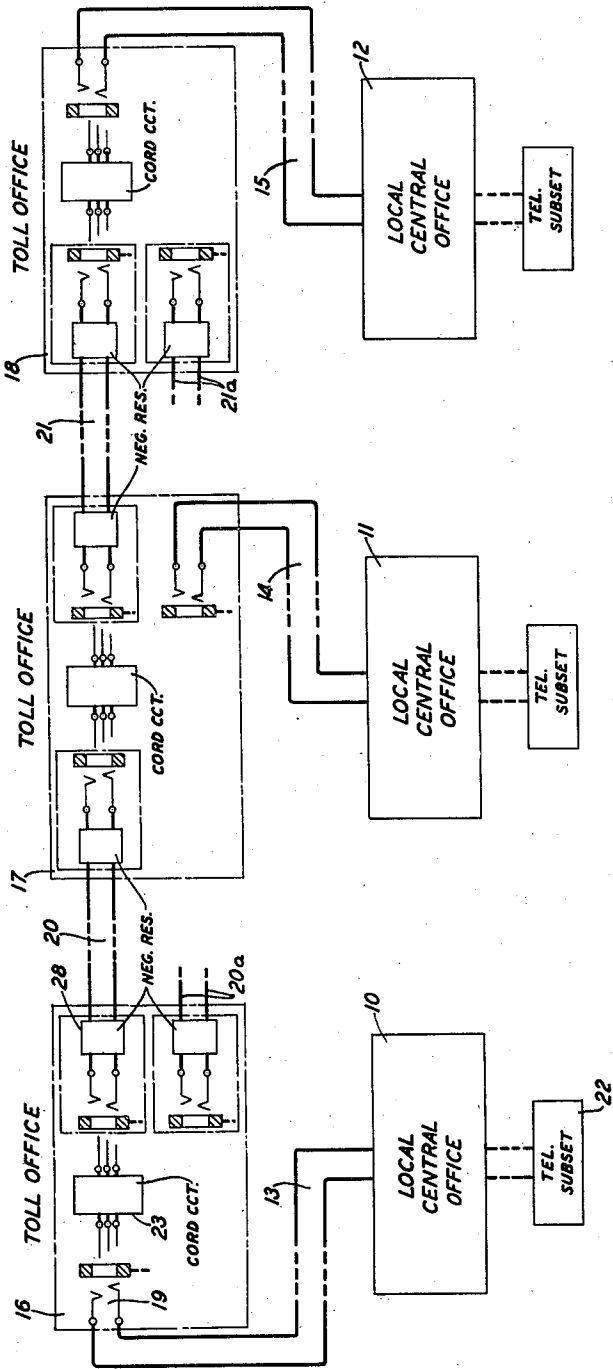
2,360,926

SIGNAL TRANSMISSION SYSTEM

Filed March 27, 1943

4 Sheets-Sheet 1

FIG. 1



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SIGNAL TRANSMISSION SYSTEM

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FIG. 2

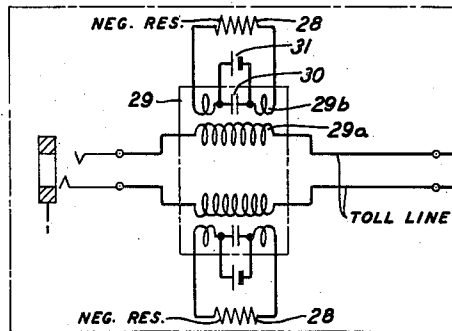


FIG. 3

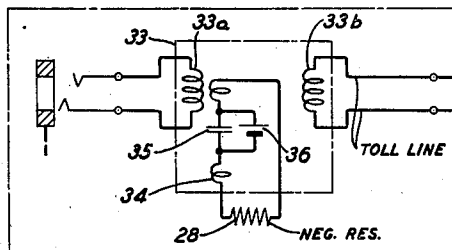


FIG. 4

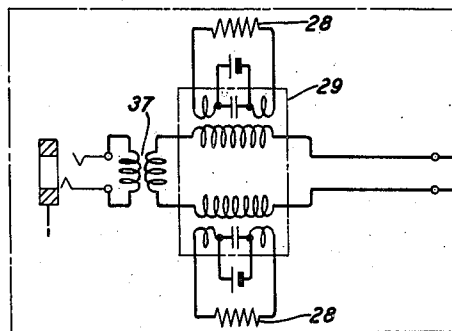
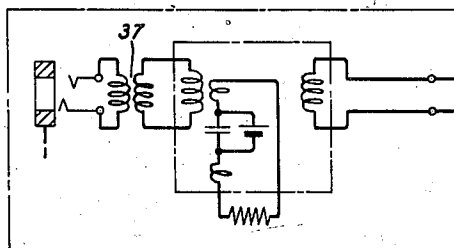


