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TWO-WAY TELEPHONE SYSTEM

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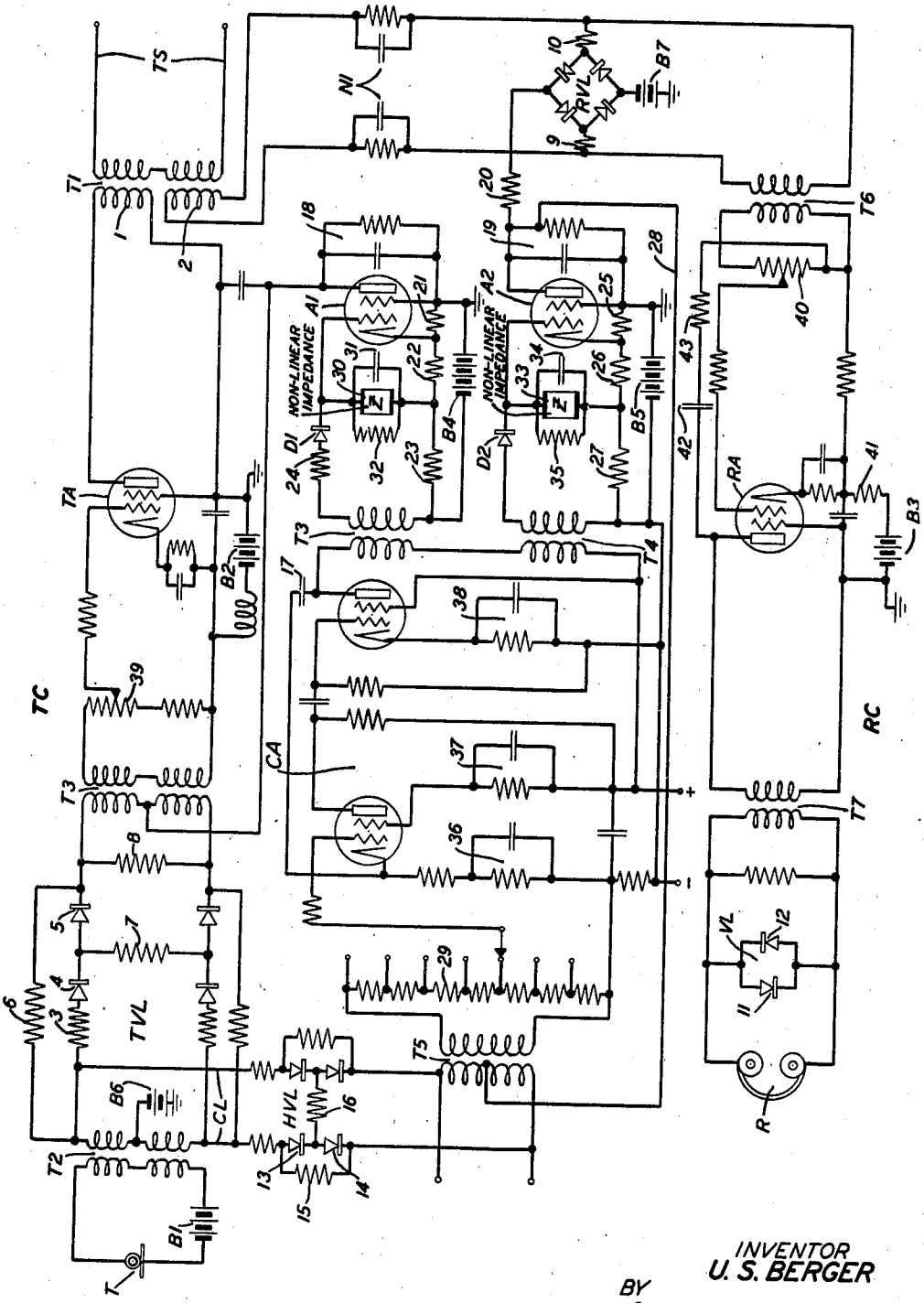

INVENTOR
U. S. BERGER

BY
Earl C. Laughlin

ATTORNEY

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TWO-WAY TELEPHONE SYSTEM

Uriah S. Berger, New York, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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The invention relates to two-way telephone transmission systems and particularly to circuits for controlling the direction and volume of signal transmission in such systems.

