

Dec. 10, 1940.

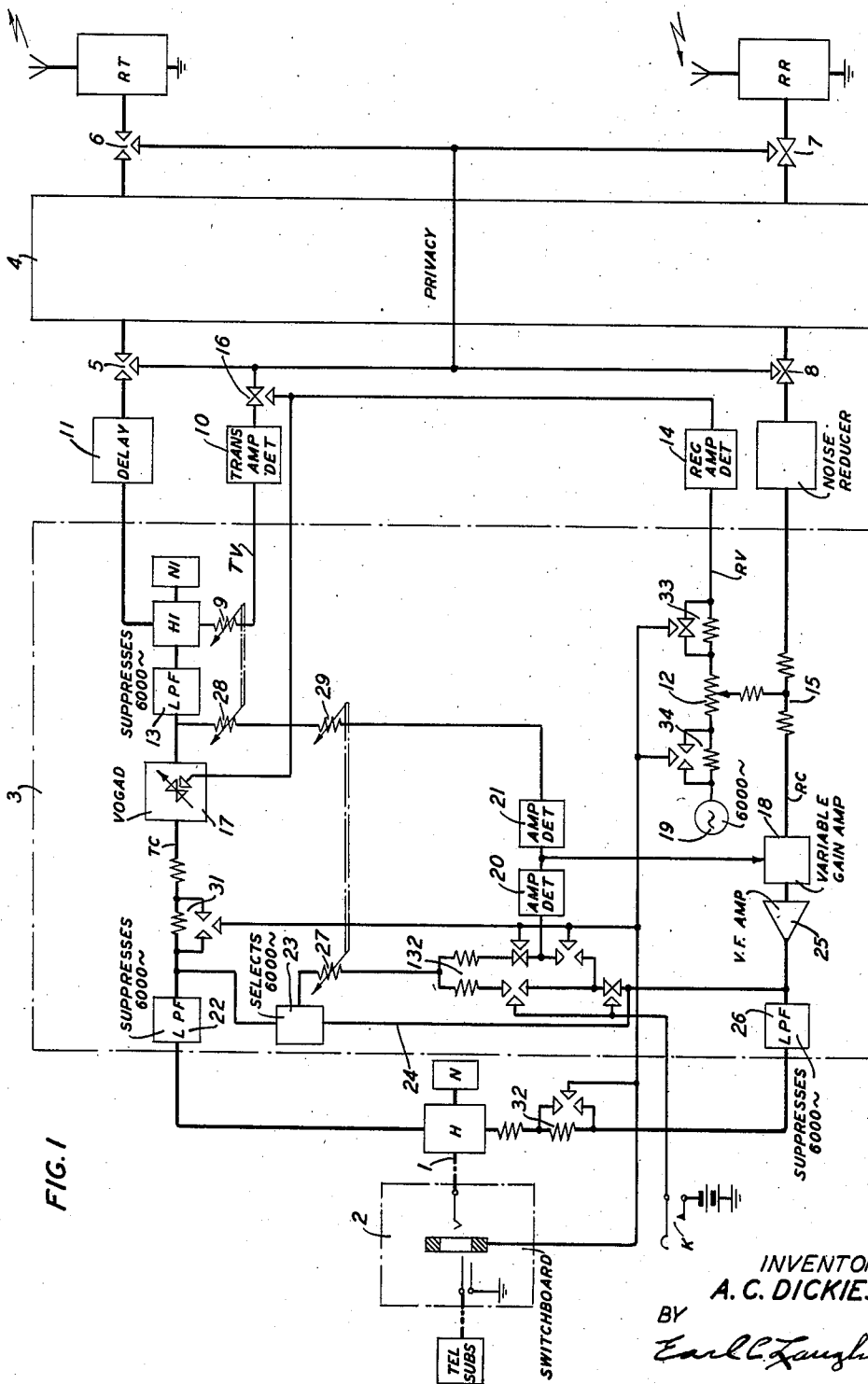
A. C. DICKIESON

2,224,569

CONTROL OF TRANSMISSION IN TWO-WAY SIGNALING SYSTEMS

Filed Oct. 4, 1939

3 Sheets-Sheet 1



INVENTOR
A. C. DICKIESON
BY
Earl C. Laughlin
ATTORNEY

Dec. 10, 1940.

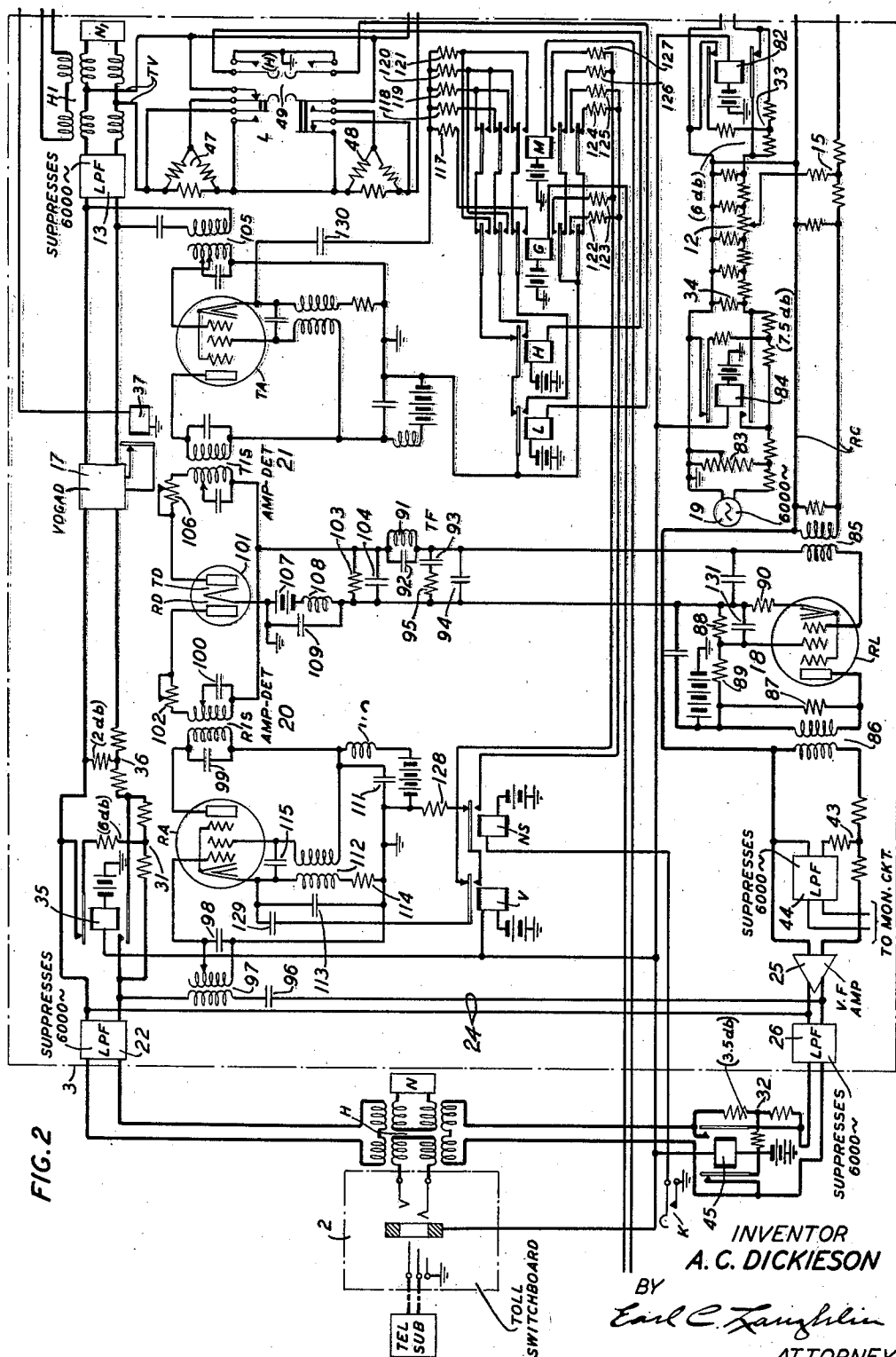
A. C. DICKIESON

2,224,569

CONTROL OF TRANSMISSION IN TWO-WAY SIGNALING SYSTEMS

Filed Oct. 4, 1939

3 Sheets-Sheet 2



Dec. 10, 1940.