FIG. 5



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SIGNAL TRANSMISSION SYSTEM

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FIG. 6

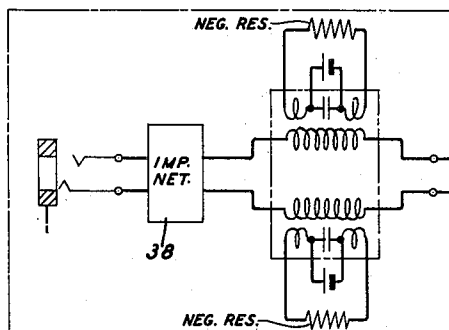


FIG. 7

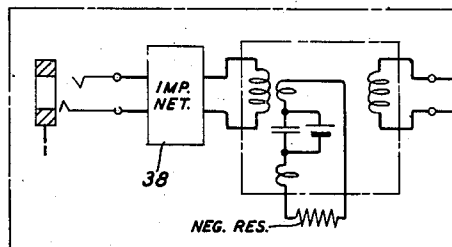


FIG. 8

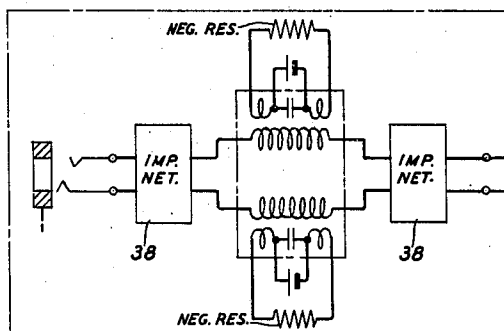


FIG. 9

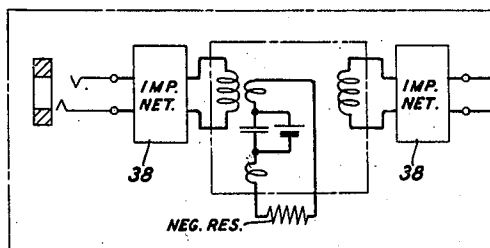
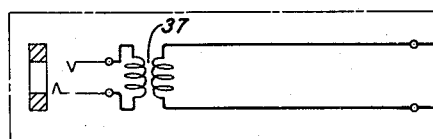


FIG. 9A



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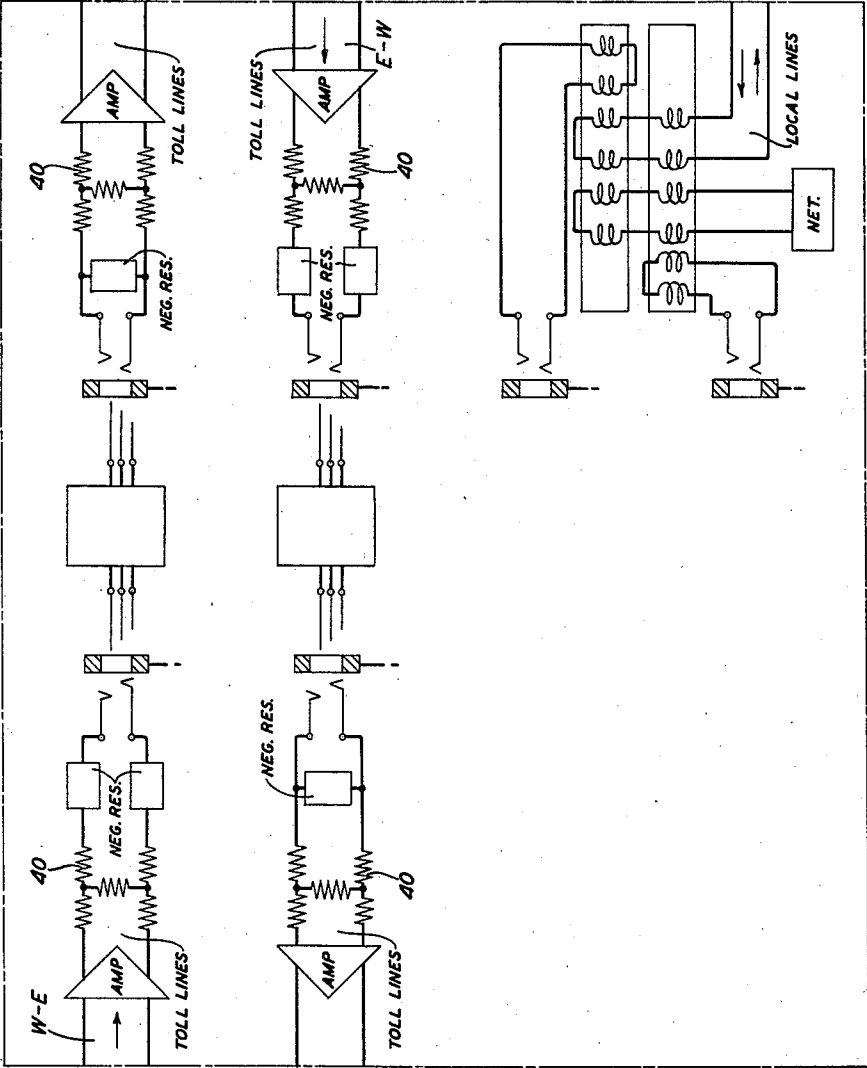
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FIG. 10