The invention is particularly applicable to, although not limited to, two-way telephone operators' circuits or sets. It has been found that for certain conditions of use, such as centralized information and intercept service, or in locations where there are very long subscribers' loops, high room noise, poor sidetone balance and low received speech levels combine to adversely affect service performance of the usual invariable anti-sidetone operator's telephone circuit.

An object of the invention is to improve the operation of such circuits.

Another object is to make an operator's telephone circuit more flexible, that is, to adapt it better for a variety of conditions encountered in service.

Another object is to provide higher sensitivity and reduced susceptibility to room noise operation in an operator's telephone circuit.

Another object is to provide higher receiving efficiency in an operator's telephone circuit without increasing the sidetone transmission.

These objects are attained in accordance with the invention by the use with such circuits of voice-operated switching and volume controls of particular characteristics. In one embodiment, vario-lossers (variable loss devices) of the copper-oxide rectifier type are employed in the operator's transmitter and receiver circuits, and a control circuit having two specially designed branches each including a detector followed by a direct current amplifier, is responsive to the voice currents of the operator when he talks to properly control the loss values of the vario-lossers so as to switch loss of the proper value and at the proper rate out of the transmitter circuit and into the receiver circuit, to provide the desired operation.

A feature of the invention is the use in the detector load circuit of each control branch, of a varistor shunted by a condenser, operating to control in the proper ratio the rate of change in gain of the transmitter and receiver circuits provided by the vario-lossers, for the purpose of reducing sidetone transients as well as to limit the hangover in operation of the control branches to facilitate the transmission of the subscriber's talking current to the operator.

Other objects and features of the invention will be brought out in the following detailed description when read in conjunction with the accompanying drawing, the single figure of which shows schematically the circuits of an operator's telephone set embodying one form of the invention.

The operator's telephone circuit of the drawing includes a voice transmitting branch TC and a voice receiving branch RC coupled by the three-winding transformer T1 to a two-wire terminating section TS which is adapted for connection in any suitable manner to a selected telephone line.

The voice transmitting branch TC includes in order reading from left to right, a telephone transmitter T with an associated energizing battery B1, the transmitting vario-losser TVL and the transmitting amplifier TA having its output connected to one winding 1 of the transformer T1. The voice receiving branch RC, which has its input connected to a second winding 2 of transformer T1, includes the frequency characteristic-correcting networks N1 in its input followed by the receiving vario-losser RVL, the receiving amplifier RA, the volume limiter VL and the telephone receiver R.

The transmitting vario-losser TVL comprises a short section of line coupled by the transformers T2 and T3 between the transmitter T and the amplifier TA, with a network comprising a linear resistor 3 and the copper-oxide rectifiers 4 and 5 in series, shunted by a linear resistor 6, connected in series with each side of the line section, and the linear resistors 7 and 8 shunted across the line section at the points indicated. The receiving vario-losser RVL comprises a bridge having a copper-oxide rectifier poled as indicated in each of its four arms, and one diagonal (horizontal) connected in series with the linear resistors 9 and 10 across the receiving branch RC in front of the receiving amplifier RA.

