

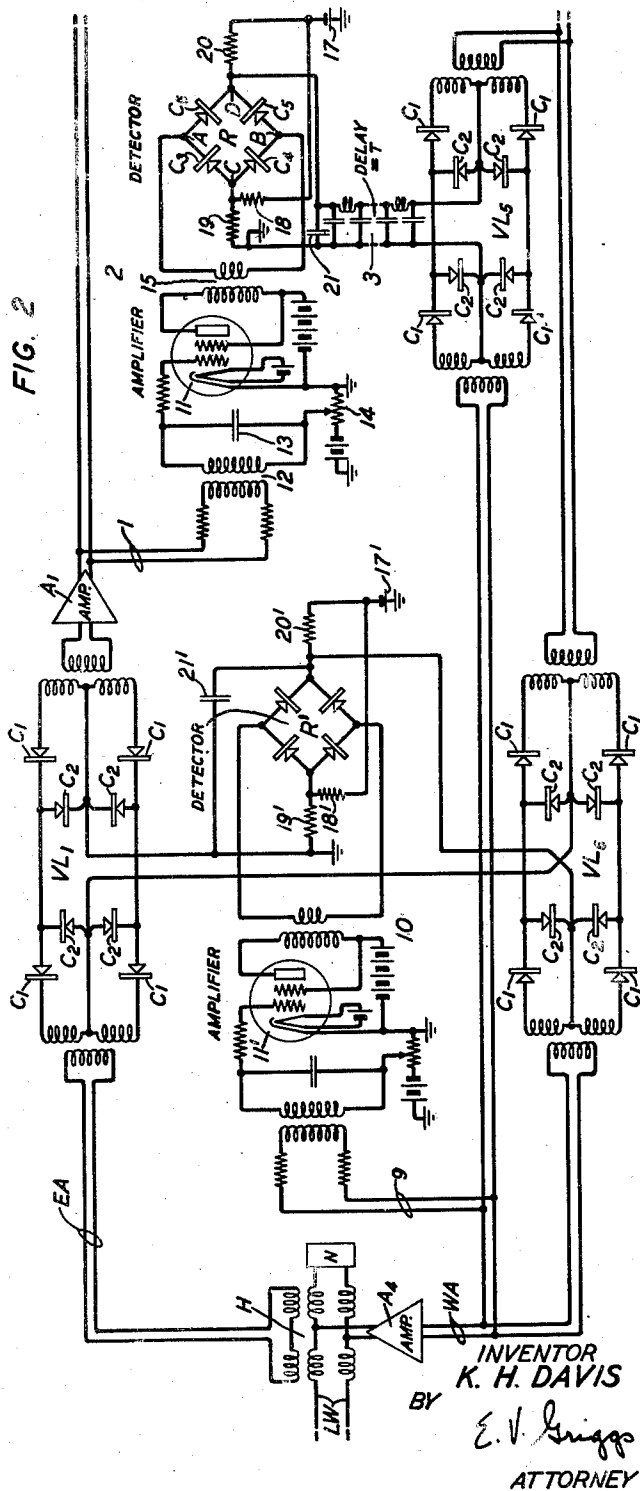
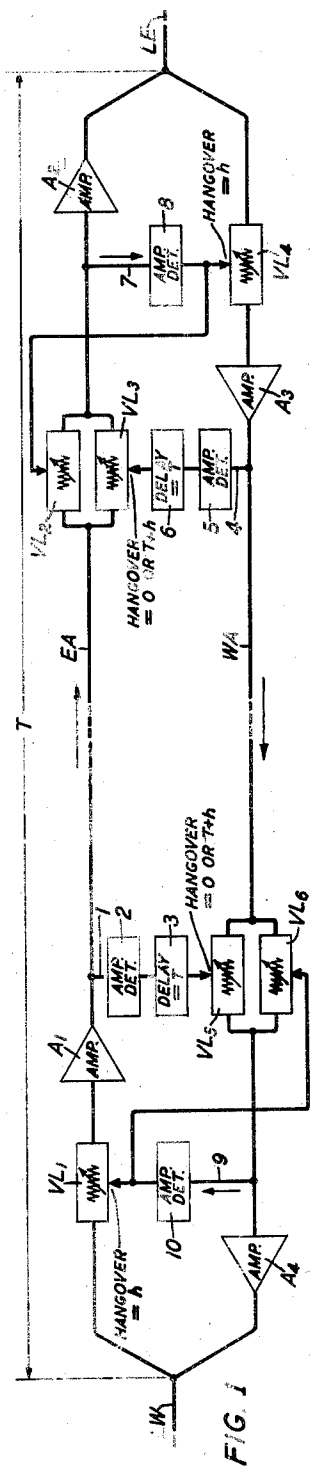
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CIRCUIT FOR CONTROLLING SIGNAL TRANSMISSION IN TWO-WAY SIGNALING SYSTEMS

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CIRCUIT FOR CONTROLLING SIGNAL
TRANSMISSION IN TWO-WAY SIGNAL-
ING SYSTEMS

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

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

To obtain proper operation of long two-way signaling systems, such as four-wire toll telephone systems, it has been found necessary in the past to make use of voice-operated switching apparatus, so-called echo suppressors or anti-singing devices, for effectively disabling the signal path for one direction when signal transmission is taking place over the path for the opposite direction, so as to prevent echoes or reflected current from being transmitted back to the transmitting end of the system and causing a disturbance or singing. The disabling apparatus usually comprises means, such as an amplifier-rectifier control circuit, connected to a two-wire path for each direction and responsive to signal transmission therein to insert a large loss in the signal transmission path for the opposite direction, or to disable the control circuit connected thereto, or to do both.

