

July 30, 1940.

C. C. TAYLOR

2,209,667

CONTROL OF TRANSMISSION IN TWO-WAY SIGNALING SYSTEMS

Filed May 13, 1939

3 Sheets-Sheet 1

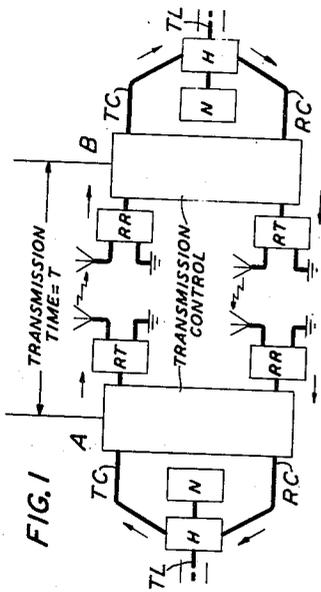
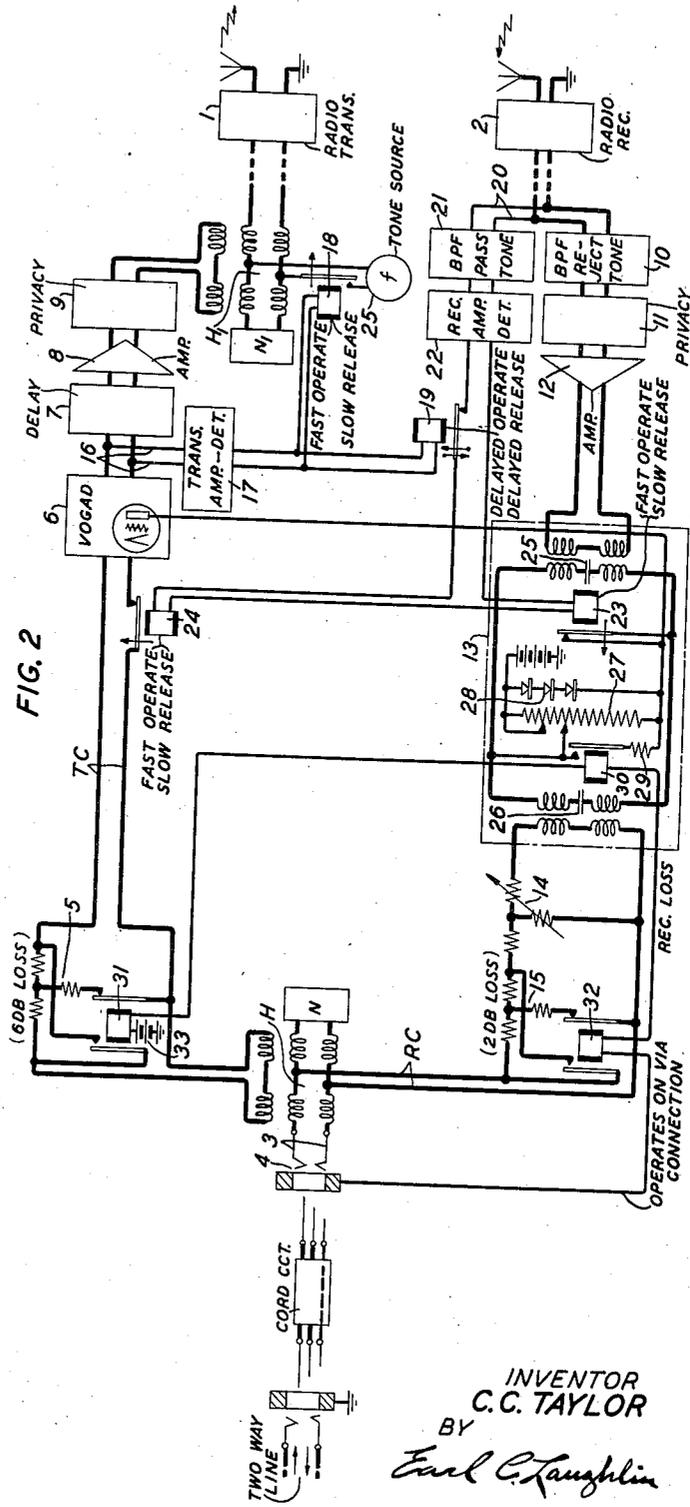