The transmitting amplifier TA comprises a single four-electrode vacuum tube stage having its control grid-cathode circuit connected to the secondary winding of the transformer T3 and its anode-cathode circuit connected to the winding 1 of the three-winding transformer T1. The primary function of the amplifier TA, because of its one-way transmission characteristic, is to prevent incoming signals received over the connected telephone line from a distant subscriber and impressed on transformer T1, from passing over the voice transmitting branch TC to the input of the voice-operated control circuit CL to be described, and causing false operation of the latter to disable the voice receiving branch RC,

but it may be used also to give a desired amount of transmitting gain, the value of which may be varied by adjustment of the manually operated potentiometer 39 in the input of the amplifier. This gain compensates for the minimum loss inserted in the transmission path by TVL. The receiving amplifier RA comprises an input transformer T6, an output transformer T7 and a single four-electrode vacuum tube amplifying stage having a negative feedback circuit including the condenser 42 and the resistor 43 in series connected between the plate of the tube and the lower end of the input potentiometer 40. The receiving amplifier RA is used to supply the desired amount of receiving gain, the manually operated input potentiometer 40 providing means for adjusting the amount of this gain. The cathode current of this amplifier is supplied from battery B3 through a high resistance 41 which serves as a filter to reject battery noise. The feedback circuit is used principally to adjust the output impedance of the amplifier to desired value, but also serves to reduce unwanted high frequency response and increases the amplifier stability.

The volume limiter VL comprising two parallel-connected copper-oxide rectifiers 11 and 12, connected in shunt with the voice receiving branch RC between transformer T7 and the receiver R, serves as a peak chopper to protect the operator from high amplitude signals.

The control circuit CL for the vario-lossers TVL and RVL has its input connected across the secondary winding of transformer T2 in the voice transmitting branch TC. It includes in its input a "hysteresis" vario-losser HVL followed by an alternating current amplifier CA comprising an input transformer T5 and two resistance-condenser coupled four-electrode vacuum tube stages used to obtain sufficient sensitivity for the control circuit. A negative feedback circuit including a series condenser 17, connected between the plate of the last stage tube and the cathode of the first stage tube, is used for improving the stability and modifying the frequency response of the control circuit. An input potentiometer 29 for amplifier CA is provided for adjusting the initial sensitivity of the control circuit CL.

Two independent detector circuits respectively including the copper-oxide detectors D1 and D2, have their inputs connected by transformers T3 and T4, respectively, to the plate-cathode circuit of the last stage tube of amplifier CA. The direct current amplifier A1 consisting of a single four-electrode amplifying vacuum tube has its control grid-cathode circuit connected directly to the output of the detector circuit including detector D1 and its anode-cathode circuit including the battery B6 and the resistance-condenser network 18 in series, connected to the transmitting vario-losser TVL across the mid-points of the secondary winding of transformer T2 and the primary winding of transformer T3. A direct current amplifier A2 comprising a single four-electrode amplifying vacuum tube has its control grid-cathode circuit connected directly to the output of the detector circuit including detector D2, and its anode-cathode circuit including plate battery B7, resistance-condenser network 19 and the resistor 20 in series connected across the vertical diagonal of the receiving vario-losser RVL.

The "hysteresis" vario-losser HVL comprising a network consisting of two series copper-oxide rectifiers 13 and 14, shunted by a linear resistor 15, in each side of the control circuit CL, and a linear resistor 16 shunted across the circuit between the rectifiers, is supplied with a variable control bias from the output of the direct current amplifier tube A2 by a direct connection 28 from the plate of that tube to the mid-point of the primary winding of the input transformer T5.

A network comprising a varistor 30, a condenser 31 and a linear resistor 32 in parallel, is connected in common to the output circuit of the detector D1 and the control grid-cathode circuit of the direct current amplifier tube A1, and a similar network comprising the varistor 33, the condenser 34 and the linear resistor 35 in parallel, is connected in common to the output circuit of the detector D2 and the control grid-cathode circuit of the direct current amplifier tube A2. The varistors 30 and 33 may each comprise a block of a material composed of silicon carbide crystals and an insulating binder (kaolin), commercially known as "Thyrite," which is disclosed in Patent No. 1,822,742, issued September 8, 1931 to K. B. McEachron.