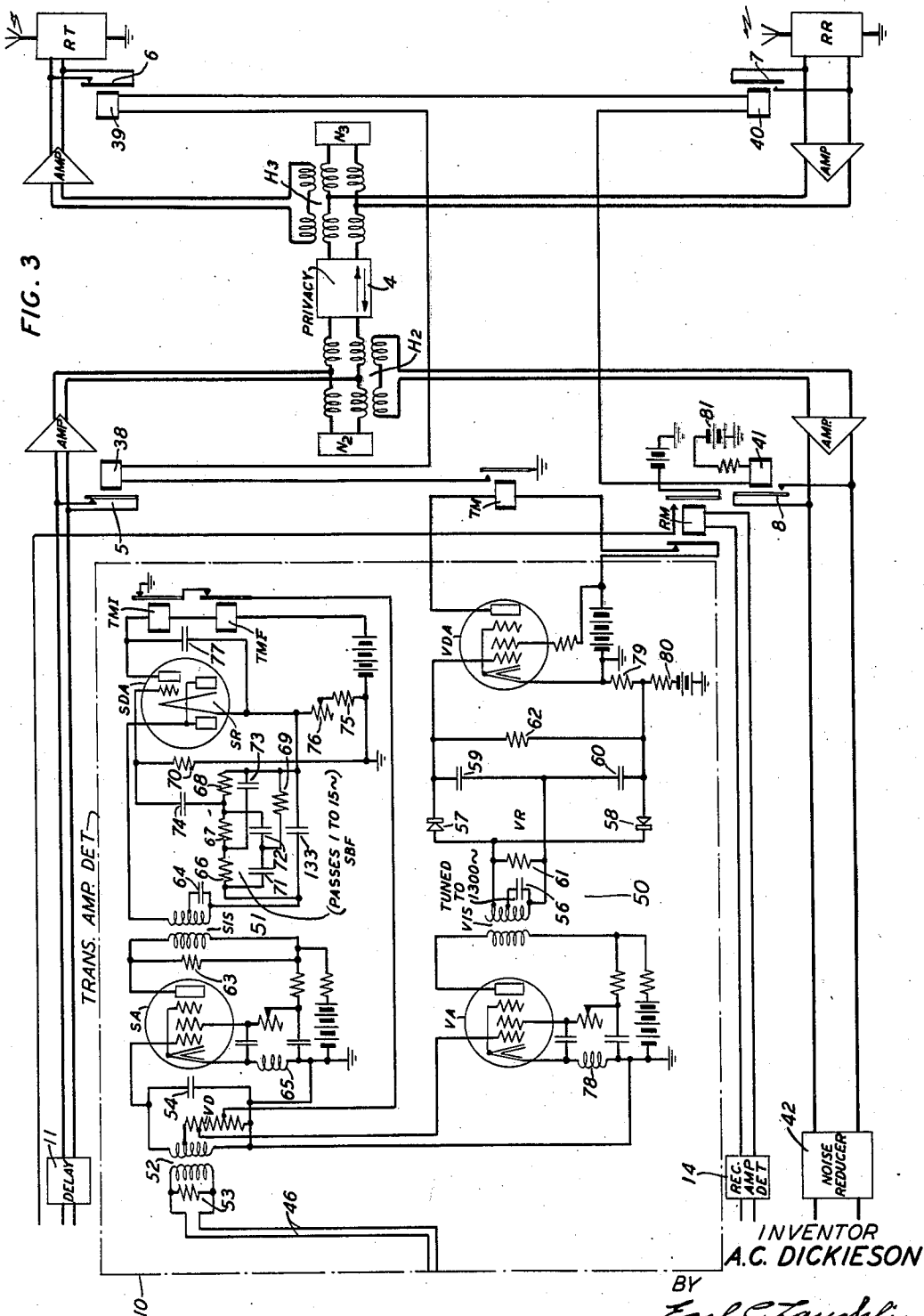
A. C. DICKIESON

2,224,569

CONTROL OF TRANSMISSION IN TWO-WAY SIGNALING SYSTEMS

Filed Oct. 4, 1939

3 Sheets-Sheet 3



UNITED STATES PATENT OFFICE

2,224,569

CONTROL OF TRANSMISSION IN TWO-WAY
SIGNALING SYSTEMSAlton C. Dickieson, Mountain Lakes, N. J., assign-
or to Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

Application October 4, 1939, Serial No. 297,832

12 Claims. (Cl. 178-44)

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

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

A related object is to improve the operation of circuits for automatically controlling the volume and direction of transmission in a two-way telephone system.

A more specific object is to provide maximum gain in the transmission paths of a two-way signal transmission system consistent with the maintenance of anti-singing conditions and discrimination against echoes, line noises, and other interference such as that arising in radio paths.

Another object is to relatively arrange and adjust automatic gain control devices and voice-operated switching devices for suppressing echoes and singing, in a two-way telephone system in such manner as to obtain improved over-all operation of the system under service conditions.

The invention is directed mainly to improvements in automatic transmission control apparatus in a control terminal for a two-way telephone system, particularly a two-way radio telephone system.

One feature is an improved tone-operated control circuit for automatically adjusting the loss in the receiving branch of the terminal in such manner as to prevent echo operation of the transmitting vodas switching circuit, echo operation of the gain increaser of the transmitting circuit, and any operation of an echo suppressor on a connected circuit by received speech or noise too weak to operate the receiving vodas switching circuit.

Another feature is an improved "syllabic" type transmitting vodas circuit comprising the combination of a vowel-operated switching detector with a consonant-operated detector enabler, to provide better discrimination between speech and line noise and improvement from the standpoint of signal clipping.

The various objects and features of the circuits of the invention will be better understood from the following detailed description when read in conjunction with the accompanying drawings in which:

Fig. 1 shows a block diagram of one terminal of a radio telephone system embodying the invention; and

Figs. 2 and 3 combined show schematically, and in part diagrammatically, in more detail the apparatus and circuits which would be used at a terminal of a radio telephone system in

accordance with one modification of the invention.