FIG. 2



INVENTOR
C. C. TAYLOR
 BY
Earl C. Laughlin
 ATTORNEY

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3 Sheets-Sheet 2

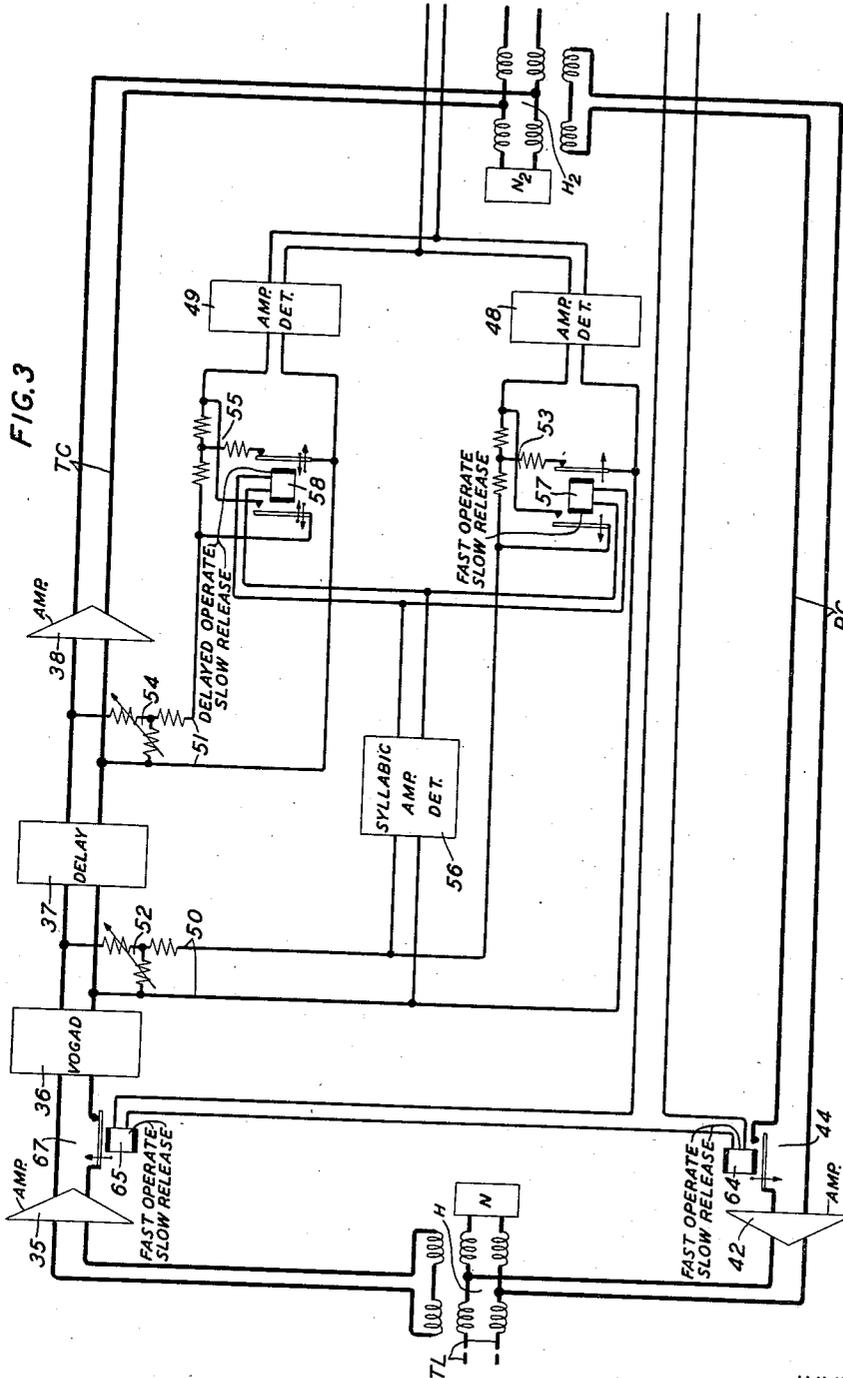


FIG. 3

INVENTOR
C. C. TAYLOR
BY
Earl C. Laughlin
ATTORNEY

UNITED STATES PATENT OFFICE

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CONTROL OF TRANSMISSION IN TWO-WAY SIGNALING SYSTEMS

Charles C. Taylor, Manhasset, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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9 Claims. (Cl. 179—170)

The invention relates to two-way signal transmission systems and particularly to the signal-controlled switching circuits employed in such systems for directionally controlling transmission while preventing singing and suppressing echoes.

An object of the invention is to improve the operation of such signal-controlled switching circuits.

Another object is to directionally control transmission in a two-way telephone transmission system in such manner as to minimize transmission lockouts and clipping, and to facilitate break-ins by a listening subscriber.

The circuits of the invention are particularly adapted for use with, although not limited to, a two-way radio telephone system, such as a transoceanic short wave radio telephone circuit, in which different radio frequencies are used in the two directions and in which, because of high frequency selectivity, geographic separation, or both, the suppression of transmission from the local transmitter to the local receiver at a terminal station is unnecessary.

In the circuits of the invention, the transmitting circuit at each terminal station of a two-way signal transmission system is normally enabled and the receiving circuit normally disabled either partially or totally. When signals are initiated at a terminal station they cause a control tone to be transmitted to the distant terminal station ahead of the signals, to control a switching circuit operating to disable the transmitting circuit and to enable the receiving circuit at that station. The receiving station switching circuit has appreciable hang-over in its operation and the arrangement for controlling the tone at the transmitting station has little or no hang-over in operation so that it operates and releases rapidly with the rise and fall of the signal amplitudes, providing desirable operation from the standpoint of clipping, lock-out and breaking time.

In one embodiment of the invention, the tone control arrangement at the transmitting station comprises a syllabic device connected to the transmitting circuit at each terminal, which is responsive to applied voice signals to increase the sensitivity of two quick response amplifier-detector circuits respectively bridged across the transmitting circuit on either side of a delay circuit, which operate in parallel to control the operation of a tone-control relay having little or no hang-over in operation.

A feature of the invention is the use at each terminal station of a switching circuit responsive

to transmitted signals to disable the receiving control tone-operated switching circuit, at the same station, the first circuit having a delay in operation and release corresponding to the transmission time between terminals, thus reducing the transmission lock-out time.

A second feature is the use for the receiving circuit disabling means of a singing suppressor the loss of which is made a function of the gain of a volume control device (Vogad) in the transmitting circuit at the same terminal and also depends upon the volume of the line and radio noise present in the receiving circuit.

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

Fig. 1 is a diagram in the form of a single line schematic showing the general arrangement of transmission apparatus at the two terminals of the usual two-way radio telephone system;

Fig. 2 and Figs. 3 and 4, combined, show schematically and in part diagrammatically different modifications of transmission control apparatus and circuits embodying the invention which would be used at each terminal of a system such as shown in Fig. 1.

In the radio telephone system of Fig. 1, each terminal station A and B comprises a one-way transmitting circuit TC including a radio transmitter RT, and a one-way receiving circuit RC including the radio receiver RR, coupled in conjugate relation with each other and in energy transmitting relation with a two-way telephone line TL by the usual hybrid coil H and associated balancing network N. Each terminal comprises in addition, signal-controlled switching circuits and apparatus for controlling signal transmission in the transmitting circuit TC and receiving circuit RC, represented by the box labeled "Transmission control." The switching circuits and apparatus which would be used at each terminal station of such a system, embodying different modification of the invention, are illustrated in the other figures of the drawings.