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UNITED STATES PATENT OFFICE

2,360,926

SIGNAL TRANSMISSION SYSTEM

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18 Claims. (Cl. 179-41)

This invention relates to an arrangement for controlling transmission loss in a signal transmission system embodying a plurality of individual transmission lines having their terminals connected together for establishing the lines in circuit. It relates more particularly to such system in which a switchless arrangement including negative resistors embodied in certain line terminals serves to vary the effective transmission loss at individual line connections, depending on whether individual terminals are connected to similar terminals, or different terminals.

Heretofore, negative resistors have been used in signal transmission systems for the purpose of introducing gain at one or more spaced points therealong. Each of such uses involves the introduction of the negative resistors between line terminals having substantially constant impedances. Also, heretofore, resistance pads have been used at the line terminals of certain signal transmission systems to regulate the effective amount of transmission loss thereat depending on whether such line terminals were connected to line terminals of the same kind or of a different kind. The selection of the kind of line terminals used with a particular line is based on the transmission capabilities of such lines, among other considerations. This usually involves the use of electromagnetic relays, control pads and associated apparatus for switching in and switching out the resistance pads, and is expensive from both initial cost and maintenance considerations. The present invention is concerned with a switchless arrangement for controlling the effective transmission loss at individual line connections in a signal transmission system as individual line terminals comprising such connections are switched from similar line terminals to different lines terminals, and vice versa.

The present invention contemplates a switchless control of the effective transmission loss at individual line connections in a signal transmission system in which the impedance of one of two line terminals constituting the individual line connections is changed from time to time.

The main object of the invention is to provide a switchless control of the effective transmission loss at the connection of the terminal of one line as the line terminal to which the former is connected is changed in kind in an electrical sense from time to time.

Another object is to provide in a single line terminal a switchless device whose effective transmission loss at a given time is determined

by the impedance of the line terminal to which the former is connected at the given time.

A further object is to provide a switchless variation of the effective transmission loss at the connection of a line terminal which may be switched between two or more other line terminals having different impedances.

Another object is to provide a switchless apparatus for changing automatically the effective transmission loss of individual terminals of a toll telephone line as the latter terminals are switched from similar toll terminals to local line terminals, and vice versa.

One type of two-wire toll telephone system includes, among other apparatus, a plurality of toll offices, a local office associated with each toll office, a toll line connecting each pair of toll offices, a local line connecting each toll office and the local office associated therewith, and a cord circuit at each toll office to connect the toll and local offices in circuit. As the individual toll terminals in certain offices may be connected thereat to another toll terminal or a local terminal, it is necessary for reasonably high quality talking on the toll system to vary the effective transmission loss at the individual connections of the toll and local toll terminals, depending on whether the toll terminals are connected to other toll terminals or local terminals.

In accordance with a specific embodiment of the present invention, resistance means provided with preselected negative resistance characteristics are effectively interposed in individual toll terminals. When two such toll terminals are connected together in one two-wire toll office, the negative resistance means of the individual toll terminals provides a certain amount of effective transmission loss or gain at such connections. When one of two such toll terminals of the one two-wire toll office is connected to a local terminal in that toll office, the negative resistance means provides a different amount of effective transmission loss or gain at such connection. The difference between such two losses or gains may be made equivalent in loss change to the mechanical insertion or removal of switching pads as mentioned above.

In the case of four-wire toll telephone systems, such negative resistance means is effectively interposed in each of the transmitting and receiving branches of individual one-way paths. When two such four-wire toll terminals are connected together in one four-wire toll office, the individual negative resistance means establish equal amounts of effective transmission loss at the in-

dividual connections in each direction of transmission. This has the effect of inserting a resistance pad of a preselected fixed amount of loss in the individual transmitting and receiving terminals of each one-way path. When one of two such four-wire toll terminals of the one four-wire toll office is connected to a local four-wire terminal in that toll office, the individual negative resistance means of the four-wire toll terminal provide certain amounts of effective transmission loss in individual connections in each direction of transmission, but such certain amounts of transmission loss are different from each other as well as from amounts of transmission loss mentioned above with reference to the connection of two four-wire toll terminals.

