Dec. 14, 1943. G. C. REIER 2,336,888

TWO-WAY TELEPHONE SYSTEM

Filed Oct. 1, 1942 2 Sheets-Sheet 1

FIG. 1

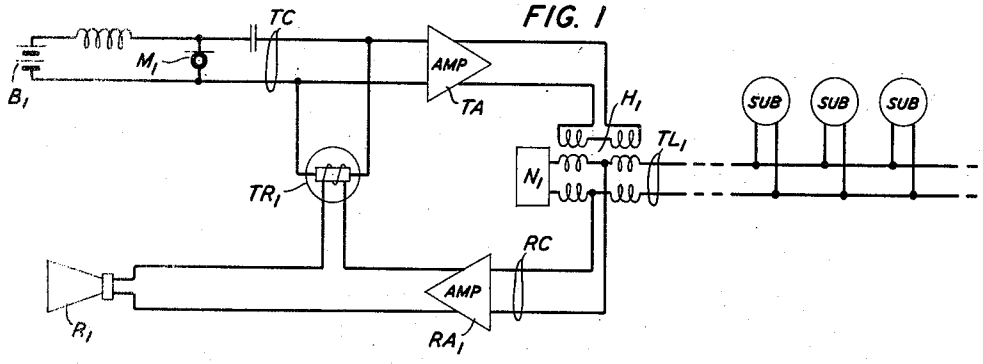

FIG. 2

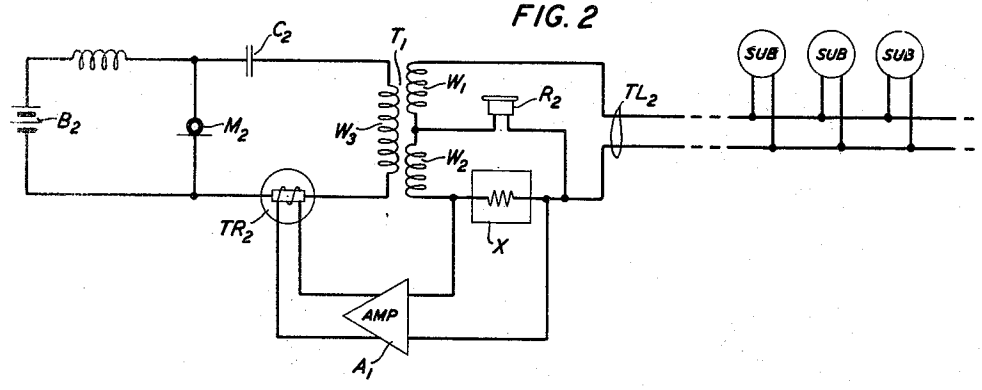

FIG. 3

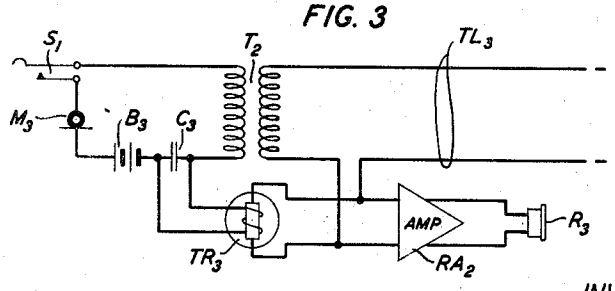

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FIG. 4

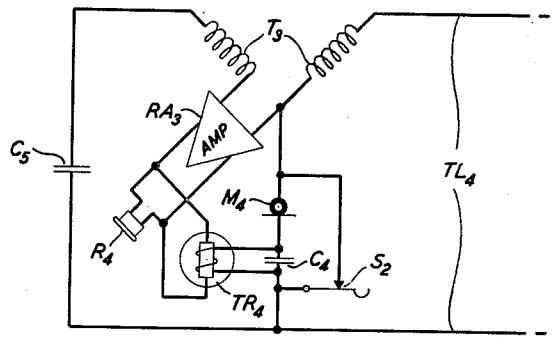
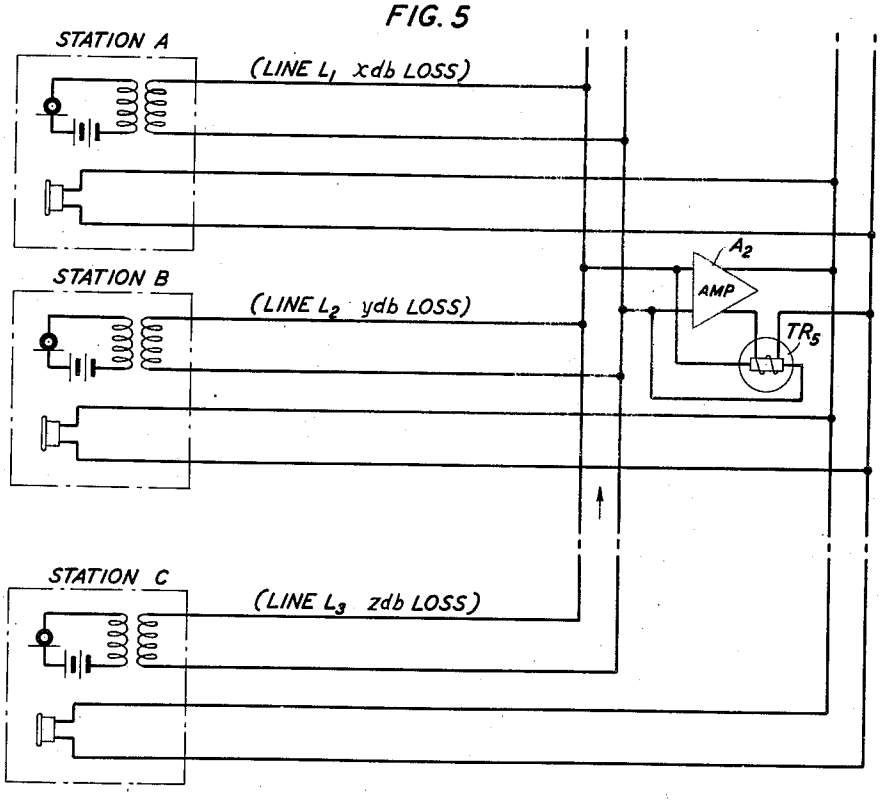


FIG. 5



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Patented Dec. 14, 1943 2,336,888

UNITED STATES PATENT OFFICE

2,336,888

TWO-WAY TELEPHONE SYSTEM

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Application October 1, 1942, Serial No. 460,373

11 Claims. (Cl. 179—1)

The invention relates to two-way telephone systems and particularly to signal-controlled switching circuits for controlling signal transmission in such systems.

An object of the invention is to simplify and improve the operation of switching circuits of this general type.

The copending patent application of K. S. Johnson, Serial No. 278,411, filed June 10, 1939, which issued June 30, 1942 as Patent No. 2,287,998, discloses the application of so-called thermistors, that is, devices in which the resistance varies rapidly with temperature, to subscribers' substation telephone sets and telephone operators' sets for the purpose of controlling side tone, that is, the sound picked up by a transmitter and heard through the associated receiver, in order to improve the effciency of such circuits or sets.

The present invention is directed to various other arrangements using thermistors in two-way telephone circuits of different types for controlling the direction and volume of signal transmission while preventing singing or reducing side tone.