Fig. 2 shows one of two like terminal stations of a two-way radio telephone system such as shown in Fig. 1 in which the transmission time between terminals is represented as T. The terminal station includes a four-wire circuit connecting a telephone line to a radio transmitter and a radio receiver which may be of any well-known type or construction. The four-wire circuit comprises a transmitting circuit TC leading

to the radio transmitter 1 and a receiving circuit RC leading from a radio receiver 2. The input of the circuit TC and the output of the circuit RC are connected in well-known manner by the hybrid coil H and associated balancing network N in substantially conjugate relation with each other and in energy transmitting relation with the two-wire circuit 3 which may be connected by the plug and jack arrangement 4 and other suitable means with a two-way telephone line.

The transmitting circuit TC includes, in order, connected between the hybrid coil H and the radio transmitter 1, a fixed loss (6 decibels) pad 5, a volume control device 6 known as a Vogad (volume operated gain-adjusting device), of any of the well-known types, for example, such as disclosed in Hogg et al. Patent No. 1,853,974, Mitchell et al. Patent No. 2,019,577 or Wright et al. Patent No. 2,043,403, a delay circuit 7, a transmitting amplifier 8 and a privacy device 9.

The receiving circuit RC includes, in order, connected between the radio receiver 2 and the hybrid coil H, the band-pass filter 10, a privacy device 11, a receiving amplifier 12, a variable loss network shown within the dot-dash box 13, operating as a receiving singing suppressor, a manually variable loss pad 14 and a fixed loss (2 decibels) pad 15.

Connected across transmitting circuit TC at a point between the Vogad 6 and the delay circuit 7 is the input of a transmitting switching circuit 16 comprising an amplifier-detector 17, and the tone control relay 18 and the receiving disabler relay 19 connected in parallel across its output. Connected across the receiving circuit RC at a point between the radio receiver 2 and the band-pass filter 10 is the input of a receiving switching circuit 20 comprising the band-pass filter 21, the amplifier-detector 22, and the singing suppressor relay 23 and the echo suppressor relay 24 connected in series across the output of the amplifier-detector 22.

A source 25 of control or tone energy of substantially constant frequency, preferably above the voice signal frequency range and which may be the same or different frequencies for the tone sources at the two terminals of the system, is adapted to be connected by operation of the tone control relay 18 under control of amplifier-detector 17 in the transmitting switching circuit 16, through the hybrid coil H₁ and associated balancing network N₁ across the circuit TC at a point between the radio transmitter 1 and the privacy device 9. When relay 18 operates, the tone energy from the source 25 passes over the circuit TC to the input of the radio transmitter 1. Operation of the receiving disabler relay 19 under the control of the amplifier-detector 17, with a delay of T with respect to relay 18, will cause the receiving switch circuit 20 to be disabled at a point between the output of the amplifier-detector 22 and the relays 23 and 24.

Operation of the singing suppressor relay 23 under control of the amplifier-detector 22 in the receiving switching circuit 20 will cause the loss inserted by the receiving singing suppressor device 13 in the circuit RC to be removed in a manner which will be described later, and operation of the echo suppressor relay 24 under control of the amplifier-detector 22 will cause the transmitting circuit TC to be disabled at a point between the loss pad 5 and the Vogad 6, so as to suppress echoes in the latter circuit, and to effectively disable the Vogad 6 and the transmitting switching circuit 16.

The band-pass filter 10 in the receiving circuit RC is adapted to pass frequencies within the range of the voice signals received from the radio receiver 2, and to suppress received waves of the frequency assigned to the tone source at the distant terminal, whereas the band-pass filter 21 in the receiving switching circuit 20 is arranged to transmit waves of the frequency assigned to the tone source at the distant terminal while suppressing waves of frequency within the voice signal frequency range.

The singing suppressor device 13 includes two repeating coils 25 and 26 connected in tandem in the receiving circuit RC, a rheostat 27 normally connected in shunt with the receiving circuit RC between the two repeating coils through the normally closed contacts of relay 23. The resistance element of rheostat 27 shunted by a series copper-oxide rectifier string 28, is connected in series in the plate-cathode circuit 20 of the Vogad 6 in the transmitting circuit TC, so that the shunt loss inserted in the receiving circuit RC by the singing suppressor device 13 depends upon the plate current of the Vogad.

When the terminal is set up for "via" calls, the relay 30 is operated to shunt a portion of the resistance element of rheostat 27 by a small resistance 29 through the contacts of that relay, in order to reduce the shunt resistance across the circuit RC and thus increase the loss of the singing suppressor device 13 by a sufficient amount to preserve the stability of the "via" connection.

The (6-decibel) fixed resistance loss pad 5 and the (2-decibel) fixed resistance loss pad 15 which remain in the transmitting circuit TC and the receiving circuit RC, respectively, for terminal calls, are adapted to be switched out of these circuits by operation of the relays 31 and 32, respectively, in the case of "via" calls. The windings of relays 31 and 32 are energized in series with the winding of the relay 30 from battery 33 when a two-wire line section is connected by the plug and jack 4 to the terminal to set up a via circuit, so that the two loss pads are removed from the four-wire terminal circuit simultaneously with the increase in the loss of the singing suppressor device 13.

The operation of a two-way radio telephone system as shown in Fig. 1 employing a circuit, such as illustrated in Fig. 2, at each terminal will now be described.

It will be assumed that the circuits at both of the two terminal stations have been set up for via calls, so that at both stations the loss pads 5 and 15 have been removed respectively from the input of the transmitting circuit TC and the output of the receiving circuit RC at each terminal, and the receiving singing suppressor 13 in the receiving circuit RC has been operated to the loss condition required for such calls in the manner described above.

The adjustable arm of the rheostat 27 is initially adjusted to determine the amount of the singing suppressor loss to be used, this adjustment depending upon the received noise. For example, with a certain received noise it will be determined that a given adjustment of the rheostat 27 will produce sufficient suppression loss so that, for a minimum return loss to be expected and low Vogad gain, echo operation of the transmitting amplifier-detector 17 will not occur nor will round trip singing occur or be within 10 decibels of occurring, assuming similar adjustments at the distant terminal. This is the mini-

imum singing suppressor loss, as the amount of this loss when signals are being transmitted from the terminal will vary with the Vogad gain in a manner which will be described.