A feature concerns the automatic change of effective transmission loss or gain at individual line connections in accordance with the relative magnitudes of the impedances of the two line terminals constituting the individual line connections. Another feature relates to the accomplishment of such change of loss or gain without the aid of electromagnetic switching apparatus. A further feature involves the use of negative resistors at individual line terminals to provide a switchless change of loss or gain at individual line connections involving such terminals, depending on the relative magnitudes of the impedances of each of the two line terminals constituting the individual line connections. Another feature includes the location of negative resistors in series or shunt of certain line terminals and the connection of each of such line terminals to a similar line terminal or a different line terminal for controlling transmission loss or gain at such line connection.

A further feature embodies the mismatching of the impedances of two line terminals connected together in circuit by means of either a transducer alone or a negative resistor alone for controlling transmission loss or gain at such line connection. Another feature concerns the use of a transducer at one line terminal and negative resistors at each of two connected line terminals including the one line terminal for controlling transmission loss or gain at such connection. Still another feature relates to the use of transducers or negative resistors or both at each of two toll terminals for controlling transmission loss or gain at individual toll connections comprising such toll terminals and local terminals, without the aid of electromagnetic switching apparatus. Still another feature involves the use of such transducers or negative resistors or both in the individual terminals of two-wire and four-wire toll terminals.

The invention will be readily understood from the following description taken together with the accompanying drawings in which:

Fig. 1 is a schematic circuit showing a specific embodiment of the invention in connection with a two-wire toll telephone system;

Figs. 2 through 9A illustrate modifications of the embodiments of the invention shown in Figs. 1 and 10; and

Fig. 10 is a schematic circuit of a four-wire toll telephone office which may embody the modifications of the invention shown in Figs. 2 through 9 and which may be substituted in Fig. 1 to establish a four-wire toll telephone system.

In the following description, the same reference numerals are employed to designate identical elements appearing in the several figures of the drawings.

Fig. 1 shows a toll telephone system comprising a plurality of local central offices 10, 11 and 12 connected over individual local transmission lines 13, 14 and 15 to individual toll telephone offices 16, 17 and 18, respectively. Each local line terminates in the individual toll offices in a telephone jack 19. A toll line 20 connects toll offices 16 and 17 and terminates in each thereof in a telephone jack; and a toll line 21 joins toll offices 17 and 18 and terminates in each thereof in a telephone jack. Toll offices 16 and 18 also embody further toll lines 20a and 21a, respectively. A subscriber's telephone subset 22 is applied to each local office. The individual toll offices also embody a telephone cord circuit 23 for connecting the local and toll offices in circuit in the familiar manner so that talking toll circuits can be established between any two desired subscribers' telephone subsets.

In accordance with a specific embodiment of the present invention, as illustrated in Fig. 1, a resistor 28 provided with a preselected negative resistance characteristic, for a purpose that will be hereinafter mentioned, is effectively interposed in series in the toll office terminal of individual toll lines 20, 20a, 21 and 21a in the manner shown in Fig. 2. Referring to Fig. 2, a repeat coil 29 has winding 29a connected in series in the upper conductor of the toll line and coupled to split winding 29b which is interrupted substantially at its mid-point by a capacitor 30 and which has the negative resistor 28 connected in shunt thereof. A source 31 of direct potential is disposed in bridge of the capacitor 30 for biasing the negative resistor 28 to control the point of operation on its characteristic. The repeat coil 29 also embodies an identical pair of coupled windings, direct current source, and capacitor for effectively connecting another negative resistor 28 in a similar manner in series in the lower conductor of the toll line terminal of Fig. 2.

In the operation of Figs. 1 and 2, let it be supposed that a subscriber at the local office 10 wishes to call a subscriber at the local office 12. To accomplish such call, the cord circuit of toll office 16 is inserted into the terminal jacks of the local line 13 and the toll line 20; the cord circuit of the toll office 17 is inserted into the terminal jacks of the toll lines 20 and 21; and the cord circuit of the toll office 18 is inserted into the terminal jacks of the toll line 21 and the local line 15. This establishes a circuit for talking between the subscribers located at the local offices 10 and 12.

In order that the amplitudes of the talking currents transmitted between local stations 10 and 12 be of such order of magnitude as to enable intelligible talking therebetween, the gain or transmission loss of the previously traced talking circuit should be fixed at a certain order of magnitude, consistent with the over-all length of the effective talking circuit. This may be achieved in the following manner: Referring to Fig. 1, it is seen that the previously traced talking circuit includes local lines 13 and 15, and toll lines 20 and 21. Let L be the impedance of each of the local and toll lines. When two lines of impedance L are connected in circuit, the current I_0 flowing therein is

$$I_0 = \frac{e}{2L} \quad (1)$$

where e is the driving voltage.