The various objects and features of the invention will be better understood from the following detailed description when read in conjunction with the accompanying drawings, Figs. 1 to 5 of which show different modifications of the invention embodied in a distant-talking, loud-speaking conference telephone circuit; an anti-side tone operator's or subscriber's substation telephone set; local or common battery "push-to-talk" telephone sets; and a four-wire private line conference telephone set, respectively.

The two-way distant-talking, loud-speaking conference telephone set of Fig. 1 comprises a transmitting circuit TC including the telephone transmitter M_1, which may be of the distant-talking type, energized from the local battery B_1, and the transmitting amplifier TA; and a receiving circuit RC including the receiving amplifier RA_1 and the loud-speaking telephone receiver R_1. The output of transmitting circuit TC and the input of the receiving circuit RC are coupled by the hybrid coil H_1 and associated line balancing network N_1 to a two-way telephone line TL_1 leading to a number of subscribers' telephone stations.

Associated with the transmitting circuit TC and the receiving circuit RC is a thermistor TR_1 of the indirectly heated type, including a variable resistance element the resistance of which rapidly decreases when its temperature is increased above a given value, shunted across the input of the transmitting amplifier TA in the transmitting circuit TC; and a heating coil for the variable resistance element, electrically isolated from the latter, which is connected in series with the output of the receiving amplifier RA_1 in the receiving circuit RC.