Fig. 1 shows in functional schematic form a semiautomatic control terminal for a radio telephone system illustrating the main features of the invention. In this figure, each single line represents a two-wire transmission path, and the transmission apparatus associated with the transmission paths are represented by suitably labeled boxes or simplified representations of their functions. Contacting arrowheads in a transmission path or within a box indicate that the path at that point or the transmission apparatus represented by the box is normally made or enabled, and separated arrowheads in a transmission path indicate that the path at that point is normally broken or disabled. An arrow directed at a make point (contacting arrowheads) in a transmission path from a box indicates that the path will be disabled by operation of the apparatus represented by the box, and an arrow directed towards a break point (separated arrowheads) in a transmission path from a box indicates that the path will be enabled by operation of the apparatus represented by the box. An arrow directed towards one box from another box indicates that the apparatus represented by the first box will be controlled in some way by operation of the apparatus represented by the latter box.

The control terminal of Fig. 1 is essentially a four-wire terminating circuit for a radio system. As indicated, this four-wire circuit comprises a transmitting circuit TC leading to a radio transmitter RT and a receiving circuit RC leading from a radio receiver RR. The input of the circuit TC and the output of the circuit RC are connected in substantially conjugate relation with each other and in energy transmitting relation with a two-way circuit 1 by a hybrid coil H and associated balancing network N in well-known manner. The two-way circuit 1 may be connected by apparatus in the toll switchboard 2 to a telephone line leading to a telephone subscriber's circuit, as indicated.

The transmission apparatus and associated control circuits illustrated in connection with the control terminal of Fig. 1 comprise only those portions necessary to explain broadly the main features of the invention. They include the volume control apparatus and circuits shown within the dot-dash box 3 at the left of the figure, for adjustably controlling the gain or loss in the transmitting circuit TC and in the receiving circuit RC, a two-way privacy device, which may

be of any of the well-known types, represented by the box 4 at the right, and voice-operated switching circuits for preventing singing and suppressing echoes, commonly known as vodas (voice-operated device anti-singing) circuits, shown in the center of the figure.

In the absence of transmitted speech signals, the transmitting circuit TC is disabled or blocked at the points 5 and 6 on either side of the transmitting portion of the privacy 4 as indicated by the separated arrows at those points, and the receiving circuit RC is operative as indicated by the contacting arrowheads at the points 7 and 8 on either side of the receiving portion of the privacy 4. Transmitting circuit TC is adapted to be rendered operative at the points 5 and 6 to transmit to the radio transmitter RT, and the receiving circuit RC is adapted to be simultaneously disabled at the points 7 and 8 under control of the outgoing telephonic signals initiated in the transmitting circuit TC, by operation of the transmitting vodas circuit TV including the transmitting amplifier-detector 10, having its input connected to the circuit TC through the hybrid coil H₁ and associated balancing network N₁. The delay circuit 11 connected between hybrid coil H₁ and the point 5 in the circuit TC, is employed to delay the transmitted signals to prevent loss of any part thereof during the period required to complete operation of the transmitting vodas TV.

A receiving vodas circuit RV including a portion of the ladder potentiometer 12 and the receiving amplifier-detector 14, has its input connected to the receiving circuit RC through the circuit dividing resistance pad 15 at a point to the left of the disabling points 8 and 7 in the circuit RC. When the receiving circuit RC is operative, speech currents of sufficient level incoming from the radio receiver RR will operate the receiving vodas RV to disable the transmitting vodas circuit TV at the point 16 in its output, and to disable the vogad (volume-operated gain-adjusting device) 17 in the transmitting circuit TC. The disabling of the transmitting vodas TV will prevent false operation of that circuit by echoes of the received speech waves, and the disabling of the vogad 17 will prevent change in its gain during the period in which the receiving vodas RV remains operated.

The sensitivity of the transmitting amplifier-detector 10 in the transmitting vodas TV should be set so that the vodas will be certain to operate on even the weak parts of transmitted speech signals. The manually-operated variable resistance pad 9 in the input of amplifier-detector 10 is provided for making part of the desired adjustment in sensitivity.

The sensitivity of the receiving amplifier-detector 14 in the receiving vodas RV should be set as high as possible consistent with preventing false operation of the receiving vodas by incoming static. The manually-operated ladder-type potentiometer 12 is provided for making part of this sensitivity adjustment as well as to make an inverse adjustment in the level of the pilot tone current in the receiving loss adjusting circuit to be described later.

The gain in the transmitting circuit TC of the terminal must be adjusted so that the circuit transmits to the radio transmitter RT a signal volume that will modulate the transmitter properly. This is accomplished in this terminal by the vogad 17 which operates automatically to adjust its gain so as to provide a predetermined

volume output. A secondary function of the vogad is to effectively vary the sensitivity of the transmitting vodas TV connected across the path TC on its output side, to compensate for the varying signal input to the vodas with strong and weak talkers. The vogad 17 may be of any of the well-known types, for example, such as disclosed in the Mitchell et al. Patent No. 2,019,577 issued November 5, 1935.

Having a vogad in the transmitting circuit TC, it becomes necessary to provide some means for automatically controlling the received volume, in order to prevent low "echo margin" due to poor balance, high radio noise forcing lower receiving detector sensitivity or low volume from the transmitting talker resulting in high vogad gain. Echo margin is expressed in decibels (db.), and may be defined as the difference between the volume delivered from the terminal apparatus to the two-wire circuit 1 under a given set of operating conditions, and the maximum volume which could be delivered by reducing the receiving loss without producing echo operation.

The proper control of the received volume is obtained by a pilot channel control circuit or tone-operated loss adjusting circuit (tola), all elements of which are shown within the dot-dash box 3, which operates automatically to sum up certain gains and losses in the transmitting circuit TC and in the receiving circuit RC, and to control a vario-repeater in the receiving circuit RC to insert loss or gain therein in accordance with the resultant measured value.

The pilot channel control circuit or tola includes an adjustable loss or gain element 18 in the receiving circuit RC, which preferably is a variable gain amplifier adapted to operate either as a vario-repeater or a vario-losser; a source 19 of pilot current of a frequency, say, 6000 cycles, outside the voice frequency range, connected to the receiving circuit RC; and two amplifier-detectors 20 and 21 connected to points in the path traversed by the pilot tone, beyond the output of the vario-repeater or vario-losser 18, operating to control the gain or loss of the latter under control of the pilot current.

The vario-repeater 18 is connected in the receiving circuit RC at a point to the left of the point of connection of the receiving vodas RV thereto. The pilot current source 19 is connected to the receiving circuit RC at a point to the right of the device 18 by the circuit dividing pad 15 through the ladder potentiometer 12 which is also effective in the input of the receiving vodas RV so that adjustment of the variable arm of the potentiometer to increase or decrease the sensitivity of the receiving vodas RV will proportionately decrease or increase the level of the 6000-cycle pilot current passing into the receiving circuit RC.

The input of amplifier-detector 21 is connected to the transmitting circuit TC at a point between the output of vogad 17 and low-pass filter 13. The input of the amplifier-detector 20 is connected between the circuits TC and RC through the selective network 23 in the selective by-pass circuit 24, tuned to 6000 cycles, extending from a point in the output of the voice frequency amplifier 25 in the receiving circuit RC and a point between the low-pass filter 22 and the input of the vogad 17 in the transmitting circuit TC.

The 6000-cycle pilot current introduced into the circuit RC through the circuit dividing pad 15 passes through the vario-repeater 18 operating as an amplifier, along with any received voice

signals that may be present in the circuit RC, and is further amplified in the voice frequency amplifier 25 to the same extent as the received voice signals. The output currents from the voice frequency amplifier 25 separate, the voice frequency output passing through the low-pass filter 26, which does not pass 6000 cycles, to the terminating hybrid coil H, and thence over the associated telephone line to the west telephone subscriber.