Now, if the subscriber associated with the two-way line connected to the west end of the terminal shown in Fig. 2 speaks, assuming there is no incoming speech wave present in the receiving circuit RC, his voice currents impressed on the input of the transmitting circuit TC will be transmitted thereover to the input of the Vogad 6 which regulates these voice currents to give the desired constant volume in its output, by adjusting its gain.

An indication of the adjustment of the Vogad gain is given from the value of the plate current flowing in the vario-repeater thereof, the higher this gain the larger this plate current. Now, if the level of the voice currents applied to the input of the Vogad are such as to increase the gain thereof above that value which will require the minimum singing suppressor loss for which the singing suppressor 13 in the receiving circuit RC has been initially adjusted as described above, the plate current flowing through the copper-oxide rectifier string 28 of the device 13 will increase and will reduce the rectifier resistance as the current increases. As this rectifier resistance shunts the resistance element of rheostat 27, and thus the resistance 29 connected across a part of the former resistance, the value of the resistance shunting the circuit RC is reduced and the singing suppressor loss therefore is increased in proportion to the increase in gain of the Vogad.

The voice currents of regulated volume in the output of the Vogad 6 are divided between the input of the delay circuit 7 in the main transmission path TC and the input of the transmitting switching circuit 16. Although the primary function of the Vogad 6 is to deliver a constant signal volume to the radio transmitter 1, it has a secondary function which is to effectively vary the sensitivity of the transmitting Vodas circuit 16 to compensate for the varying signal input to that device with strong and weak talkers.

The voice currents diverted into the switching circuit 16 will be amplified and rectified by the amplifier-detector 17 to cause the operation of the switching relays 18 and 19, the latter relay with a delay time of T with respect to relay 18, where T is substantially equal to the one-way transmission time between the two terminal stations. Relay 18 will operate to connect the source 25 of tone waves to the transmitting circuit through the hybrid coil H₁, and the tone waves from that source will pass over the output of the circuit TC to the radio transmitter 1 which radiates the tone to the distant terminal. The speech waves meanwhile will pass through the delay circuit 7, amplifier 8, the privacy device 9 and the hybrid coil H₁ to the radio transmitter 1 and will also be radiated thereby.

Operation of the switching relay 19 at a time T after relay 18 operates, causes the tone-operated receiving circuit 20 at the same terminal to be disabled in its output thus preventing subsequent operation of that switching circuit only after the tone waves transmitted to the distant terminal have seized control of the switching circuits at the distant terminal.

The operation of the distant terminal (not shown) in response to the received tone and voice waves, will be explained by referring to the apparatus at that terminal by the same reference numbers as the similar apparatus at the local terminal but followed by a prime (') mark.

The tone waves received by the radio receiver 2' will be detected therein and transmitted over the receiving circuit RC'. The band-pass filter 10' in the receiving circuit RC' will suppress the tone frequency, but it will be selected by the parallel band-pass filter 21' in the receiving switching circuit 20' and will cause operation of the amplifier-detector 22' to energize the winding of relays 23' and 24' connected to its output. The operation of the relay 24' will disable the transmitting circuit TC' at the receiving terminal in front of the Vogad 6', and the simultaneous operation of the switching relay 23' will break the shunt connection across the receiving circuit RC' between the repeating coils 25' and 26' through the resistance 29' and a part of rheostat resistance 27' in parallel, thereby removing the loss normally produced in the receiving circuit RC' by the singing suppressor device 13'.

When the voice signals reach the receiving terminal, they will be picked up and detected by the radio receiver 2' and transmitted through the receiving circuit RC'. The received voice waves will be passed by the band-pass filter 10', and then will proceed through the privacy device 11', the amplifier 12', the receiving singing suppressor device 13', receiving loss control pad 14' and the hybrid coil H' over the associated two-wire line to the listening subscriber. The receiving singing suppressor device 13' provides little or no loss to the transmission of the received voice currents due to its previous operation by the received control tone wave as described above to the low loss condition. The volume sent out to the subscriber is adjusted manually by the manually variable loss pad 14' to a value considered best for intelligibility with the noise or static conditions prevailing. This volume is maintained the same for all connections in this control current operation for a given noise condition.

When the subscriber associated with the transmitting terminal of the system ceases talking the transmitting amplifier-detector 17 releases to release first the switching relay 18 and at a time T+.05 second thereafter relay 19 in its output, disconnecting the tone source 25 from the transmitting circuit TC and removing the disability in the output of the tone-operated receiving control circuit 20, thereby returning the switching circuits at the transmitting terminal to the position indicated in Fig. 2. When the reception of control tone ceases at the receiving terminal, the switching relays 24' and 23' in the tone-operated receiving circuit 20' release after a predetermined hang-over period to be discussed below to remove the disability in front of the Vogad 6' in the transmitting circuit TC' and to reconnect the shunt circuit through a portion of the potentiometer resistance 27' and resistance 29' in parallel across the receiving circuit RC' to provide a singing suppressor loss in that circuit the value of which depends on the initial adjustment of the singing suppressor device 13' and the gain setting at which the Vogad remains.

As explained below, the operate and release or hang-over times of the switching relays at the transmitting and receiving terminals in the system described above in accordance with the invention are selected so as to assure optimum conditions for breaking and minimum lockout.

The method of securing optimum breaking time, that is, the shortest time that one speaker must pause to permit the other talker to reverse the circuit, is as follows:

As the transmitting circuit TC, TC' at each of the two terminals is normally enabled, there is no possibility of speech signal "clipping" occurring in the transmitting branch in consequence of operation of the transmitting amplifier-detector. Thus, there is no requirement for appreciably long hang-over on the tone control relay 18, 18' to prevent speech mutilation. The tone control relay, therefore, is provided with a relatively short hang-over (0.06 second, for example) so that it will tend to follow the voice waves closely in on-off operation, that is, it will operate and release rapidly with the rise and fall of the voice amplitudes. With the tone following speech control closely, the tone-operated switching circuit at the receiving end, may be given an appreciable hang-over, (say approximately 0.05 second) without making the system have an appreciably longer breaking time than present Vodas switching circuits employing a normally disabled transmitting circuit and employing the voice waves themselves for controlling the switching operations. The hang-over is added at the contacts of the switching relays in the switching circuit, and thus permits the advantage of a hang-over there without the disadvantage of long hang-over and slow breaking which results if there is hang-over at both transmitting and receiving points. A hang-over at the receiving point has the advantage that it permits a lower sensitivity without clipping occurring in the middle of phrases, and therefore there is less possibility of false operation from noise.