If a negative resistance $-r$ is effectively inserted in series in one of the two lines of imped-

ance L connected in circuit, the current I_1 flowing therein is

$$I_1 = \frac{e}{2L - r} \quad (2)$$

The gain inserted in the circuit of Equation 2 with reference to that of Equation 1 is

$$G_1 = 20 \log \left(\frac{I_1}{I_0} \right) = 20 \log \left(\frac{2L}{2L - r} \right) \quad (3)$$

If a negative resistance $-r$ is effectively connected in series in each of the two lines of impedance L , the current I_2 flowing therein is

$$I_2 = \frac{e}{2L - 2r} \quad (4)$$

The gain inserted in the circuit of Equation 4 with reference to that of Equation 1 is

$$G_2 = 20 \log \left(\frac{I_2}{I_0} \right) = 20 \log \left(\frac{2L}{2L - 2r} \right) \quad (5)$$

For convenience we may write

$$G_1 = 20 \log \left(\frac{1}{1 - \frac{r}{2L}} \right)$$

$$G_2 = 20 \log \left(\frac{1}{1 - \frac{r}{L}} \right)$$

If now we select

$$\frac{r}{L} = 0.82$$

then

$$G_1 = 20 \log \left(\frac{1}{1 - 0.41} \right) = 4.67 \text{ decibels} \quad (6)$$

$$G_2 = 20 \log \left(\frac{1}{1 - 0.82} \right) = 15.3 \text{ decibels} \quad (7)$$

Thus, the gain for each line of impedance L having a negative resistance $-r$ embodied effectively in series therein is 4.65 decibels; while the gain where two lines of impedance L , both of which have a negative resistance $-r$ embodied effectively in series therein, is 15.3 decibels. This corresponds to the disconnection of certain effective switching pad loss,

$$\left[\frac{15.3}{2} - 4.65 = 3 \text{ decibels} \right]$$

from each of the two lines L connected together and having a negative resistance embodied in series therewith. Obviously, further increases of gain can be realized by connecting in circuit additional lines of impedance L and equipping each of the latter with negative resistors $-r$ of the series type indicated in Fig. 2.

As the talking circuit described above with reference to Figs. 1 and 2 includes a local line terminal having no negative resistors and a toll line terminal embodying a negative resistor effectively in series therein connected together at individual toll offices 16 and 18, it is apparent from Equation 6 that the negative resistor introduces a gain of 4.65 decibels in each such line connection. Also, as this talking circuit further includes two toll line terminals, each embodying a negative resistor in series therein, connected together at toll office 17, it is apparent from Equation 7 that the negative resistors cooperate to introduce a gain of 15.3 decibels in such connection. As previously pointed out, the latter gain is equivalent to the disconnection of a 3 decibel resistance pad from each of the two toll terminals. In Fig. 2, repeat coil 29, due to the adjust-

ment of the impedances at its terminals, permits the use of varying sizes of negative resistors for introducing a given amount of gain or loss in individual toll line connections. The use of this repeat may be advantageous when the sizes of the available negative resistors are limited.

Now, let it be supposed that a subscriber at local office 10 wishes to call a subscriber at local office 11. To accomplish this, the cord circuit of toll office 16 is inserted into terminal jacks of local and toll lines 13 and 20, respectively, and cord circuit of toll office 17 is inserted into the terminal jacks of local and toll lines 14 and 20, respectively. Each toll line terminal is equipped with series negative resistors according to Fig. 2. As each toll line terminal embodying a negative resistor in series therein is connected, at the toll offices 16 and 17, to a local line terminal embodying no negative resistors, it is apparent from Equation 6 that the negative resistors at the individual toll terminals introduce a gain of 4.65 decibels in each such line connection.

Fig. 3 is similar to Fig. 2 except negative resistor 28 is effectively interposed in shunt of the toll line terminal. For this purpose, repeat coil 33 has its respective primary and secondary windings 33a and 33b applied across the toll line terminal, and a split tertiary winding 34 coupled to both of these windings. Interposed at the midpoint of the tertiary winding 34 is a capacitor 35 in bridge of which is a source 36 of a direct current for so biasing the negative resistor 28 as to control the point of operation on its characteristic. It can be demonstrated in connection with Figs. 1 and 3 included in the previously described talking circuits involving two local offices in circuit with two or three toll offices that (1) when a local line terminal having no negative resistor is connected to a toll line terminal embodying a negative resistor in shunt thereof in accordance with Fig. 3, the negative resistor introduces a certain amount of gain into each line connection so equipped, which amount of gain is different from that introduced by series negative resistors according to Fig. 2; and when two toll terminals embodying negative resistors in shunt thereof in accordance with Fig. 3 are connected together, the negative resistors introduce a gain of 15.3 decibels into such connection, which gain is identical with that introduced by series negative resistors according to Fig. 2. This gain is equivalent to the disconnection of a 3 decibel resistance pad from each of the two toll terminals. However, when a toll terminal embodying a negative resistor of the series type, Fig. 2, is connected to a toll terminal embodying a negative resistor of the shunt type, Fig. 3, a further amount of transmission loss or gain is inserted in such connection, which further amount is different from the certain amount mentioned above with reference to the connection of two terminals embodying negative resistors of the series type, Fig. 2, or two terminals embodying negative resistors of the shunt type, Fig. 3.