The 6000-cycle pilot current in the output of amplifier 25 passes into the by-pass circuit 24 and is divided by the selective network 23 tuned to 6000 cycles therein, between the input of the amplifier-detector 20 and the transmitting circuit TC.

The portion of the 6000-cycle tone passing into the transmitting circuit TC is prevented from passing thereover to the left by the low-pass filter 22, the pass range of which does not include the frequency 6000 cycles. The 6000-cycle pilot current, therefore, is transmitted to the right through the vogad 17. The low-pass filter 13 in the transmitting circuit TC on the output side of the vogad prevents the 6000-cycle pilot current from passing to the right over that circuit. The pilot current, however, will pass through the sensitivity-adjusting variable loss pads 28 and 29 into the input of amplifier-detector 21 and will be amplified and detected thereby.

The outputs of the two amplifier-detectors 20 and 21 and the vario-repeater 18 in the tola are interconnected in the manner to be described in connection with the detailed showing of these circuits in Fig. 2 so that the amplifier-detector having the greatest output exercises sole control over the adjustment of the vario-repeater 18. When a sufficient amount of 6000-cycle pilot current is received by either amplifier-detector, the rectified output of the one having the greater output will be applied to the vario-repeater 18 in such manner as to make it operate as a transmission loss, instead of as an amplifier, to maintain the 6000-cycle tone input to the amplifier-detector 20 or 21 constant.

Since echo margin to transmitting vodas detector equals receiving vodas detector sensitivity less transmitting vodas detector sensitivity, plus loss from the receiving vodas detector to the two-wire line 1, plus return loss at that point, plus loss from the two-wire line 1 to the transmitting vodas detector 10, it is obvious that by properly choosing the relationship between the sensitivity of the 6000-cycle amplifier-detector 21 and the output level of the 6000-cycle pilot oscillator 19, the echo margin can be held at zero (0) for any vogad gain, other factors being fixed.

The connection of the amplifier-detector 20 to the 6000-cycle pilot current path at a point ahead of the vogad 17 prevents the gain increaser of the latter from operating falsely on echoes of incoming speech or noise which are not of sufficient amplitude to operate the receiving amplifier-detector 14 of the receiving vodas RV. Operation of the receiving amplifier-detector 14 by incoming speech disables both the gain increaser and gain decrease of the vogad, so that the vogad gain is held constant between the reversals of circuit direction eliminating a period of readjustment each time the local subscriber talks. It is very undesirable to allow the gain increaser of the vogad to operate on static or incoming speech too weak to control the direction of the circuit since it interferes with outgoing speech.

Considering the operation of the tola and amplifier-detector 20 alone, the action is such that the level of the 6000-cycle tone is held constant at the input of amplifier-detector 20 for any setting of the sensitivity of the receiving vodas amplifier-detector 14 if detector 20 is controlling. This means that the loss to the 6000-cycle tone in the receiving detector sensitivity potentiometer 12 plus the loss of the tola is a constant, or in other words, receiving amplifier-detector sensitivity plus tola loss is a constant, other factors remaining fixed. Since echo margin to the vogad gain increaser equals receiving vodas amplifier-detector sensitivity less the sensitivity of the gain increaser of the vogad plus the loss between the receiving amplifier-detector and the input to the vogad where the gain increaser is connected, it is obvious that, exactly as in the case of the transmitting vodas detector, by properly choosing the relationship between the 6000-cycle amplifier-detector 21 and the output of the 6000-cycle oscillator 19, the echo margin can be held at zero (0) for any receiving vodas amplifier-detector sensitivity, other factors remaining fixed. The only other variable is the return loss at the hybrid coil H, which, of course, directly affects the loss from the receiving amplifier-detector 14 to the input of vogad 17 and therefore echo margin. The manually adjustable variable loss pads 27 and 29 in the inputs of the amplifier-detectors 20 and 21, respectively, are arranged to be adjusted simultaneously to take care of different degrees of return loss.

The automatic receiving loss adjusting circuit of the invention illustrated in Fig. 1 and described above, has an additional function when a toll telephone circuit equipped with an echo suppressor is connected to the terminal. In this case, the echo suppressor is prevented from operating on incoming speech or noise from the radio receiver RR which is not of sufficient amplitude to operate the receiving vodas amplifier-detector 14. This operation is undesirable since there would be two points in the circuit at which similar degradation of the circuit could originate and the problem of the technical operator in minimizing this degradation would be greatly increased. The receiving loss control circuit (tola) insures that there is sufficient loss inserted in receiving circuit RC so that the speech or noise sensitivities of the receiving vodas amplifier-detector 14 and of the echo suppressor in the connected toll circuit are approximately the same as viewed from the radio receiver RR. Since the apparent sensitivity of the echo suppressor as seen from the radio receiver RR is greater than that of the gain increaser of the vogad 17 seen from the same point, it is possible to use the same control amplifier-detector 20 for this purpose, merely increasing its sensitivity by the required amount. Since the sensitivity of the echo suppressor in the connected circuit would be independent of the return loss at the hybrid coil H, return loss control of the sensitivity of the amplifier-detector 20 is eliminated. The required changes in sensitivity of the amplifier-detector 20 are accomplished by controlling the loss value of loss pad 132 in its input from the sleeve circuits of the switchboard 2 and key K, as indicated diagrammatically.

Other changes in the terminal resulting in increased nominal delivered volume, less nominal loss to speech from the near-end subscriber, decreased maximum sensitivity of receiving vodas detector and decreased initial level of the pilot

current supply may be accomplished by controlling from the sleeve circuits of switchboard 2 resistance loss pads 32, 31, 33 and 34 in the receiving circuit RC, transmitting circuit TC, receiving vodas RV and pilot tone supply current, respectively, to remove or insert the required amount of loss, as indicated.

Figs. 2 and 3 when placed side by side with Fig. 2 at the left show schematically a radio control terminal, such as illustrated diagrammatically in Fig. 1, with certain of the transmission apparatus and circuits shown in detail in accordance with a preferred form of the invention.

The elements of the control terminal of Figs. 2 and 3 corresponding to the elements in the more diagrammatic showing of the terminal in Fig. 1 are identified by the same identification characters.

The transmitting circuit TC of the control terminal shown in Figs. 2 and 3 includes in order connected between the hybrid coil H and the radio transmitter RT:

The low-pass filter 22, included in the tone-operated loss adjuster circuit (tola), for suppressing the 6000-cycle pilot tone from the four-wire termination;

A 6-decibel loss pad 31 normally in circuit but arranged to be removed therefrom by operation of relay 35 from the sleeve control circuit of switchboard 2 when the channel is made part of a via connection;

A 2-decibel fixed loss pad 36 which is used to properly set the operating range of the vogad;

The vogad 17 serving as an automatic control of the volume of speech applied to the radio transmitter RT, the control circuits of which are adapted to be disabled to prevent further change in gain by operation of relay 37 under control of the receiving master relay RM in the receiving vodas RV when the terminal is receiving signals, as indicated diagrammatically;

A second low-pass filter 13, included in the tone-operated loss adjuster circuit, for suppressing the 6000-cycle pilot tone from the outgoing portion of the circuit TC;

A hybrid coil H₁ and associated balancing network N₁ for connecting the input of the transmitting vodas TV to the circuit TC;

The delay circuit 11 for delaying the transmission of outgoing signals over the circuit TC during the period required to complete operation of the transmitting vodas TV;

A short-circuiting connection 5 normally disabling the transmitting circuit TC, and which is adapted to be opened to render circuit TC operative at that point by operation of the switching relay 38 in the transmitting vodas TV;

A two-way privacy device 4 coupled in common to the transmitting circuit TC and the receiving circuit RC by hybrid coil transformers H₂ and H₃ and associated balancing networks N₂ and N₃; and

A second short-circuiting connection 6 normally disabling transmitting circuit TC on the outgoing side of privacy 4 and adapted to be opened to render the circuit TC operative at that point by operation of switching relay 39 in the transmitting vodas TV.