Preferably, the same hang-over (.05 second) should be added to the echo suppressor relay 24 or 24', controlled by the tone-operated receiving switching circuit, plus an additional hang-over of, say 0.02 second, when the system is being used for via calls, to suppress static echoes which follow cessation of speech signals and which may be delayed by the connected two-way line. This additional hang-over may be required only for the higher noise conditions.

Transmission lock-out time, that is, the time interval during which the parties associated with the two terminals of the system may each secure control of his own terminal but not of the distant terminal if they both start talking, normally a time interval equal to the transmission time T over the radio link plus relay operating time, may be reduced in the following manner.

The operation of the receiving disabler relay 19, 19' at the transmitting station is preferably delayed after operation of the tone control relay 18, 18' at the same terminal, for a time interval T where T is equal to the transmission time of the tone over the system from the transmitting terminal to the distant terminal. This may be obtained by suitable design of that relay or of that relay and of a chain of associated relays (not shown) by any of the well-known means to make the disabling relay slow-operating to the required degree. In a typical transoceanic radio telephone system, the time required for the tone transmitted from one terminal to complete operation of the singing suppressor relay 23, 23' and the receiving echo suppressor relay 24, 24' after arrival at the receiving terminal would be in the neighborhood of about 0.005 second, so that with delayed operation each of relays 19, 19' a talker secures control of his own terminal only .005 second before he secures control of the distant terminal. There would thus be only a period of about .005 second in which

lockout may occur. Lock-out time may be reduced to zero by further delaying the operation of the receiving disabler relay, but the advantage of doing this is doubtful. Singing may not occur because the local signal receiving circuit which is normally disabled will be prevented from becoming enabled before the distant signal receiving circuit is enabled.

To reduce the possible disturbance due to false operation of the receiving amplifier-detector by static, because of the lag in the operation of the receiving disabler relay 19, 19', it may be desirable to give the receiving disabler relay a hang-over beyond the release of the tone control relay 18, 18' (say T+.05 second). Although the lock-out condition would not be changed by such a design, some advantage in two-way operation will be secured by this in preventing any false operation of the receiving echo suppressor relay 24, 24' during this period in which a signal cannot reach the amplifier-detector from the distant terminal.

Figs. 3 and 4 placed side by side with Fig. 3 at the left show schematically a two-way radio telephone terminal embodying a modified form of the invention suitable for a radio-telephone circuit in which the same radio frequency is used in the two directions.

Referring to Figs. 3 and 4 it will be seen that, as in the system of Fig. 2, this terminal includes a transmitting circuit TC leading to a radio transmitter 1 and a receiving circuit RC leading from a radio receiver 2, having their respective input and output coupled in substantially conjugate relation with each other and in energy transmitting relation with a two-wire line section TL by the hybrid coil H and associated balancing network N. The transmitting circuit TC includes, in order, connected between the hybrid coil H and the radio transmitter 1, the one-way amplifier 35, the Vogad 36, the delay circuit 37, the one-way amplifier 38, the two-way or bilateral privacy device 39 and the band-pass filter 40, and the receiving circuit RC includes, in order, connected between the radio receiver 2 and the hybrid coil H, the band-pass filter 41, the bilateral privacy device 39 and the one-way amplifier 42.

The two-way or bilateral privacy device 39, which may be of the type disclosed in Fletcher Patent No. 1,573,929, issued February 23, 1926 or in Dickieson Patent No. 2,132,205 issued October 4, 1938, is coupled in common to the transmitting circuit TC and the receiving circuit RC by hybrid coils H₂ and H₃ and associated balancing networks N₂ and N₃, so as to allow the use of the same privacy device for both directions of transmission, while maintaining a conjugate relation between the other portions of the circuits TC and RC.

The transmitting circuit TC is normally enabled, but the receiving circuit RC is normally disabled at a point 43 near its input between band-pass filter 41 and hybrid coil H₃, and at a point 44 near its output between hybrid coil H₂ and amplifier 42.

A source 45 of control waves or tone of substantially constant frequency *f* which is preferably outside the voice frequency range and is a different frequency for the tone generators at the two terminals of the system, when the same carrier frequency is used for transmission in the two directions, is adapted to be connected through a band-pass filter 46 passing the tone frequency, to the circuit TC at a point between band-pass

filter 40 and radio transmitter 1 by operation of the tone control relay 47. The band-pass filter 40 is designed to suppress the tone f , and to pass waves of frequencies within the voice signal frequency range.

The tone control relay 47 is adapted to be operatively energized either by the output currents of the amplifier-detector 48 or of amplifier-detector 49, which have their outputs connected in parallel to the winding of that relay and their inputs respectively connected through circuits 50 and 51 to the transmitting circuit TC on the input and output side of delay circuit 37. The input circuit 50 to amplifier-detector 48 includes a manually variable resistance pad 52 and a removable fixed resistance pad 53, and the input circuit 51 to amplifier-detector 49 includes a manually variable resistance pad 54 and a removable fixed resistance pad 55.

Connected across the circuit TC at a point between the output of the Vogad 36 and the delay circuit 37 is the input of a circuit, preferably including in common with the circuit 50 the variable resistance pad 52, comprising the "syllabic" control device 56, and the electromagnetic relays 57 and 58 adapted to be operatively energized in parallel from the output of the device 56 when it is operated, to respectively remove the loss pad 53 from the input circuit 50 to the amplifier-detector 48 and to remove the loss pad 55 from the input circuit 51 to amplifier-detector 49.