By preselecting the characteristics of the individual negative resistors, each line connection embodying a toll terminal can be provided with a predetermined amount of transmission loss or gain whereby the amplitudes of the talking currents in a given toll circuit can be so controlled as to improve the quality of talking transmission therein. Such improvement is, of course, not limited to the toll circuits identified hereinabove, but can be obtained in a toll circuit embodying a number of discrete toll lines in excess of three.

In the foregoing toll circuits, it is understood that the net transmission loss or gain of the entire toll circuits may be adjusted by means, other than those mentioned herein, to establish the proper level of transmission between the two local subscribers for obtaining reasonably high quality talking in the toll circuit extending therebetween.

Thus, when a line terminal equipped with a negative resistor of the series or shunt type, Fig. 2 or 3, is connected to a line terminal unequipped with a negative resistor, the series negative resistor introduces one amount of gain or loss in such connection while the shunt negative resistor introduces a different amount of gain or loss in such connection. When two line terminals, each equipped with a negative resistor of the series type, Fig. 2, are connected together, a certain amount of transmission loss or gain is introduced in such connection; and this certain amount of transmission loss or gain is the same as that introduced in a connection including two line terminals, each of which is equipped with a negative resistor of the shunt type, Fig. 3. When a line terminal equipped with a series negative resistor, Fig. 2, is connected to a line terminal equipped with a shunt negative resistor, Fig. 3, a further amount of transmission loss or gain is introduced in such connection, which further amount is different from the amounts of transmission loss or gain mentioned above with reference to the other types of terminal connections.

Fig. 4 is similar to Fig. 2 except a repeat coil 37 is interposed between the negative resistors and the toll terminal jack. Repeat coil 37 varies the effective value of the terminating impedance of the toll line as seen from the negative resistors. As the effective transmission loss or gain established in a line connection embodying the terminal of Fig. 4, is determined by the impedance of the terminal to which the negative resistor terminal, Fig. 4, is connected in such line connection, the repeat coil 37 serves to supplement the effectiveness of the negative resistors for varying the transmission loss or gain in such connection, provided such connection embodies only one repeat coil 37.

Fig. 5 is similar to Fig. 3, except it also embodies repeat coil 37 interposed between the negative resistor and the toll terminal jack. Repeat coil 37 controls the effective value of the terminating impedance of the respective toll line as seen from the negative resistor and thereby the effective transmission loss or gain in a line connection embodying one repeat coil 37 only according to Fig. 3 as previously pointed out in connection with a line connection embodying one repeat coil 37 only according to Fig. 4.

In certain cases, the negative resistors, Figs. 4 and 5, may be omitted so that the effective transmission loss or gain at a line connection embodying one repeat coil 37 only is controlled by the impedance effects of the repeat coil 37 alone, Fig. 9A. When two toll terminals, both of which are equipped according to Figs. 4 and 5, are connected together, the impedance effect due to the repeat coil 37 of one toll terminal is cancelled by the impedance effect due to the repeat coil 37 of the other terminal, and hence the two toll terminals, Fig. 4 or 5, simplify essentially to two toll terminals according to Fig. 2. Hence, when two line terminals equipped according to Fig. 9A are connected together, the net loss at such connection is substantially zero; but when one terminal is equipped according to Fig. 9A and is con-

nected to another terminal unequipped with the repeating coil 37 of Fig. 9A a certain magnitude of reflection loss is effectively introduced in such connection. When toll terminals according to Fig. 4 or Fig. 5 are individually connected to a local line terminal, the individual toll terminals introduce individual amounts of transmission loss or gain in the connection such that the amount of loss or gain due to the toll terminal of Fig. 4 is different from that due to the toll terminal of Fig. 5. This is equivalent to the insertion or removal of individual resistance pads whose effective resistance values correspond in magnitude to the impedances of the negative resistor terminals according to Figs. 4 and 5.

Figs. 6 and 7 are similar to Figs. 4 and 5, respectively, except impedance networks 38 are substituted for the repeat coils 37 for controlling the terminating impedance of the individual toll terminals. Networks 38 may comprise resistance pads, autotransformers, and similar transducers.

Figs. 8 and 9 are similar to Figs. 6 and 7, respectively, except impedance networks 38 are disposed on the line sides of the negative resistors. Fig. 8 is similar to Fig. 6 except identical impedance terminating networks 38, 38 are disposed on opposite sides of the negative resistors 28, 28. Fig. 9 is similar to Fig. 7 except identical impedance terminating networks 38, 38 are disposed on opposite sides of the negative resistor 28.