The receiving circuit RC includes in order between the radio receiver RR and the hybrid coil H:

The normally open short-circuiting connection 7 adapted to be closed to disable receiving circuit RC at that point in response to operation of the switching relay 40 in the transmitting vodas TV;

The two-way privacy 4 common to the transmitting circuit TC also;

The normally open short-circuiting connection 8 adapted to be closed to disable the circuit RC at that point in response to operation of the switching relay 41 in the transmitting vodas TV;

A noise reducer 42, which may be of the type disclosed in Norman Patent No. 2,063,334 issued December 8, 1936, operating to introduce an appreciable loss for low inputs and a very low loss for high inputs, thus discriminating between the usual line noise and speech waves of relatively high amplitudes;

The circuit dividing resistance pad 15 provided for connecting the input of the amplifier-detector 14 of the receiving vodas RV, and the source 19 of pilot tone (6000 cycles) for the tone-operated loss adjuster circuit, to the receiving circuit RC through the ladder potentiometer 12;

The variable gain amplifier 18 operating both as a vario-repeater and as a vario-losser in the tone-operated loss adjuster circuit (tola);

The circuit dividing pad 43 provided for connecting a monitoring circuit to the receiving circuit RC through the low-pass filter 44 operating to suppress the 6000-cycle pilot tone while passing the speech frequency waves;

The voice frequency amplifier 25;

A low-pass filter 26, included in the tone-operated loss adjuster circuit, which is used to keep the 6000-cycle control current out of the four-wire terminating circuit; and

A 3.5-decibel loss pad 32 which is normally connected in circuit but may be removed by operation of the relay 45 from the sleeve control circuit of switchboard 2 when the terminal is connected to a toll line to form a via connection.

When the terminal is being used for transmitting, the switching relays 38, 39, 40 and 41 are operated under control of the transmitting amplifier-detector 10 of the transmitting vodas TV to respectively open the normal short-circuiting connections 5 and 6 to render the transmitting circuit TC operative to transmit the outgoing speech signals, and to simultaneously close the short-circuiting connections 7 and 8 to disable the receiving circuit RC, so as to prevent the setting up of a singing condition between the circuits TC and RC.

The transmitting vodas TV includes besides the transmitting amplifier-detector 10 an input portion 46 including the relay-controlled variable loss pads 47 and 48 which, depending on the setting of the key control 49, provide a total loss of 0, 5, or 10 decibels in the input of the transmitting amplifier-detector 10 to control its sensitivity, the particular sensitivity adjustment chosen depending on the circuit conditions at the time of operation.

The transmitting amplifier-detector 10 is designed to be unoperated by the maximum noise which may be expected on the transmitting circuit TC but to be operated quickly by speech signals of both high and low amplitudes. New features of this amplifier-detector to be described below provide added discrimination between speech and line noise, and the reduction in false operation afforded by this protection enables improved operation to be attained for the case in which noisy telephone lines are connected to the terminal.

The amplifier-detector 10 comprises a voltage amplifier-detector 50 for controlling the operation of the switching relays of the transmitting vodas, and a syllabic type amplifier-detector 51

operating as an enabler for the voltage amplifier-detector 50, the two amplifier-detectors 50 and 51 being coupled to the common input circuit 46 through the input transformer 52, the primary winding of which is shunted by the terminating resistance 53 and the secondary winding of which is shunted by the condenser 54. A portion of the secondary winding of input transformer 52 is shunted by a resistance VD arranged as a voltage divider.

The voltage-operated amplifier-detector 50 comprises one stage of alternating current amplification consisting of a single pentode vacuum tube VA having its cathode connected to the lower terminal of the secondary winding of input transformer 52 and the lower terminal of voltage divider VD, and its control grid connected to the upper tap of the voltage divider VD; an interstage transformer VIS having a primary winding connected in the plate-cathode circuit of the tube VA and a secondary winding tuned to 1300 cycles by the condenser 56; a rectifier VR consisting of copper oxide rectifier elements 57 and 58 and condensers 59 and 60, having its input connected to the secondary winding of the interstage transformer VIS across shunt resistance 61; a stage of direct current amplification consisting of a single pentode vacuum tube VDA the control grid-cathode circuit of which is connected to the output of rectifier VR across shunt resistance 62; and the master transmitting relay TM which controls the operation of the switching relays 38 to 41, having its operating winding connected in the plate-cathode circuit of the amplifying tube VDA.

The syllabic amplifier-detector 51 comprises a stage of alternating current amplification consisting of the single pentode amplifying vacuum tube SA having its control grid-cathode circuit connected to the terminals of the secondary winding of input transformer 52; an interstage transformer SIS having a primary winding shunted by resistance 63, connected in the plate-cathode circuit of tube SA, and a secondary winding which is tuned to 1800 cycles by the shunt condenser 64; a rectifier SR comprising the diode portion of the diode-triode vacuum tube SDA, connected to the secondary winding of transformer SIS through series condenser 133; a band-pass filter SBF passing frequencies between 1 and 15 cycles, consisting of resistances 66 to 70 and condensers 71 to 74, in the output of the diode detector portion of tube SDA; a direct current amplifier consisting of the three-electrode amplifying portion of the tube SDA, having its control grid-cathode circuit connected to the output of filter SBF; and the relays TMI and TMF having their operating windings connected in series in the plate-cathode circuit of the amplifier portion of tube SDA.

The various plate, screen and grid filters and bias circuits shown are necessary for the successful operation of the amplifier-detectors 50 and 51. The tube SA obtains its grid bias by cathode voltage drop through the retard coil 65 which also provides series feedback. The tube SDA obtains its grid bias by cathode voltage drop through the fixed resistance 75 and adjustable resistance 76. The condenser 77 operates as the plate filter for tube SDA. The tube VA obtains its grid bias by cathode voltage drop through the retard coil 78 which also provides series feedback, and the associated condenser and resistance provide the screen filter for the same tube. The tube VDA obtains its grid bias

from the filament battery by means of the voltage divider consisting of resistances 79 and 80.

In the unoperated condition of relays TMI and TMF, that is, with no speech waves being applied to the input of amplifier-detector 10 through input transformer 52, the lower resistance portion of the voltage divider VD is short-circuited through the normally closed contacts of these relays in series, so that the voltage input to the amplifying tube VA of the voltage amplifier-detector 50 is decreased by about 10 decibels. This reduction in sensitivity is sufficient to prevent false operation of the voltage amplifier-detector 50 in response to any normal amount of line noise from the transmitting circuit TC which may be impressed on its input through input transformer 52. The line noise will be prevented from causing false operation of the syllabic amplifier-detector 51 by the band-pass filter SBF therein which will transmit only the syllabic frequencies of speech and will not transmit the relatively steady noise.