The "syllabic" control device 56 may be any device adapted to operate in response to signals applied to its input having the syllabic characteristic of speech signals, and to be substantially unresponsive to comparatively steady noise waves, due to room and circuit noise. Such a device may consist of an amplifier-detector circuit tuned to a frequency within the speech frequency range, for example, 1,000 cycles, followed by a filter or tuned circuit adapted to selectively transmit the syllabic frequencies of speech, for example, a low-pass filter having a cut-off at about 22 cycles per second. This circuit preferably would have a high impedance input so that it will insert little loss in the transmission circuit across which it is bridged. Suitable circuits of this type are disclosed, for example, in Nyquist Patent No. 1,749,811, Mathes 1,892,284, Bjornson 1,859,019, Fisher 2,026,305 and Dickieson 2,132,205.

Connected across the receiving circuit RC at a point between the radio receiver 2 and the band-pass filter 41, which filter is adapted to suppress waves of the frequency of the tone transmitted from the distant station while transmitting waves of frequencies within the voice signal band, is the input of a tone-operated switching circuit 59. This switching circuit includes a band-pass filter 60 in its input to select the tone waves received from the distant terminal while suppressing the voice frequency signaling band, a variable resistance loss pad 61, an amplifier-detector 62 and the electromagnetic switching relays 63, 64, 65 and 66 adapted to be energized in series from the output of amplifier-detector 62. The singing suppressor relays 63 and 64, when energized, operate to remove the normal disabilities from the circuit RC at the points 43 and 44, respectively. The echo suppressor relays 65 and 66 when energized operate to disable the transmitting circuit respectively at a point 67 between the output of amplifier 35 and the input to the Vogad 36 and at a point 68 between the hybrid coil H_3 and the band-pass filter 40.

Operation of amplifier-detector 48 or amplifier-detector 49 in the transmitting switching circuit in response to signals applied to their respective inputs will operatively energize the receiving disabler relay 69 in parallel with the tone-control relay 47, but operation of the former relay is delayed with respect to that of the tone-control relay 47 for a time T substantially equal to the transmission time of the tone waves between the two terminal stations of the system, by any suitable delay means 70, which may be, for example, a slow-operating relay circuit.

As explained below in connection with the description of operation of a two-way system employing the circuit as shown on Figs. 3 and 4 at each terminal station, the operate and release or hang-over times of the switching relays at the two stations are selected in accordance with the invention to secure very small lock-out time and optimum breaking conditions while taking advantage of hang-over at the receiving station to aid in control tone operation through fading.

Now, if the telephone subscriber associated with the two-way line TL connected to the west end of the terminal station shown in Figs. 3 and 4, speaks, assuming there are no incoming speech waves present in the receiving circuit RC of the terminal, his (west's) voice currents will be impressed by the hybrid coil H on the input of the transmitting circuit TC and will be amplified by amplifier 35 and pass into the Vogad 36. The Vogad 36 will adjust its gain in accordance with the level of the applied waves so as to produce the desired constant volume for the waves in its output, which will be divided between the delay circuit 37 in the main signaling circuit and the common input 50 to the syllabic device 56 and the amplifier-detector 48.

The value of the removable loss pads 53 and 55 in the respective inputs to the amplifier-detectors 48 and 49 are selected such that with no speech waves being transmitted, the sensitivities of these amplifier-detectors are effectively reduced so that they cannot be falsely operated by noise of the maximum amplitude which might be expected to be received from the circuit TC. This value would be in the order of 8-10 decibels. Echoes of signals received in the receiving circuit RC cannot cause false operation of the syllabic device 56, because such received signals, or rather the preceding tone waves, will have previously operated the receiving control circuit 59 and thus relay 65 to block the circuit TC at a point 67 in front of the syllabic device. The sensitivities of the transmitting amplifier-detectors 48, 49 with the removable loss pads 53 and 55 removed from their inputs are initially made approximately the same by adjustment of the manually variable loss pads 52, 54 with respect to incoming energy, the sensitivity of the receiving amplifier-detector 62 in receiver control circuit 59 being set by adjustment of loss pad 61 so that it will not be falsely operated by incoming static or line noise in the absence of speech transmission.

Part of the voice energy in front of the delay circuit 37 will pass into circuit 50 and will cause the syllabic device 56 to be operated to energize the relays 57 and 58 in its output. Relay 57 is designed to be quick-operating, for example, to operate in 0.03 second, but the operating time of relay 58 is made somewhat longer, the slight delay in operation providing some noise protection. Relay 57 is designed to have a small hang-over

time somewhat longer than the operate time, say 0.06 second, and the hang-over time of relay 58 is preferably made slightly longer than that of relay 57, being for example, about 0.09 second.

5 Relays 57 and 58 will operate quickly to respectively short-circuit the loss pad 53 in the input of amplifier-detector 48 and to short-circuit the loss pad 55 in the input of amplifier-detector 49 thereby effectively increasing the sensitivities of these amplifier-detectors by, say, 10
10 decibels, the sensitivity increase of the amplifier-detector 49 because of the longer operating time of relay 58 becoming effective about the time the voice waves reach the output of delay circuit 37. The amplifier-detectors 48 and 49 are
15 now in condition to operate relay 47 quickly by impressed speech waves, and hold it operated longer as these waves decay, there being a hang-over of respectively 0.06 second and 0.09 second
20 following the release of the syllabic device 56 on this sensitivity increase. Release of relays 57 and 58 by reducing sensitivity of amplifier-detectors 48 and 49 prevents their continued operation on line noise.

25 The voice waves impressed on the amplifier-detector 48 through circuit 59 will cause its immediate operation to quickly operate the tone control relay 47 in its output and start the energization of the delayed-operating receiving disabler relay 69 through delay circuit 70. The
30 voice currents in the signaling path meanwhile are being delayed in the delay circuit 37, so that the operation of amplifier-detector 49 in response to the voice currents through circuit 51, though its sensitivity has been increased, is
35 delayed with respect to that of amplifier-detector 48 for a time equal to the time of transmission through delay circuit 37, which is determined as the time necessary to reduce to a tolerable amount the clipping in the speech transmission
40 of an average telephone subscriber.