When the circuit of Fig. 1 is being used for receiving, the incoming signal energy received over the line TL_1 from one of the associated subscribers' stations will be impressed by the hybrid coil H_1 on the receiving circuit RC in which it will be amplified by the receiving amplifier RA_1, and the amplified signals will be transmitted through the heating coil of thermistor TR_1 to the loud-speaker R_1 which will convert them to sound. The thermistor TR_1 is designed so that the amount of amplified signal energy passing through its heating coil will be sufficient to heat its variable resistance element to the temperature at which its resistance value is low. This will provide a low resistance path in shunt with the input of the transmitting amplifier TA, thus introducing an appreciable loss at that point in the circuit. The energy appearing in the transmitting circuit TC as a result of the acoustic coupling between the loud-speaker R_1 and the transmitter M_1 will be so reduced by this loss before it is applied to the transmitting amplifier TA that the setting up of a singing condition around the loop formed by the circuits TC and RC and the electrical and acoustic couplings between them, is prevented.

When the circuit is being used for transmitting, the talking current generated in the transmitting circuit TC as a result of the voice waves applied by the talker to the transmitter M_1, the variable resistance element of the thermistor TR_1 shunted across that circuit being in its normal high resistance condition with no heating current supplied to its heating coil, will be transmitted to the amplifier TA with little attenuation. The main portion of the amplified speech waves in the output of the transmitting amplifier TA will pass through the hybrid coil H_1 to the two-way line TL_1 and will pass over that line to the signal receiving apparatus at the distant telephone subscribers' stations. Unless the line TL_1 is perfectly balanced by the line balancing network N_1, a portion of the outgoing speech energy will be reflected at the hybrid coil H_1 into the receiving circuit RC. This reflected energy or echo will be amplified by the receiving amplifier RA and will be fed back as a side tone

into the transmitting circuit TC through the acoustic coupling between loud-speaker R_1 and transmitter M_1. However, the loss inserted into the input of the amplifier TA by the thermistor TR, due to its heating by the amplified energy in the output of the amplifier RA_1 applied to the thermistor heating coil, will limit the volume of the transmitter side tone to an unobjectionable amount.

Fig. 2 shows a modification of the invention applied to a two-way telephone set of the anti-side tone type, which may be an operator's telephone set or a subscriber's substation telephone set.

As shown, the two-way telephone set of Fig. 2 includes a telephone transmitter M_2 energized by the local battery B_2, the telephone receiver R_2, the line balancing resistance network X and the three-winding transformer T_1. The windings W_1 and W_2 of transformer T_1 are connected in series with the resistance network X and thence to one conductor of the two-way line TL_2 leading to a number of distant telephone subscriber's stations as shown. The third winding W_3, which is inductively coupled to the windings W_1 and W_2, is connected through the series direct current blocking condenser C_2 across the transmitter M_2.

In accordance with the invention, the variable resistance element of the thermistor TR_2, similar to the thermistor TR_1 in the circuit of Fig. 1, is connected in series with the closed circuit including transmitter M_2 and the winding W_3 of transformer T_1 in series, so that its normal high resistance when cold effectively inserts loss in the transmitter circuit. The heating winding of the thermistor TR_2 is connected across the output of an amplifier A_1 the input of which may be connected across the terminals of the balancing network X, as shown, or alternatively in series with that network. Therefore, when the operator or local subscriber talks into the transmitter M_2, his talking energy passing through the transformer T_1 is split between the telephone line TL_2 and the resistance network X. The portion of the talking energy appearing in the resistance network X is amplified in the amplifier A_1 and is applied as heating current to the heating winding of the thermistor TR_2. The thermistor TR_2 is so designed that the resulting heating of its variable resistance element will produce an appreciable reduction in its resistance in series with the transmitter circuit and thus will effectively increase the transmitting efficiency of that circuit for the outgoing voice signals.

Speech signals received over the line TL_2 from a distant talker at one of the distant telephone stations will pass through the resistance network X and the windings W_2 and W_1 of the transformer T_1 in series, and will actuate the telephone receiver R_2 connected across the winding W_2 and the resistance network X in series. The portion of the signal energy appearing in the resistance network X will be small compared to the signal energy appearing in that network when the telephone set is used for transmitting. The received signal energy appearing in network X will be amplified by amplifier A_1, and will be applied as heating current to the heating coil of the thermistor TR_2. If the thermistor is properly designed, this relatively small amount of heating current will be insufficient to heat its variable resistance element to the temperature required to produce an appreciable reduction in its resistance value. Thus, the normal loss produced in the transmitter circuit by the thermistor TR_2 will be maintained and the room noise picked up by the transmitter and introduced into the receiver through the side tone path will be materially reduced.