Now let it be assumed that outgoing speech signals from a telephone subscriber connected to the terminal are being transmitted over the transmitting circuit TC. A portion of the speech signals will be diverted into the transmitting vodas TV through hybrid coil H₁, and with a level determined by the adjustment of loss pads 47 and 48 in the input circuit 46 thereof will be impressed along with the noise waves received from the circuit TC on the input of the transmitting amplifier-detector 10 through input transformer 52, and will be divided between the syllabic amplifier-detector 51 and the voltage amplifier-detector 50.

The portion of the speech signals and noise entering the syllabic amplifier-detector 51 will pass through the interstage transformer SIS which, being tuned to 1800 cycles, will pass most of the higher voice frequencies (1500 to 3000 cycles). It has been found that for consonants in speech a better signal-to-noise ratio is obtained in the region of 1800 cycles and that words beginning or ending in consonants are the most susceptible to clipping. The tuning of the syllabic amplifier-detector circuit 51 to 1800 cycles as described, effectively makes this amplifier-detector a consonant-operated enabler device and provides improved operation of the vodas.

The waves passed by the tuned transformer SIS are transmitted through the series condenser 133 to the diode-detector portion of the tube SDA, which operates to demodulate the speech frequencies and to produce all the low frequencies caused by the syllabic nature of the speech, these products appearing across condenser 133. Those of the demodulated products which are between 1 and 15 cycles pass through the band-pass filter SBF and are then amplified by the amplifying triode portion of the tube SDA.

The amplified waves in the plate-cathode circuit of the triode portion of the tube SDA pass through the operating windings of the relays TMI and TMF in series. These relays are poled and biased differently so that the TMI relay operates at the beginning of a word or syllable and the TMF relay operates at the end of a word or syllable if the speech amplitude is sufficient. The result of operation of either of these relays is to remove the short circuit from the lower resistance portion of the voltage divider VD thereby increasing the voltage input to the amplifying tube VA in the voltage amplifier-detector 50 by

about 10 decibels, and thus effectively increasing its sensitivity by that amount.

The speech and line noise impressed on the input of the amplifying tube VA are amplified thereby and passed through the interstage transformer VIS. This transformer being tuned to 1300 cycles will be particularly effective in transmitting the lower speech frequencies (800 to 1500 cycles), and in this frequency range a better signal-to-noise ratio is obtained for the vowels in speech. The tuning of the circuit in this manner, therefore, makes the voltage amplifier-detector 50 effectively a vowel-operated device.

The waves passed by interstage transformer VIS are rectified in rectifier VR, and the rectified voltages are applied across resistance 62 to the control grid-cathode circuit of the direct current amplifier tube VDA which is normally biased by the biasing circuit shown to approximately cut off. This normal bias is overcome by the opposing rectified voltage causing space current to flow in the anode-cathode circuit of the tube VDA to operatively energize the winding of the master relay TM therein. Relay TM operated will close an energizing circuit from battery 81 to the windings of switching relays 38 to 41, inclusive. Relays 38 to 41 will then operate in the manner previously described to unblock the transmitting circuit TC for outgoing speech signals, and to simultaneously disable the receiving circuit RC so as to suppress echoes and prevent singing.

The combination of the vowel-operated switching detector with consonant-operated detector enabler described provides added discrimination between speech and line noise and thus improved operation of the transmitting vodas TV especially from the standpoint of reduction in signal clipping.

In the absence of outgoing speech signals in the transmitting circuit TC, the receiving circuit RC being operative, speech signals received from the radio receiver RR will pass over the circuit RC through the noise reducer 42. The speech signals in the output of the noise reducer 42 will be divided, one part passing over the circuit RC to the west through the hybrid coil H and switchboard 2 to the west subscriber, and the other part passing through the ladder type potentiometer 12 to the input of the receiving amplifier-detector of the receiving vodas RV. If the level of the speech current is high enough and if the loss introduced by the ladder type potentiometer is low enough the output currents of the amplifier-detector 14 will cause operation of the receiving master relay RM in its output. Relay RM operated will open its left-hand contacts to disable the energizing circuit for the transmitting relay TM in the transmitting vodas TV. Relay RM operated also will close through its right-hand contacts an energizing circuit for relay 37 which will operate to disable the transmitting vodad 17, as indicated diagrammatically.

It is to be understood that the hold-over times of the switching relays in the transmitting vodas TV by the usual condenser-resistance hang-over circuits (not shown) will be made such that on release of the transmitting vodas TV with cessation in the supply of controlling voice currents, the relays 38 to 41 will be maintained operated for sufficient hang-over intervals to prevent loss of any part of the outgoing signal transmission and to suppress all echoes of that transmission in the receiving circuit RC. Also, by similar hang-over circuits (not shown) the hold-over

times of the switching relays of the receiving vodas RV will be made such that these relays will remain operated after cessation in received speech signals for sufficient hang-over time intervals to prevent false operation of the transmitting vodas TV or false adjustment of the gain of the vodad 17 by echoes of the received speech signals.

It will be noted that a removable (6 decibels) loss pad 33 normally disconnected from the receiving vodas RV will be connected in that circuit by operation of a relay 82 from the sleeve circuits of the toll switchboard 2 when the terminal is connected to a long toll telephone line to form a via circuit to provide a suitable reduction of the sensitivity of the receiving amplifier-detector 14 required in the case of such a connection. Also, the required inverse adjustment of the level of the pilot current from the source 19 for this condition is provided by causing the operation of the relay 84 from the sleeve circuits of toll switchboard 2 to effectively remove the loss pad 34 of 7.5 decibels normally connected in the output of oscillator 19.

The detailed circuits of the important apparatus in the tone-operated loss adjuster circuit (tola) illustrated diagrammatically within the dot-dash box 3 of Fig. 1 will be brought out in the following complete description of the corresponding more detailed circuit shown in Fig. 2.

The 6000-cycle pilot current from the source 19 first passes through the loss pad 83 having a semipermanent adjustment so as to make the output from the source 19 of the proper initial level, and then through the ladder potentiometer 12, which, as pointed out above, takes cognizance of the setting of the sensitivity of the receiving vodas RV, and is introduced into the receiving circuit RC through the circuit dividing pad 15. The 6000-cycle pilot tone and any received speech signals which may be present in the receiving circuit RC then pass through the vario-repeater 18.

As indicated, the vario-repeater 18 consists essentially of the repeating coil 85 having its primary winding terminated in a resistance, operating as an input transformer, the pentode amplifying vacuum tube RL and the output transformer 86 therefor having its primary winding terminated in the resistance 87. The screen grid of the tube RL receives its voltage from a voltage divider made up of the resistances 88 and 89 and filter condenser 131. The control grid bias for the tube RL is supplied by the voltage drop across resistance 90. The direct current voltage controlling the amplifier gain is fed to the control grid through the filter TF made up of retard coil 91, condensers 92, 93 and 94 and terminating resistance 95.

The voice signal and pilot tone output of the amplifying tube RL pass from output transformer 86 through dividing network 43 to the voice frequency amplifier 25 and are amplified therein. The voice current only passes from the dividing network 43 through low-pass filter 44 to the monitoring circuit. The output currents from the voice frequency amplifier 25 separate, the voice frequency output going through the low-pass filter 26 and loss pad 32 to hybrid coil H, thence through switchboard 2 to the west subscriber.