Fig. 10 shows a four-wire toll office which comprises two one-way paths and which may be substituted for the individual two-wire toll offices 16, 17 and 18, Fig. 1. For example, the toll office of Fig. 10 may be substituted for the individual toll offices 16, 17 and 18, Fig. 1, by connecting the local lines to the proper local terminal and toll lines to the proper toll terminals. Referring to Fig. 10, series negative resistors of any one of the types shown in Figs. 2, 4, 6 and 8 may be effectively interposed in the receiving branches of each of the W-E and E-W one-way paths while shunt negative resistors of any one of the types shown in Figs. 3, 5, 7 and 9 may be interposed in the transmitting branches of each of the W-E and E-W one-way paths. In one representative case, when a toll terminal was connected to a local terminal there was obtained a 24.6 decibel receiving gain and a 2.5 decibel transmitting gain in each of the one-way paths; and when the two-way toll terminals were connected together, an 11.1 decibel gain was obtained in the individual transmitting and receiving branches of each one-way path. The 11.1 decibel gain is substantially the equivalent of inserting an 8 decibel resistance pad,

$$\left(\frac{24.6 + 2.5 - 11.1}{2} \right)$$

in the individual transmitting and receiving terminals of each one-way path when two four-wire toll terminals are connected together. This effect is opposite to that described above for the operation of Figs. 1 through 9 where the effect, when identical two two-way toll terminals were connected together, was that a 3 decibel resistance pad was effectively removed from each of the toll terminals. It is to be understood that the same result could be obtained when the series and shunt negative resistors are effectively connected in the individual transmitting and receiving branches, respectively, or in various other combinations.

What is claimed is:

1. In combination, a plurality of lines for transmitting signal current, means to connect

the terminals of said lines for arranging said lines in circuit, and means comprising networks having predetermined impedance versus frequency characteristics and disposed in the terminals of certain of said lines for automatically controlling the effective impedance to said signal current when a line equipped with said network means is connected in circuit, said network means being so constructed and arranged that the effective impedance at a connection of the terminals of two of said certain lines is less than the impedance at the connection of a terminal of one of said certain lines with the terminal of another line not equipped with said network means.

2. In a signaling system, a switching point, a plurality of lines for transmitting signal current terminating thereat, certain of said lines having a first terminal impedance characteristic and the remainder of said lines having a second characteristic, switching means for interconnecting the terminals of desired ones of said lines, and individual static means associated with the terminals of the lines of the first characteristic so constructed and arranged that the effective impedance to said signal current at the connected terminals of two lines of said first characteristic is less than the effective impedance at the connected terminals of two lines only one of which is of said first characteristic.

3. The combination according to claim 1 in which said networks include resistance means provided with preselected negative resistance characteristics.

4. The combination according to claim 1 in which said networks include resistance means provided with preselected negative resistance characteristics, and electrical transducers positioned in preselected certain terminals.

5. In combination, a plurality of lines transmitting signal current and having predetermined magnitudes of terminal impedances for the signal current, means to connect the terminals of said lines for arranging said lines in circuit, and means to control the effective impedance for the signal current at individual connections of the terminals of certain lines, including means provided with preselected negative resistance characteristics and interposed in each of said certain line terminals to establish an effective impedance of a lesser degree of magnitude at the connection of two of said certain terminals than at the connection of one of said certain terminals with a terminal not provided with means including a negative resistance.

6. In combination, a plurality of first and second type lines for transmitting signal current and having predetermined terminal impedances to said signal current, means to connect desired terminals of said lines to establish a transmission circuit thereover, and static impedance reducing means, including a network comprising a predetermined negative resistance, disposed in each of the terminals of said first type lines so arranged as to reduce to a lower value the overall terminal impedance when two of said first type lines are connected than when first and second type lines are connected.

7. In combination, a plurality of first and second type lines for transmitting signal current and having predetermined magnitudes of terminal impedance to said signal current, means to connect desired terminals of said lines to establish a signal transmission circuit thereover, and impedance reducing means including a negative

resistance of preselected value interposed in the terminals of said first type lines to reduce the effective impedance to signal current applied thereto, said negative resistance means having the characteristic of reducing the over-all terminal impedance at two connected lines of the first type to a lower value than the terminal impedance at the connection of a first type line with a second type line.

8. In a telephone system comprising a switching office and a plurality of first and second type signal current transmission lines terminating thereat in impedance having a predetermined value when said signal current is transmitted thereover, switching means at said office for connecting the terminals of any two of said lines together, and impedance reducing means including a negative resistance associated with the terminals of said first type lines and so constructed and arranged that the effective impedance to said signal current at the connection of two of such first type lines is reduced to a lower value than the impedance reduction at the connection of a line of the first type with one of the second type.

9. The telephone system according to claim 8 in which said negative resistance means is effectively connected in series to each of said certain line terminals.

10. The telephone system according to claim 8 in which said negative resistance means is effectively connected in shunt of each of said certain line terminals.