Biasing voltages for the detector D1 and the grids of the direct current amplifier tube A1 are provided by the voltage drops produced in the series resistors 21 to 23 by current from battery B4, and for detector D2 and the grids of amplifier tube A2 by the voltage drops produced in the series resistors 25 to 27 by current from battery B5.

The time constants of the vario-lossers TVL, RVL and HVL are determined by the resistance-condenser combinations 30, 31, 32 and 33, 34, 35, in the grid circuits of the direct current amplifiers A1 and A2 in a manner which will be described later. The resistance-condenser networks 36, 37, 38 in amplifier CA are screen and cathode current limiting networks.

The manner in which the circuits of the operator's telephone circuit accomplish the objects of the invention will be brought out in the following complete description of operation.

Normally, with no speech input to the control circuit CL, the direct current amplifier tubes A1 and A2 are biased to cut-off. The batteries B6 and B7 are smaller than the batteries B4 and B5, respectively. Therefore, with the tubes A1 and A2 cut off (idle condition); there are no voltage drops produced in the resistors of 18 and 19, and the mid-tap on the primary winding of transformers T3 and the top apex on the vario-losser RVL are at higher positive potentials than the mid-tap on the secondary winding of transformer T2 and the bottom apex of vario-losser RVL, respectively. This causes a small current to flow through the copper-oxide rectifiers in the vario-lossers TVL and RVL in the direction which is opposite to that in which these rectifiers are pointed, making the rectifier resistance high so that TVL provides a normal high loss in TC and RVL a normal low loss in RC. Thus, with no speech input to the operator's transmitter T, there is a high loss in the transmitting voice branch TC and a low loss between the input of the receiving amplifier RA in the voice receiving branch RC and the telephone line connected to the terminating section TS of the telephone set, so that room noise coming into the transmitter is highly attenuated and speech signals incoming over the connected line and impressed by transformer T1 on the voice receiving branch RC pass freely to the receiving amplifier RA in which they will be amplified and with a volume as limited by

the peak volume limiter VL will be reproduced by the telephone receiver R of the operator.

A small current also normally flows from the battery B5 through the resistance of 19, the conductor 28, the primary windings of the input transformer T5 of the control amplifier CA and the rectifiers 13, 14 of the "hysteresis" vario-losser HVL in the input of the control circuit CL in a direction which is the opposite to that in which they are pointed. With this bias, these rectifiers have a relatively high resistance, so that the vario-losser HVL normally provides an appreciable loss in the input of the control circuit, which is made by proper selection of the circuit elements sufficient to prevent false operation of the control circuit CL in response to sharp applied noises, such as would be produced by the dropping of cords and plugs encountered at any manual switchboard.

When the operator speaks, her speech waves pass through the input transformer T2 to the transmitting losser TVL and the input of the control circuit CL. The portion passing into the control circuit CL is attenuated by the vario-losser HVL and is then impressed by the transformer T6 on the control amplifier CA which amplifies it in accordance with the gain setting of potentiometer 29.

A portion of the amplified speech energy in the output of the amplifier CA is impressed by the transformer T3 on the input of the copper-oxide detector D1, and the other portion is impressed by the transformer T4 on the input of the copper-oxide detector D2. The rectified signal outputs of the detectors D1 and D2 respectively produce positive potentials on the control grids of the direct current amplifier tubes A1 and A2, causing plate current flow from batteries B6 and B7, respectively, through the copper-oxide rectifiers in the three vario-lossers TVL, RVL and HVL in the direction in which these rectifiers are pointed.

The reverse biasing current then flowing through the copper-oxide rectifiers 13, 14 of the vario-losser pad HVL in control circuit CL, reduces their series resistances to a very low value so that the loss value of the pad HVL is effectively reduced to an amount determined by the values of the resistance 16 shunting the mid-points of the copper-oxide rectifiers, which in the set constructed was about 7 decibels less than before speech was applied. A very short pulse of input will switch out this loss, increasing the sensitivity of the control circuit about 7 decibels, but this higher sensitivity will be maintained for only a short time (approximately 20 milliseconds) after the input signal ceases. Thus, a sharp noise, such as that from a plug tip hitting the operator's key shelf may increase the sensitivity momentarily, perhaps to operate the control circuit to interrupt incoming speech from the subscriber. However, noise conditions at the switchboard with which such sets are to be used are usually such that the background noise is rarely sufficient to prolong the false operation caused by "clicks." Thus, the mutilation of received speech is relatively small even with extremely high room noise, e. g., 75 to 80 decibels above reference noise level.