The 6000-cycle tone is transmitted through bypass circuit 24 connecting the receiving circuit RC to the transmitting circuit TC, which is tuned by condensers 96 and 98 and transformer 97 to transmit the 6000-cycle tone but to provide a 75

high loss to transmission in the voice band. A portion of the 6000-cycle tone is transmitted through the circuit 24 to the transmitting circuit TC of the terminal, and another portion is impressed by the transformer 97 tuned by condensers 98 and 96 to 6000 cycles on the control grid-cathode circuit of the pentode amplifying vacuum tube RA forming the amplifier portion of amplifier-detector 20. The 6000-cycle tone is amplified by the tube RA and appears across the interstage transformer RIS which is tuned by condensers 99 and 100 across its primary and secondary windings respectively to 6000 cycles. The 6000-cycle tone passing interstage transformer RIS is applied to the plate of one diode portion RD of the vacuum tube 101, operating as the detector portion of amplifier-detector 20, through adjustable series resistance 102 which permits adjustments of the maximum detector sensitivity desired. The rectified direct current output of the diode RD appears across load resistance 103 shunted by condenser 104 and is applied to the control grid of the vario-amplifier tube RL in receiving circuit RC through the filter TF above mentioned.

The portion of the 6000-cycle pilot current introduced into the transmitting circuit TC through by-pass circuit 24 is prevented from passing thereover to the left by the low-pass filter 22, the pass range of which does not include the frequency 6000 cycles. The 6000-cycle pilot current, therefore, is transmitted to the right through loss pads 31 and 36 and vogad 17. The low-pass filter 13 prevents the 6000-cycle pilot current in the output of the vogad from passing to the right over the circuit TC. The pilot current, however, is impressed by input transformer 125 tuned by the associated condensers to 6000 cycles on the pentode amplifying vacuum tube TA forming the amplifier portion of amplifier-detector 21, and appears across the interstage transformer TIS which is tuned by the associated condensers to 6000 cycles. The 6000-cycle tone passing interstage transformer TIS is then applied to the plate of the other diode portion TD of the vacuum tube 101, forming the detector portion of amplifier-detector 21, through the series sensitivity-adjusting resistance 106. The rectified direct current output of the diode TD of detector tube 101 also appears across load resistance 103 connected through filter TF to the control grid circuit of the vario-repeater tube RL in the receiving circuit RC.

Each of the diode plates of the detector tube 101 is biased negatively about 20 volts by the voltage drop produced in the associated elements by current from battery 107 so that no rectified output appears from either diode RD or TD until the alternating current voltage applied to the diode is slightly greater than 20 volts peak. This bias is filtered by retard coil 108 and condenser 109. The plate supply of the tube RA is filtered by retard coil 110 and condenser 111. Screen current and cathode current for the tube RA flows separately through input transformer 112 which is used as a retard to hold the cathode at a high impedance above ground in the vicinity of 6000 cycles except for resistance shunts controlling the sensitivity. Condenser 113 tunes transformer 112 to approximately 6000 cycles. Resistance 114 supplies bias to the control grid of the tube RA. Condenser 115 acts as a filter for the screen lead of the tube RA. The corresponding (unnumbered) elements provide the

same functions in connection with amplifier tube TA.

The sensitivity of each amplifier-detector 20 or 21 is controlled by changing the amount of cathode feedback in the amplifier tubes RA and TA, respectively, which is determined by the size of the resistance shunted from the cathode to ground. In amplifier-detector 21, resistances 117 to 121 give five different sensitivities in 5-decibel steps over a range of 20 decibels, as determined by the armature positions of relays M, G, H and L, the first two of which are operated from the technical operator's position and the latter two by the key 49 controlling the sensitivity of the transmitting vodas TV. In the amplifier-detector 20, the resistances 122 to 128 give seven different sensitivities ranging from 0 to 21 decibels, as determined by the armature positions of the relays V, NS, G and M, controlled from switchboard 2. The sensitivities of the two amplifier-detectors 20 and 21 are made to depend on the operating adjustments of the control terminal, and are chosen so that a safe echo margin will be maintained. Condensers 129 and 130 prevent the cathode current of tubes TA and RA from flowing through the control resistances.

It will be apparent from the above description that the connection of the control grid of the variable-gain amplifier tube RL in the receiving circuit RC through filter TF and load resistance 103 in parallel to the two diode portions of the tube 101 constituting the detector portions of amplifier-detectors 20 and 21, respectively, is such that the amplifier-detector having the greatest output exercises sole control over the control grid bias and thus the gain of the variable-gain amplifier tube RL, this control being of an amount and in a direction to change the normal gain of the tube RL to a large loss. The control is made very sharp, that is, at the critical input level to one of the amplifier-detectors, a change of input of one decibel changes the amplifier gain by about 40 decibels.

The two amplifier-detectors 20 and 21 are connected to points in the pilot current path beyond the output of the variable-gain amplifier RL. As a result, for changes in 6000-cycle loss between the source 19 of 6000-cycle tone and the input of the controlling amplifier-detector, the level of the 6000-cycle tone at that amplifier-detector is held constant for a given detector sensitivity. The result of this is to prevent echo operation of the transmitting amplifier-detector 19 in the transmitting vodas TV, echo operation of the gain increaser control of the vogad 17, and any operation of an echo suppressor on a toll circuit connected to the terminal through switchboard 2, by radio received speech or noise too weak to operate the receiving amplifier-detector 14 of the receiving vodas RV.

If the radio noise level increases while the amplifier-detector 20 or 21 is controlling the vario-repeater 18, the technical operator might decrease the sensitivity of the amplifier-detector 14 of the receiving vodas RV by shifting the position of the movable contact of the ladder type potentiometer 12 to the left. This would raise the level of the pilot current from the source 19 passing through the vario-repeater 18 and reaching the input of amplifier-detector 20 or 21. The controlling detector output would then be increased enough to restore the output of vario-repeater 18 to about its former level of 6000-cycle current. The fact that the output is the same as before while the input to the vario-re-

peater 18 has been increased shows that under the stated condition when receiving vodas sensitivity is decreased, the receiving circuit (RC) loss is increased by about an equal amount expressed in decibels.

If the volume of speech current delivered to the terminal from the two-wire line 1 is reduced, the gain of voad 17 rises, increasing the level of pilot control current which reaches amplifier-rectifier 21. If this amplifier-rectifier was already controlling the behavior of the vario-repeater RL in the receiving circuit RC, the change will cause the loss in the receiving circuit RC to increase in an amount about equal to the increase in voad gain.

If the toll line connected to the terminal is noisy enough to require a reduction in sensitivity of the transmitting amplifier-detector 10 of the transmitting vodas TV by operating the L key of key control 49 so as to prevent locking the vodas in the transmitting condition, the relay L operates inserting a 5-decibel pad between the transmitting circuit TC and the transmitting vodas amplifier-detector 10. The operation of relay L of key control 49 also changes the cathode resistor of the amplifier tube TA of the amplifier-detector 21 so as to reduce its sensitivity by 5 decibels. If the amplifier-detector 21 is controlling the performance of the vario-repeater 18, the control point is shifted towards higher volume and the loss of the vario-repeater 18 is reduced while a satisfactory echo margin is maintained. Conversely, operation of the H key of the keying control 49 gives higher than normal sensitivity of the amplifier-detector 21 and greater loss inserted by the vario-repeater 18 in receiving circuit RC.

Many modifications in the circuits illustrated and described which are within the spirit and scope of the invention will occur to persons skilled in the art.