The tone control relay 47 is designed to be quick-operating and to have no hang-over in operation itself so that with the increased sensitivities of the two amplifier-detectors 48, 49
45 the relay in its on and off operation will follow the voice waves closely, giving a short hang-over following the passage of the voice wave through the delay circuit 37, but not dropping out too frequently during continuous transmission of
50 speech because of the somewhat tandem action of the two amplifier-detectors. Thus, the tone energy from source 45 under control of relay 47 will be applied over the transmitting circuit TC to the radio transmitter, and removed therefrom
55 simultaneously with the rise and fall of the speech energy in the circuit.

The speech currents in the output of delay circuit 37 will pass through amplifier 38, hybrid
60 coil H₂, bilateral privacy 39, hybrid coil H₃ and band-pass filter 40 to the radio transmitter 1 and will be radiated thereby, as will be the preceding tone f₁.

The operation of the distant terminal (not shown) in response to the received tone and
65 speech signals will be explained by referring to the apparatus at that terminal by the same reference numbers as the similar apparatus at the local terminal (Figs. 3 and 4), but followed by a prime (') mark.

70 The tone waves f₁ received by the radio receiver 2' will be detected therein and transmitted over the receiving circuit RC'. The band-pass filter 41' will suppress the tone waves from that circuit,
75 but they will be selected by the parallel band-pass

60' in the receiving control circuit 59' and will pass through resistance pad 61' to the amplifier-detector 62' causing its operation to energize the windings of relays 63', 64', 65' and 66' in its output. The singing suppressor relays 63' and 64'
5 will then operate to remove the normal disabilities at the points 43' and 44' in the receiving circuit RC', and the echo suppressor relays 65' and 66' will substantially simultaneously operate to disable the transmitting circuit at the points 67' and
10 68'.

With the tone following speech control closely, the tone-operated control circuit 59' at the receiving terminal may be given an appreciable hang-over in operation, say 0.05 second, without
15 making the system have an appreciably longer breaking time than present Vodas circuits employing appreciable hang-over at both terminals. This hang-over may be applied readily by making the singing suppressor relays 63' and 64' and the
20 echo suppressor relays slow-releasing to the required degree.

In order that lock-out time may be reduced in a system employing, at each terminal, circuits as
25 shown in Figs. 3 and 4, the operation of the receiving disabler relay 69 at the transmitting end in response to the transmitted voice currents is delayed with respect to that of the control tone relay 47 for a time interval T substantially equal
30 to the one-way transmission time between the terminal stations, or more exactly for a time equal to that required for the tone from the transmitting terminal to pass from the contacts of the tone relay 47 to the tone-operated amplifier-
35 detector 62' at the receiving terminal station. For the reasons given above in connection with Fig. 2, this will limit the lock-out period to a small value, say, in the order of 5 milliseconds for a typical system. Singing may not occur because
40 the local receiving circuit RC is in its normally disabled condition, and will be prevented from becoming enabled due to the delayed operation of relay 69 before the distant receiving circuit RC' is enabled.

As in the case of the system shown in Fig. 2,
45 the receiving disabler relay (69, 69') at the terminal stations is preferably given a hang-over in operation beyond the release of the tone control relay (47, 47') slightly more than T, say, T + .05 second, to reduce the effect of possible false operation
50 of the tone-operated amplifier detector.

When the voice signals reach the receiving terminal they will be picked up and detected in the
55 radio receiver 2' and then transmitted over the receiving circuit through band-pass filter 41', bilateral privacy 39, amplifier 42', hybrid coil H' and telephone line TL' to the listening subscriber, the receiving circuit RC' having been previously enabled at the points 43' and 44' by the tone waves
60 in the manner which has been described.

When the transmission of voice signals ceases at the transmitter station, the syllabic device 56 releases and causes, after the slight hang-over
65 period referred to above, the relays 57 and 58 to release to reinsert the loss pads 53 and 55 in the input of the amplifier-detectors 48 and 49 to reduce their sensitivities. The release of amplifier-detectors 48 and 49 with cessation in the applied
70 speech waves causes the tone control relay to immediately release to cut off the supply of control tone to the radio transmitter 1. The receiving disabler relay after the much longer hang-over interval referred to above releases to make the receiving control circuit 59' operative again. At the receiving terminal, the release of the am-
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plifier-detector 62' in the receiving control circuit 59' with cessation in the supply of control tone thereto will cause the release of relays 63', 64', 65' and 66' at the end of their hang-over periods specified above to return the transmitting circuit TC' to its normally operative condition and to redisable the receiving circuit RC' at the point 43' and 44'.

It is to be understood that the values specified above for the operate and release or hang-over times of the switching relays in the system of the invention described above are to be taken by way of example only and not as limiting the invention.

Various modifications of the circuit illustrated and described within the spirit and scope of the invention will be apparent to persons skilled in the art.

What is claimed is:

1. A two-way signal transmission system comprising terminal stations and a two-way signal transmission medium connecting said stations, each station including a normally enabled signal transmitting circuit, a signal receiving circuit, switching apparatus for rendering said receiving circuit operative and disabling said transmitting circuit to suppress echoes and prevent singing, selectively operated by distinctive control waves transmitted over said medium from the other terminal under control of the signals transmitted therefrom, and means for improving the operation of said switching apparatus comprising means for making the transmitted control waves follow the transmitted signals closely in on and off operation, and means providing the control wave-operated switching apparatus at the terminals with sufficient hang-over in operation to aid in the operation through fading of the control waves and to insure suppression of all signal echoes with cessation in the applied control waves.