The "hysteresis" vario-losser HVL is controlled from the direct current amplifier tube A2 which also controls the receiving vario-losser RVL, rather than from the amplifier A1 controlling the transmitting vario-losser TVL, because of faster operation of the detector D2 associated with the former amplifier (there is no resistor in series with the detector D2 corresponding to the series resistor 24 associated with the detector D1). If the control were taken from the direct current amplifier A1, the purpose of the series resistor 24 in series with its associated detector D1 would be defeated, and undue clipping of the outgoing speech would result. The association of the "hysteresis" loss pad with the receiving control branch provides a shorter hangover time in the switching and also contributes to more gradual loss switching, since it acts as a non-linear shunt on the receiving vario-losser pad RVL. The term "hysteresis" is applied to the vario-losser HVL, since hysteresis in the voice-operated switching art is defined as the input into the control circuit required to just operate it in excess of the input required to just release it, and the initial sensitivity of the control circuit CL is reduced in an amount corresponding to the loss of the "hysteresis" pad switched. Once the operator's speech has operated the control circuit, the change in bias produced by the increased current flowing through the copper-oxide rectifiers in HVL reduces their series resistances so that the hysteresis loss is effectively removed and less input is required to keep the control circuit operated than was required to initially operate it.

The increased biasing current flowing from the outputs of the amplifiers A1 and A2 respectively through the series copper-oxide rectifiers of the transmitting vario-losser TVL and the shunt copper-oxide rectifiers of the receiving vario-losser RVL while the operator continues to talk, by decreasing the resistance of the rectifiers, reduces the loss value of the former vario-losser to a very low value, and increases the loss value of the latter vario-losser to a high value. This effectively increases the gain in the voice transmitting branch TC for the operator's outgoing voice currents which are amplified by amplifier TA and then pass through transformer T1 and two-wire section TS to the connected line, while effectively reducing the gain of the voice receiving branch RC so that the transmission of sidetone energy through the latter branch is not increased.

While the operator talks, the condenser 31 (0.1 microfarad), shunting varistor 30 in the upper detector branch is charged through the large (10,000 ohms) resistor 24 and the forward resistance of the copper-oxide detector D1, while the condenser 34 (.075 microfarad) shunting the varistor 33 in the lower detector branch is charged through the forward resistance of the copper-oxide oxide detector D2 only, thereby providing the different variable biases on the grids of the direct current amplifier tubes A1 and A2 required to relatively adjust the rate of change of gain produced by the vario-lossers TVL and RVL in the transmitter and receiver branches in the desired manner.

When the operator ceases talking and the input to the detectors D1 and D2 in the two control branches is removed, the voltages built up across the condensers 31 and 34 in the load circuits of the respective detectors D1 and D2 are discharged through the associated "thyrite" varistors 30 and 33, the discharges being quite rapid at first due to the low resistance of varistors caused by the relatively high voltage. As the voltages on the two condensers 31 and 34 decay, the resistances of the associated varistors 30 and 33 increase, retarding the rate of decay further. Since the loss of each copper-oxide