What is claimed is:

1. A control circuit for a two-way signal transmission system including a four-wire circuit having at a terminal an outgoing signal transmitting path and an incoming signal transmitting path, comprising signal-controlled switching apparatus for directionally controlling signal transmission in said system while suppressing echoes and preventing singing, an automatic device in said outgoing path for controlling outgoing signal volume, and means for automatically adjusting the loss or gain of said incoming path so that it delivers the largest received signal volume consistent with maintaining echo margin to prevent false operation of said signal-controlled switching apparatus and said automatic volume control device in said outgoing path, in response to transmission in said incoming path, comprising a variable loss device in said incoming path, means for transmitting a pilot current first through said variable loss device, and then through said automatic volume control device in said outgoing path, and means automatically responsive to the pilot current output of the one of said devices having the largest output to suitably adjust the loss value of said variable loss device.

2. A control circuit for a two-way telephone signaling system including at a terminal thereof a signal transmitting path and a signal receiving path, comprising signal-controlled switching apparatus for directionally controlling signal transmission in said paths while suppressing echoes and preventing singing, an automatic device for controlling outgoing signal volume in

said transmitting path, received signal volume control means including a variable loss device in said receiving path, means for transmitting a pilot current first through said variable loss device and then through said automatic volume control device in said transmitting path, and means automatically responsive to the pilot current output of the one of said devices having the largest output to adjust the loss value of said variable loss device so that said receiving path delivers the largest signal volume consistent with maintaining echo margin against false operation of said switching apparatus and said automatic volume control device in said transmitting path, by echoes of transmission in said receiving path.

3. The combination of claim 1, in which said system includes a two-way telephone circuit with an associated echo suppressor, connected to said terminal of said four-wire circuit, and said signal-controlled switching apparatus includes a portion controlled from said outgoing path for conditioning said terminal for transmitting signals only, and a second portion controlled from said incoming path for conditioning the terminal for receiving signals only, and the adjustment of the loss or gain of said incoming path by said automatic means is such as to prevent any operation of the echo suppressor associated with the connected telephone circuit by signals or noise waves transmitted over said incoming path, which are too weak to operate said second portion of said switching apparatus.

4. A control circuit for a two-way signal transmission system including at a terminal thereof a signal transmitting path, a signal receiving path and signal-controlled switching apparatus connected to the transmitting path, comprising a volume-operated gain adjusting device in said transmitting path, a variable loss device in said receiving path, means to transmit a pilot current first through said variable loss device and then through said gain adjusting device, and means automatically responsive to the pilot current output of the one of said devices having the greater output to adjust the loss device so that said receiving path delivers the maximum signal volume consistent with maintaining echo margin to prevent false operation of said switching apparatus by signal echoes.

5. A control circuit for a two-way signaling system comprising at a terminal thereof signal transmitting and receiving circuits, one wave-operated switching device connected to the transmitting circuit, responsive to outgoing signals to condition the terminal for transmitting only, a second wave-operated switching device connected to the receiving circuit and responsive to received signals therein, in the absence of prior outgoing signals in the transmitting circuit, to disable said one switching device, a voad in said transmitting circuit in front of the point of connection of said one switching device thereto, a variable loss device in said receiving circuit beyond the point of connection of said second switching device thereto, means to apply control tone of a frequency outside the signal frequency range to said receiving circuit in front of said variable loss device, means to select said tone in the output of said variable loss device, and to apply the selected tone to said transmitting circuit in front of said voad, and means automatically responsive to the tone output of said variable loss device or the tone output of said voad, to adjust the loss of said variable device in an amount

and in a direction such that said receiving circuit delivers the greatest signal volume consistent with maintaining echo margin to prevent false operation of said one switching device and of said vogad by signal echoes and noise in said system.

6. The control circuit of claim 5, in which the sensitivity of said one switching device is made such that it will operate in response to substantially all transmitted signal amplitudes, the sensitivity of said second switching device is set as high as possible consistent with preventing its false operation by noise or static incoming in said receiving circuit, and the level of the control tone applied to said receiving circuit is reduced in proportion to the increase in sensitivity of said second switching device, so that for a given setting of sensitivity of the said second switching device, the adjustment of said variable loss device is such as to maintain the control tone at constant level in the output of said variable loss device or in the output of said vogad depending on which controls the adjustment.

7. The control circuit of claim 5 in which said means automatically responsive to the tone output of said variable loss device and of said vogad comprise separate wave amplifier-detectors tuned to the frequency of said control tone, the input of one amplifier-detector being connected to said receiving circuit in the output of said variable loss device and the input of the other amplifier-detector being connected to said transmitting circuit in the output of said vogad, said variable loss device comprises a variable gain amplifying vacuum tube having a control grid circuit including a resistance, and the outputs of both of said amplifier-detectors being connected across said resistance so that the maximum voltage drop therein in response to the detected outputs determines the gain setting of said tube.

8. The control circuit of claim 5, in which the amount of tone applied to said receiving circuit is made inversely proportional to the sensitivity of said second switching device.

9. The control circuit of claim 5, in which the last-mentioned means comprises two wave detectors tuned to the frequency of said control tone having their inputs respectively connected to said receiving circuit in the output of said variable loss device, and to said transmitting circuit in the output of said vogad, and their outputs connected to said variable loss device in such manner that the stronger has sole control of its adjustment.

10. The combination of claim 5, in which said signal system is a telephone system, and said one switching device comprises a voltage operated

amplifier-detector and a syllabic type amplifier-detector connected to said transmitting circuit, said voltage operated amplifier detector having an initial sensitivity such that it will be unoperated by the usual line noise applied from said transmitting circuit, but will be operated in response to applied speech waves to condition the terminal for transmitting only, said syllabic type amplifier-detector being unresponsive to applied noise but being operatively responsive to speech waves received from said transmitting circuit to increase the sensitivity of said voltage-operated amplifier-detector, said syllabic amplifier detector being tuned to be more selective to the consonants than to vowels in the applied speech waves, and said voltage-operated amplifier-detector being tuned to be more selective to vowels than to consonants in the applied speech waves, whereby improved operation of said one switching device from the standpoint of reduction in signal clipping is attained.

11. In combination with a transmission circuit for transmitting signal waves of voice frequency and subject to comparatively steady disturbing noise waves, a voice-operated switching device comprising a voltage amplifier-detector and a syllabic amplifier-detector supplied from said circuit through a common input circuit, and means normally reducing the sensitivity of said voltage amplifier-detector so that it is unresponsive to applied noise waves of normal amplitude level, said syllabic amplifier-detector being unresponsive to applied noise waves but responsive to the syllabic frequencies of applied speech waves to increase the sensitivity of said voltage amplifier-detector so that it will operate quickly in response to applied speech waves, said voltage amplifier-detector being tuned to be more selective to the vowels than to the consonants in the applied speech waves, and said syllabic amplifier-detector being tuned to be more selective to the consonants than to the vowels in applied speech waves whereby improved operation of said voice-operated switching device is obtained.

12. The combination of claim 11 in which said voltage amplifier-detector is tuned to a frequency in the neighborhood of 1300 cycles so as to be particularly effective in transmitting the speech frequencies in the lower range extending from 800 to 1500 cycles, and said syllabic amplifier-detector is tuned to a frequency in the neighborhood of 1800 cycles so as to be particularly effective in transmitting speech frequencies in the higher range extending from 1500 to 3000 cycles.

ALTON C. DICKIESON.