Fig. 3 shows a modification of the invention applied to a local battery "push-to-talk" subscriber's telephone set. As shown, the transmitter circuit comprises a transmitter M_3, the "push-to-talk" switch S_1, the primary winding of the transformer T_2, the blocking condenser C_3 and the local battery B_3 in series. The two-way line TL_2 is connected across the secondary winding of the transformer T_2. The receiving circuit including receiving amplifier RA_2 and the telephone receiver R_3 connected across its output, has its input connected in series with one side of the line TL_3 and the secondary winding of the transformer T_2. The thermistor TR_3, similar to the thermistors TR_1 and TR_2 in the previous figures, has its heating coil connected across the condenser C_3 in the transmitter circuit and its variable resistance element connected across the input of the amplifier RA_2 in the receiving circuit.

During receiving, the "push-to-talk" switch S_1 is operated to the open position, as shown, so that the transmitting circuit is disabled and no heating current is applied from the battery B_3 to the heating winding of the thermistor TR_3. Thus, the variable resistance element of the thermistor TR_3 is cold, so that it provides a high resistance across the input of the receiving amplifier RA_2 in the receiving circuit, and that circuit will transmit the speech waves received over the line TL_3 from the distant station to the receiver R_3 with maximum transmission efficiency. During transmitting, the "push-to-talk" switch S_1 is operated to the closed position, so that the transmitter M_3 is energized by the battery B_3 and transmits the operator's speech waves through the transformer T_2 to the line TL_2. Also, the heating coil of the thermistor TR_3 is directly supplied with heating current from the local battery B_3. If the thermistor is properly designed, this heating current will be sufficient to raise the temperature of its variable resistance element to that value which will cause an appreciable drop in its resistance value to provide a low resistance path in shunt with the input of the receiving amplifier RA_2 effectively reducing its gain and reducing the amount of side tone between the transmitter and receiver during the transmitting condition of the set. This arrangement will permit the use of a transmitter and a receiver with very high volume efficiencies.

Fig. 4 shows a subscriber's "push-to-talk" telephone set of the type in which the transmitter is energized over the associated two-way telephone line from a common battery at a central station. As shown, the transmitting circuit, which includes the telephone transmitter M_4 and the condenser C_4, is coupled through condenser C_5 and the transformer T_3 to the two-way line TL_4. The transmitting circuit is normally disabled by a short-circuiting connection across transmitter M_4 and condenser C_4 in series through the normally closed contacts of the "push-to-talk" switch S_2. The receiver R_4 is connected to the output of a receiving amplifier RA_3, the input of which is connected in series with the windings of the transformer T_3 and the condenser C_5 across the line TL_4.

The thermistor TR_4 has its heating winding connected across the condenser C_4 in the trans-

mitter circuit, and its variable resistance element shunted across the receiver R_4 in the output of the receiving amplifier RA_3. In the normal "receiving" condition of the set with the transmitter T_3 and the condenser C_4 in series short-circuited through the closed "push-to-talk" switch S_2, the transmitter M_4 will be unenergized and also no heating current will be supplied to the heating winding of the thermistor TR_4, and the normal high resistance of the cold variable resistance element of that thermistor, therefore, will be shunted across the receiver R_4, thus inserting little loss in the receiving circuit. Thus, the voice currents received over the line TL_4 and impressed on the input of the receiving amplifier RA_3 will be transmitted to the receiver R_4 with maximum efficiency.

In the transmitting condition of the set, the "push-to-talk" switch S_2 is operated to the open position so that it removes the short-circuit across the transmitter M_4 and the condenser C_4. The current from the distant common battery received over the line TL_4 then will energize the transmitter M_4 and will pass through the heating winding of the thermistor TR_4. With the thermistor TR_4 properly designed, this heating current will be sufficient to raise the temperature of the variable resistance element of that thermistor to the value required for making its resistance value small. The low resistance shunt thus produced across the receiving circuit in the output of amplifier RA_3, will insert a loss in the receiving circuit which will reduce effectively the amount of side tone between the receiving circuit and the transmitting circuit while the circuit is being used for transmitting. As in the case of the local battery "push-to-talk" subscriber set of Fig. 3, the thermistor arrangement of Fig. 4 will permit the use of a transmitter and receiver with very high volume efficiencies.