11. The telephone system according to claim 8 in which the said negative resistance associated with at least one of said lines is connected in effective series relationship therewith and the negative resistance associated with at least one other of said lines is connected in effective shunt relationship therewith and at least one of said terminal interconnections involves one terminal having an associated series type negative resistance and one terminal having an associated shunt type negative resistance.

12. A toll telephone system comprising a plurality of toll offices, a local central office associated with individual toll offices, a line for transmitting signal current between each local office and one toll office and terminating in said latter office in one magnitude of impedance for the signal current, a line for transmitting the signal current between associated pairs of toll offices and terminating in said latter offices in a different magnitude of impedance for the signal current, means at individual toll offices to connect the terminals of said lines for establishing at least three toll offices and two local offices in circuit, and means including means provided with a preselected negative resistance characteristic and interposed in each toll office terminal of individual toll lines to control the effective transmission loss at each toll office connection of the individual toll and local lines in said circuit such that when two toll line terminals are connected together in one toll office in said circuit said negative resistance means of individual toll line terminals vary the magnitude of the effective impedances thereat to establish one amount of effective transmission loss at the connection of said two toll line terminals in said one toll office and such that when one toll line terminal is connected to one local line terminal at another toll office in said circuit said negative resistance means of said one toll line terminal varies the magnitude of the effective im-

pedance thereat to establish a different amount of effective transmission loss at the connection of said one toll and local line terminals at said other toll office.

13. A toll telephone system comprising a plurality of toll offices, a local central office associated with each of said toll offices, a toll line extending between each pair of toll offices, a local line extending between each toll office and the local office associated therewith, means at each toll office to connect at least three toll offices and at least two local offices in circuit, and means including means provided with preselected negative resistance characteristics and interposed in individual toll line terminals at each of said toll offices to control the effective transmission loss at individual toll office connections which include toll terminals connected to toll terminals and toll terminals connected to local terminals.

14. A telephone system comprising a switching office, a plurality of transmission lines each of which is terminated in four wires in said office such that each two wires serves to transmit in opposite directions, means to connect two of said lines in circuit at said office, and means including means provided with a preselected negative resistance characteristic and connected effectively in each two-wire terminal of certain four-wire lines to control the effective transmission loss in individual two-wire terminals of said certain four-wire lines such that when two certain four-wire lines are connected together in said circuit said negative resistance means individual to each of the two-wire terminals transmitting in the same direction establish substantially equal amounts of effective transmission loss in each of said latter two-wire terminals and such that when one certain four-wire line is connected to one other four-wire line in said circuit said negative resistance means individual to the two-wire terminals of said one certain four-wire line established other amounts of effective transmission loss which other amounts are different from each other and different from said equal amounts of transmission loss.

15. The telephone system according to claim 14 in which one of said negative resistance means is connected effectively in series in one two-wire terminal of each of said certain four-wire lines, and another of said resistance means is connected effectively in shunt of the other two-wire terminal of each of said certain four-wire lines.

16. The telephone system according to claim 14 in which individual certain four-wire lines comprise a receiving two-wire terminal and a transmitting two-wire terminal for transmitting

in the same direction, and one of said negative resistance means is connected effectively in series in the individual receiving two-wire terminals, and another of said resistance means is connected effectively in shunt of individual transmitting two-wire terminals.

17. A toll telephone system comprising a plurality of toll offices, a local central office associated with each of said toll offices, a four-wire toll line extending between each pair of toll offices, a local line extending between each local office and the toll office associated therewith and terminating in the latter office in a four-wire line, means at said toll offices to connect at least three toll offices and two local offices in circuit, and means including means provided with preselected negative resistance characteristics and interposed in individual two-wire terminals of each of said four-wire toll terminals to control the effective transmission loss at individual two-wire connections of each of said four-wire toll terminals, which connections include toll terminals connected to toll terminals and toll terminals connected to local terminals.

18. A toll telephone system comprising a plurality of toll offices, a local central office associated with each of said toll offices, a two-wire transmission line extending between each toll and local office and terminating in each toll office in a four-wire line, a four-wire line extending between each pair of toll offices, means at said toll offices to connect at least three toll offices and two local offices in circuit, and means including means provided with a preselected negative resistance characteristic and interposed in each two-wire terminal of individual four-wire toll lines to control the effective transmission loss in said circuit such that when two four-wire toll lines are connected together in one toll office in said circuit said negative resistance means of the individual two-wire toll terminals of said four-wire toll lines at said one toll office establish substantially equal amounts of transmission loss in the respective individual two-wire toll connections and such that when one four-wire toll line is connected to one four-wire local line at another toll office in said circuit said negative resistance means of the individual two-wire toll terminals of said one four-wire toll line at said other toll office establish other amounts of transmission loss in the respective individual two-wire toll local connections, which other amounts are different from each other and different from said equal amounts of transmission loss.

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