rectifier vario-losser pad TVL, RVL and HVL is a function of the current through it, and the current changes with time, the loss through each pad changes with time. By properly choosing the voltage-resistance characteristics of the varistors 30, 33, the correct change in gain can be obtained. It is extremely important to have this rate of change in gain right in both vario-lossers TVL and RVL, since the transmission around the sidetone path involves both vario-lossers simultaneously. If one should have a rapid change in gain while the other had its gain changed slowly, there would be times when the sidetone transmission would be considerably in excess of or considerably less than the steady state values. This would result in a "sidetone transient" which might reach a value 25 decibels greater than normal. This would be annoying to the operator since it would give a blasting effect. Further precautions are taken against this by intentionally slowing down the rate of increase in gain of the voice transmitting branch TC to match better the more gradual reduction in gain in the voice receiving branch RC produced by the varistor 33. This is accomplished by the use of the additional (10,000 ohms) resistor 24 in series with the detector D1 in the control branch controlling the transmitting vario-losser TVL. The large resistor 32 shunting the varistor 30 and the large resistor 35 shunting the varistor 33 are provided for protective purposes. In the set constructed, these resistors had the values, 2 megohms and 1 megohm, respectively, the values of the associated condenser elements being as given above in parenthesis.

The operator's telephone set in accordance with the invention, which was built and tested, had the following other approximate characteristics:

The voice transmitting branch was initially set at 4 decibels loss and the voice receiving branch at 6 decibels gain;

The control circuit CL was tuned to maximum response at 800 cycles, the initial sensitivity being 5 decibels less at 300 and 3000 cycles, and the sensitivity before switching out "hysteresis" pad HVL was made variable in 7 steps from 22 to 34 decibels below .001 watt at 800 cycles, measured at transmitter input, by proper design of the input potentiometer 29 for the control amplifier CA.

By proper selection of the values of the elements in the resistance-condenser combinations 36, 37 and 33 in the grid circuits of the two tubes in the control amplifier CA, and the impedances of the circuits containing the vario-losser pads TVL, RVL and HVL, to provide the proper switching time constants, the "hysteresis" pad HVL was made to switch about 7 decibels loss in about 10 milliseconds and to release in about 20 milliseconds; the transmitter vario-losser pad TVL was made to switch about 27 decibels loss to provide a room noise sidetone loss of about 25 decibels at 1000 cycles (±3 decibels at 200 and 5000 cycles), the loss being switched in about 10 milliseconds and released in about 60 milliseconds; and the receiving vario-losser pad RVL was made to switch about 27 decibels loss, providing speech sidetone loss of 25 decibels at 1000 cycles and 6 decibels higher speed sidetone loss at 5000 cycles, the loss being switched in about 8 milliseconds and released in about 50 milliseconds. The switching and release times will vary with the signal amplitudes. The above estimated times are given to convey some idea of the amplitudes involved.

An additional feature of the set which was built and tested was an increase in the sidetone at high frequencies, so that the set did not sound dead to the operator. This was obtained by proper selection of the elements in the feedback circuit of the receiving amplifier RA to adjust its frequency response characteristic.

Various modifications of the circuits illustrated and described above, which would be within the spirit and scope of the invention, will occur to persons skilled in the art.

What is claimed is:

1. A telephone set comprising line terminals, a voice signal transmitting circuit and a voice signal receiving circuit including amplifier means, connected to said line terminals, a vario-losser in each of said circuits, the vario-losser in the transmitting circuit being normally biased so as to introduce a substantial loss in that circuit and the vario-losser in the receiving circuit being normally biased so as to introduce a very small loss therein, a control circuit connected to said transmitting circuit, having two control branches each including a signal detector, responsive to outgoing voice signals in said transmitting circuit to respectively vary the bias on and thus the loss of the vario-losser in said transmitting circuit and of the vario-losser in said receiving circuit in such manner as to increase the gain of the former circuit and to reduce the gain of the latter circuit, and a network including a capacitor shunted by a varistor the resistance of which increases as the voltage across it decreases, in the detector load circuit of each control branch for independently controlling the time constants of the two control branches to control the rate of change in gain produced by said vario-lossers.