Fig. 5 shows a modification of the invention applied to a four-wire private line conference telephone circuit. In the circuit of Fig. 4, the telephone transmitting apparatus of a plurality of subscribers' stations A, B, C . . . . . are connected by the lines L_1, L_2, L_3 . . . . ., respectively, in parallel to the input of a one-way amplifier A_2 and the telephone receiving apparatus of the same subscribers' stations are connected in parallel to the output of the amplifier A_2. The lines L_1, L_2, L_3 . . . . . may be of different lengths or impedances, the net loss of the line L_1, for example, being equal to x decibels, the net loss of the line L_2 being equal to y decibels, and the net loss of the line L_3 being equal to z decibels, where x is larger than y or z and z is smaller than x or y.

The heating coil of the indirectly heated thermistor TR_5 is connected in series with the output of the amplifier A_2, and its variable resistance element is shunted across the common portion of the lines L_1, L_2 and L_3 leading to the input of the amplifier A_2.

The gain of the amplifier A_2 is set so as to provide satisfactory transmission between the transmitting apparatus of station A associated with the line L_1 having the greatest amount of net loss (x decibels) and the receiving apparatus of all the other subscribers' stations. The thermistor TR_5 is designed so that when the subscriber associated with station A is talking, the average amplitude level of the amplified speech waves appearing in the output of amplifier A_2 will supply insufficient heating current to the heating coil of that thermistor to heat its variable resistance element to the temperature which will cause its resistance value to be appreciably reduced; but when the station B or C associated with a shorter line L_2 or L_3, or having a smaller amount of net loss (y or z decibels) is transmitting, the higher level of the amplified voice signals in the output of amplifier A_2 will apply a sufficient amonut of heating current to the heating winding of the thermistor to raise the temperature of its variable resistance element to the value at which its resistance is reduced. This will cause a loss to be inserted in the input of the amplifier A_2, effectively reducing the gain of the latter and thereby preventing the excess speech signal volumes due to the use of the shorter or lower loss lines from being impressed on the receiving apparatus of the other stations. Thus, the thermistor arrangement effectively compensates for differences between the effective net losses of the several lines used in the conference connection, providing uniform transmission in all cases.

In the arrangements of the invention described above, the thermistors are described as being of the usual type in which the resistance decreases rapidly as the temperature increases above a given value, i. e., the temperature coefficient is negative. Thermistors of the type in which the resistance increases as the temperature increases, i. e., positive temperature coefficient thermistors, may be employed in place of the negative temperature coefficient thermistors described, to obtain an equivalent result. If the positive temperature coefficient thermistors are used, in each modification where the variable resistance elements of the negative coefficient thermistor is shown as inserted in series with the transmission circuit, the positive temperature coefficient thermistor would be connected in shunt with that circuit, and in the modifications where the negative temperature coefficient thermistor is shown as connected in shunt with a transmission circuit, the positive temperature coefficient thermistors would be inserted in series with that circuit. The constituent elements of the thermistors used in the circuits of the invention may be of any suitable type, for example, of any of the types which have been described in the aforementioned Johnson patent application.

Various other modifications of the circuit illustrated and described which are within the spirit of the invention will occur to persons skilled in the art.

What is claimed is:

1. In a two-way signal transmission system, a two-way signal transmission line, a signal transmitting circuit and a signal receiving circuit connected to said line, a one-way amplifier for amplifying at least a portion of the signals received from said signal transmitting circuit or from said line, a variable resistance element the resistance of which varies non-linearly with temperature, connected to one of said circuits in such manner that its resistance value determines the transmission efficiency of that circuit and the effective gain of said amplifier, and means operative during a period of signal transmission to heat said variable resistance element to vary its resistance value.

2. The system of claim 1, in which the heating of said variable resistance element to vary its resistance value is controlled by the signal output of said amplifier.

3. The system of claim 1, in which said one-

way amplifier is connected in said signal receiving circuit and said variable resistance element is connected in the input of said amplifier.

4. In combination in a two-way telephone system, a two-way signal transmission line, a voice signal transmitting circuit and a voice signal receiving circuit connected to said line, a one-way amplifier for amplifying the voice signals received by said signal receiving circuit from said signal transmitting circuit or said line, a variable resistance element the resistance of which varies non-linearly with temperature in one of said circuits, and means operative during a period of signal transmission between one of said circuits and said line for heating said variable resistance element so as to vary its resistance value and thus the transmission efficiency of the circuit in which it is connected.

5. In combination in a two-way telephone system, a two-way signal transmission line, a voice signal transmitting circuit and a voice signal receiving circuit including an amplifier, connected to one end of said line, a thermistor comprising a variable resistance device the resistance value of which decreases rapidly when its temperature is increased above a certain value, connected in shunt with said transmitting circuit, and heating means responsive to the amplified signal output of said amplifier in said receiving circuit when voice signals are being received over said line to raise the temperature of said variable resistance element above said certain value so as to insert a loss in said transmitting circuit.