2. A two-way signal transmission system comprising terminal stations and a two-way signal transmission medium connecting said stations, each station including a normally enabled signal transmitting circuit, a normally disabled signal receiving circuit, switching apparatus for rendering said receiving circuit operative and disabling said transmitting circuit to suppress echoes and prevent singing, selectively controlled by control waves of distinctive frequency transmitted over said medium from the other terminal in response to initiation of signal waves thereat for transmission, and means to reduce signal transmission lockout and clipping, and to facilitate breaking, comprising means at each terminal for making the transmitted control waves follow the transmitted signals closely in on and off operation, means providing said switching apparatus at each terminal with sufficient hang-over in operation to insure suppression of all signal echoes when the applied control wave energy falls off, and means at each terminal also responsive to the initiation of signal waves thereat to disable the control wave-operated switching apparatus at the terminal but with a time delay with respect to the transmission of the control waves substantially equal to the transmission time between the two terminals of the system, and to maintain the switching apparatus so disabled for a like time interval after the transmission of said control waves ceases.

3. In a two-way signal transmission system including two stations connected by a two-way transmission medium, a normally enabled signal transmitting circuit and a normally disabled signal receiving circuit at each station, control

means at one station responsive to the initiation of signals thereat for transmission for sending distinctive control waves out over said medium to condition the other station for signal receiving only, and responsive substantially immediately to cessation in the transmitted signals to stop the transmission of said control waves, and means to maintain said other station so conditioned for a sufficient time interval after cessation in the received control waves to suppress echoes of the received signals.

4. In a two-way signal transmission system including two stations connected by a two-way transmission medium, means at each station responsive to the initiation of signals thereat for transmission to the other station, to send out control waves of distinctive frequency differing for each station, over said medium to the other station, and responsive substantially immediately to cessation in transmitted signals to stop the transmission of said control waves, switching means at each station selectively responsive to received control waves to condition the station for signal receiving only, means at each station for maintaining the station so conditioned for a sufficient time interval after cessation in received control waves to suppress all echoes of the received signals, and other switching means at each station also responsive to the signals initiated thereat for transmission, but operative at a time after the control waves have been sent out from the station substantially equal to the transmission time between the stations, to disable the control wave-responsive switching means at the same station, and to maintain it disabled for a like time interval after control waves transmission from the station ceases.

5. A two-way signal transmission system comprising two stations and a two-way transmission medium connecting said stations, each station comprising a transmitting circuit which is enabled and a receiving circuit which is disabled in the absence of signal transmission between the stations, control means operatively responsive to the initiation of signals for transmission to send out control waves of distinctive frequency, differing for each station, over said medium to the other station, and responsive substantially immediately to cessation in the transmitted signals to stop the transmission of the control waves from the station, switching means selectively responsive to the received control waves to disable the transmitting circuit and render the receiving circuit of the station operative, and other switching means also operatively responsive to the signals initiated at the station for transmission but at a time after said control means operates substantially equal to the transmission time between said stations, to disable the selective switching means at the station, and to maintain said selective switching means disabled for an equivalent time interval after control wave transmission from the station ceases.

6. A two-way telephone transmission system comprising a two-way transmission medium connecting stations each including a normally enabled transmitting circuit, a normally disabled receiving circuit, control means responsive to initiation of telephone signals in said transmitting circuit to cause distinctive control waves to be sent out over said medium to the other station ahead of the signals, and responsive substantially immediately to any cessation in the transmitted signals to stop the transmission of said control waves, switching means selectively

responsive to the distinctive control waves received over said medium from said other station to disable said transmitting circuit, and to render said receiving circuit operative to receive the following signals, said switching means having an appreciable hang-over in operation so as to maintain the transmitting circuit disabled for a sufficient time to suppress all signal echoes when the applied control waves cease and other slow-operating and slow-releasing switching means also responsive to the signals initiated in said transmitting circuit to cause the disablement of the selective switching means at the station substantially at the time the control waves transmitted from the station initiate operation of the selective switching means at the other station.

7. The telephone transmission system of claim 6 in which said control means comprises a source of said distinctive control waves, a delay circuit in the transmitting circuit of the station, two wave-responsive devices connected to said transmitting circuit on either side of said delay circuit, the sensitivities of said wave-responsive devices being normally set so as to prevent their operation by a predetermined amount of circuit noise received from said transmitting circuit, a switching device responsive quickly to operation of either of said wave-responsive devices to connect said source to said medium, a syllabic device connected to said transmitting circuit, substantially unresponsive to noise but responsive to telephone signals transmitted over said circuit, to so increase the sensitivities of said wave-responsive devices as to enable their quick operation by the transmitted signals, said switching device having substantially no hang-over in operation so that it will release quickly to disconnect said source from said medium in response to the release of both wave-responsive devices when the applied signal input thereto ceases, the time delay of said delay circuit being determined by the tolerable clipping experienced in speech transmission of an average telephone subscriber.

8. A terminal station for a two-way signal transmission medium, comprising a normally en-

abled transmitting path including a Vogad, a normally disabled receiving path, switching means connected to the transmitting path and responsive to initiation of signals therein to cause distinctive control energy to be sent out over said medium in advance of the signals, the disablement of said receiving path being produced by a variable loss device therein whose loss is a function of the gain of the Vogad in the transmitting path, switching means connected to said receiving path in front of the disabling point therein, selectively responsive to distinctive control waves received from said medium to remove the disabling loss from the receiving path and to disable said transmitting path in front of said Vogad and said switching means connected to that path, and means responsive to operation of the latter switching means to disable the selective switching means connected to the receiving path.

9. In combination, a one-way telephone wave transmission path subject to interfering noise waves, a transmission delay circuit in said path, a separate wave-responsive device connected to said path on either side of said delay circuit, the sensitivity of each wave-responsive device being initially set so as to prevent operation of the device by noise waves impressed thereon from said path of a given maximum amplitude, a syllabic device connected to said path in front of said delay circuit, unresponsive to noise waves but adapted to be operated in response to the syllabic variations in applied telephone waves to increase the sensitivity of both of the wave-responsive devices to allow their quick operation in response to telephonic waves applied from each path, and a quick-operating, quick-releasing switching device operatively responsive to operation of either of said wave-responsive devices, the delay time selected for said delay circuit being determined by the clipping of the voice transmission of an average telephone subscriber.

CHARLES C. TAYLOR.