2. The telephone set of claim 1, in which the detector in each control branch is followed by a direct current amplifier the output current of which controls the loss value of a different one of the vario-lossers in accordance with its amplitude, said capacitor and shunting varistor being connected in common to the output circuit of the detector and the input circuit of the direct current amplifier, the capacitor being charged by the detected voice signals and discharging through the varistor when the signals cease.

3. The telephone set of claim 1, in which the vario-lossers in said transmitting and receiving circuits include a plurality of copper-oxide rectifier elements, the detector in each of said control branches being followed by a direct current amplifier the output current of which is passed through the copper-oxide rectifiers in a different one of said vario-lossers to control the resistance values of the rectifiers in accordance with the amplitude of said currents.

4. The telephone set of claim 1 in which the detector in each control branch is followed by a direct current amplifier the output current of which controls the loss value of a different one of said vario-lossers in accordance with its amplitude, said network being connected in common to the output circuit of the detector and the input circuit of the direct current amplifier, and one of said control branches includes means for making the charging current to said capacitor therein different from the charging current to the capacitor in the other control branch.

5. The telephone set of claim 1 in which the

vario-lossers in said transmitting and receiving circuits include a plurality of impedance elements having a non-linear resistance-current characteristic, the detector in each of said control branches being followed by a direct current amplifier the output current of which is passed through said non-linear impedance elements in a different one of said vario-lossers so as to control the loss value thereof in the desired manner, said network in each control branch being connected in common to the output circuit of the detector and the input circuit of the direct current amplifier, said control branch controlling the loss value of the vario-losser in said transmitting circuit including means for making the operation of that control branch slower than that of the other control branch.

6. A telephone set comprising line terminals, a voice signal transmitting circuit and a voice signal receiving circuit each including amplifying means, connected to said line terminals, a vario-losser in each of said circuits, a control circuit connected to said transmitting circuit, having two control branches each including a signal detector followed by a direct current amplifier, responsive to outgoing signals in said transmitting circuit to control the loss values of the two vario-lossers, so as to effectively increase the gain of said transmitting circuit and reduce the gain of said receiving circuit, a third vario-losser in the input of said control circuit normally having a loss value sufficient to prevent false operation of that control circuit by noise waves of certain types, and means responsive to the output current of one of said direct current amplifiers when voice signals are being applied to said control circuit to reduce the loss value of said third vario-losser and thereby increase the sensitivity of said control circuit.

7. An operator's telephone set comprising a two-wire terminating section adapted for connection to a telephone line, a voice transmitting circuit including a telephone transmitter and an amplifier and a voice receiving circuit including a telephone receiver and an amplifier, inductively coupled to said terminating section, a vario-losser including series non-linear impedance elements in said transmitting circuit, a second vario-losser including shunt non-linear impedance elements, in said receiving circuit, a control circuit connected to said transmitting circuit in front of the vario-losser therein, having two control branches each including a signal detector followed by a direct current amplifier, the output circuit of one of said direct current amplifiers being connected across the vario-losser in said transmitting circuit so that its output current flows through said series non-linear impedance elements and the output of the other direct current amplifier being connected across the vario-losser in said receiving circuit so that its output current flows through said shunt impedance elements, said direct current amplifiers being normally biased so that said first vario-losser normally provide a high loss in said transmitting circuit and said second vario-losser normally provides a low loss in said receiving circuit, the poling of the non-linear impedance elements in the two vario-lossers with respect to the outputs of the controlling direct current amplifiers being such that the increase in the flow of the output current through said non-linear impedance elements when the operator talks reduces the loss in the transmitting circuit and increases the loss in said receiving circuit, and additional means to reduce sidetone transients when said operator talks including a network consisting of a capacitor shunted by an element having a negative resistance-current characteristic connected across the detector output circuit in each control branch, of such values as to provide the proper relative time constants for the two control branches.

8. The telephone set of claim 7, in which an additional series resistor is connected between the detector in the control branch controlling the loss of the vario-losser in said transmitting circuit, to slow up the operation of that control branch with respect to the operation of the other control branch.

URIAH S. BERGER.