6. In combination, a two-way telephone line, an antiside tone telephone set connected to said line, having a transmitting circuit including a telephone transmitter, a receiving circuit including a telephone receiver, and a line balancing network, an impedance element the resistance of which decreases rapidly when heated above a given temperature, connected in series with said transmitting circuit, means for diverting a portion of the signal energy produced in said network when said set is being used for transmitting telephone signals to said line, means for amplifying the diverted signal energy, and means for utilizing the amplified signal energy to heat said impedance element above said given temperature so as to reduce the loss in said transmitting circuit.

7. In combination in a two-way telephone system, a two-way line, a telephone set having a transmitting circuit including a telephone transmitter, coupled to one end of said line and a receiving circuit including a receiving amplifier and a telephone receiver, connected directly to said one end of said line so as to receive telephone signals incoming over said line, a source of direct current for energizing said transmitter, a switch which in one operating position conditions said transmitting circuit for transmitting telephone signals generated in said transmitter to said line, and in another operated position disables said transmitting circuit, a variable resistance device the resistance of which decreases rapidly when its temperature is increased above a certain value, connected effectively in shunt with the input or output of the amplifier in said receiving circuit, said variable resistance device having a relatively high resistance when said switch is operated to said other position to condition said telephone set for signal receiving only, providing a low loss in and therefore maximum transmission efficiency for said receiving circuit, and means responsive to the operation of said switch to said one position to condition said set for signal transmitting, to cause said variable resistance device to be heated from said direct current source to a temperature above said certain value so that its then reduced resistance effectively inserts an appreciable side tone reducing loss in said receiving circuit.

8. The system of claim 7 in which said variable resistance device has a heating element connected in said transmitting circuit in series with said direct current source so as to be supplied with heating current from said source when said transmitting circuit is rendered operative by operation of said switch to said one position.

9. The system of claim 7 in which, when said transmitting circuit is operative, said transmitter is supplied with its energizing current and said variable resistance device is supplied with heating current over said line from said source.

10. In combination in a telephone system, one or more telephone transmitting circuits, one or more telephone receiving circuits, a signal transmission circuit connecting said one or more telephone transmitting circuits to said one or more telephone receiving circuits, a one-way amplifier in said transmission circuit for amplifying the telephone signals transmitted thereover, the gain of said amplifier being initially set to provide the required amount of signal amplification to compensate for a given amount of circuit loss between the connected telephone transmitting and receiving circuits, a thermistor the resistance value of which decreases with its temperature when heated above a given temperature value, connected in shunt with the input of said amplifier, and means responsive to an increase in the amplitude level of the signals in the output of said amplifier due to transmission from one of said telephone transmitting circuits to said one or more telephone receiving circuits over a connection having a circuit loss a given amount less than said given loss, to heat said thermistor above said given value to reduce its resistance value and thus effectively reduce the gain of said amplifier for that connection.

11. In combination in a two-way conference telephone system, a plurality of subscribers' stations each including telephone transmitting apparatus and telephone receiving apparatus, telephone lines of varying lengths or impedances connecting the telephone transmitting apparatus of each subscriber station to the telephone receiving apparatus of all the other stations, said lines having a portion in common including a one-way amplifier for amplifying the telephone signals transmitted between the telephone transmitting apparatus of each station and the telephone receiving apparatus of the other stations, a thermistor having a variable resistance element the resistance of which decreases in accordance with the temperature to which it is heated, shunted across the input of said amplifier, and a heating element therefor connected in the output of said amplifier, the gain of said amplifier and the characteristics of said thermistor being such that when the heating element of the latter is supplied with the amplified signals in the output of said amplifier, of an amplitude level such as would be produced by normal signal transmission between the transmitting apparatus of one station and the receiving apparatus of the other stations over a line connection of a given length or impedance, the resistance value of the variable resistance element of said thermistor is such that

the required amount of transmission amplification is produced by said amplifier, and when said heating element of said thermistor is supplied with amplified signals of a greater amplitude level such as would be produced by signal transmission between the telephone transmitting apparatus of one station and the receiving apparatus of the other stations over a line connection of a given shorter length or a given smaller impedance, the variable resistance element of said thermistor will be heated to a temperature which will reduce its resistance and thus the gain of said amplifier sufficiently to provide the required amount of transmission amplification for the latter connection.

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