In certain systems of the prior art, the echo suppressor circuits are located at or near the terminals of the four-wire circuit, in which case they are called terminal echo suppressors. Terminal echo suppressors may be either of the transmitting terminal type or of the receiving terminal type. In the former type of terminal echo suppressor, the control unit at each terminal comprises a "suppressor" portion responsive to signals in the outgoing one-way path to disable the incoming one-way path at the terminal, and a "disabler" portion responsive to signals in the incoming one-way path to disable the "suppressor" portion. In the latter type of terminal echo suppressor, the control unit at each terminal comprises a "suppressor" portion responsive to signals in the incoming one-way path to disable the outgoing one-way path at the terminal, and a "disabler" portion responsive to signals in the outgoing one-way path to disable the "suppressor" portion.

In accordance with the present invention, a transmitting terminal echo suppressor unit and a receiving terminal echo suppressor unit are located at or near both terminals of the four-wire circuit. In one embodiment, the suppressor portion of each transmitting terminal echo suppressor unit, which disables the incoming path at the terminal, has a delay in operation sub-

stantially equal to the one-way transmission time over the four-wire circuit, and substantially zero hangover in operation on cessation in the supply of controlling energy, whereas the suppressor portion of the receiving terminal echo suppressor, which disables the outgoing path, is comparatively quick-operating and has a short hangover in operation. In an alternative arrangement the circuits are similar except that the suppressor portions of the two transmitting terminal echo suppressor units have a long hangover in operation substantially equal to the one-way transmission time over the four-wire circuit.

A feature of the invention is the use of a bypass type of echo suppressor disabler which insures continuity of input to the suppressor portion of the receiving terminal echo suppressor once it is operated. The circuits of the invention are an improvement over other types of terminal echo suppressors in that they provide minimum breaking time, reduce probability of complete or partial signal lock-out and prevent double talking echoes.

The objects and advantages of the circuits of the invention will be better understood from the following detailed description thereof when read in connection with the accompanying drawing in which:

Fig. 1 shows diagrammatically a four-wire toll telephone system equipped with voice-operated terminal echo suppressors in accordance with the invention; and

Fig. 2 shows schematically the construction of the echo suppressor circuits which may be used at each terminal of the system of Fig. 1, in accordance with a preferred form of the invention.

The diagram of Fig. 1 is not an actual circuit diagram, but rather a single line layout, each line indicating a transmission path. The boxes with the representation of a variable resistance therein, associated with the two sides of the four-wire circuit, represent variable attenuation networks, and an arrow pointing to one of these networks indicates that the amount of attenuation introduced by the network into the transmission path in which it is connected, will be varied by operation of the associated control device (amplifier-detector), represented by a box, in response to impressed signals.

The four-wire telephone circuit of Fig. 1 comprises a one-way transmission path EA including the one-way amplifying devices A₁ and A₂, for repeating telephonic signals between the west two-way line LW and the east two-way line LE, and a one-way transmission path WA including

the one-way amplifying devices A₃ and A₄, for repeating telephonic signals in the direction from east to west between the line LE and the line LW. The paths EA and WA may be connected at their terminals in substantially conjugate relation with each other and in energy transmitting relation with the lines LW and LE in any suitable manner, for example, by the use of hybrid coils and associated balancing networks (not shown).

A variable loss pad VL₁ is connected in the path EA near the west terminal of the four-wire circuit, and two variable loss pads VL₂ and VL₃ in parallel with each other, are connected in the path EA near the east terminal of the four-wire circuit. Similarly, a variable loss pad VL₄ is connected in the path WA near the east terminal of the four-wire circuit, and two variable loss pads VL₅ and VL₆ in parallel with each other, are connected in the path WA near the west terminal of the four-wire circuit. Each of the pads VL₁ and VL₃ normally provides a low transmission loss in series with the path EA, whereas the variable loss pad VL₂ normally provides a large transmission loss in series with that path. Similarly, the variable loss pads VL₄ and VL₅ normally provide a low transmission loss in series with the path WA, whereas the variable loss pad VL₆ normally provides a large transmission loss in series with the latter path.

Connected across the path EA near the west terminal of the four-wire circuit at a point beyond the output of the loss pad VL₁ is the input of the suppressor portion 1 of a transmitting terminal echo suppressor unit, including a wave-operated control device (amplifier-detector) 2, which is adapted to be operated in response to impressed signal waves received from the path EA in any suitable manner to adjust the variable loss pad VL₅ in the path WA, to change it from the normal low loss condition to a large loss condition. The suppressor circuit 1 is also arranged by any suitable means, for example, by the insertion of a transmission delay circuit 3 therein, as indicated, to delay the adjustment of the pad VL₅ an interval of time T after the signal waves from the path EA are impressed upon the control device 2, where T is equal to the one-way transmission time over the four-wire circuit between terminals.

Similarly, connected across the path WA at a point near the east terminal of the four-wire circuit but beyond the output of the variable loss pad VL₄ therein, is the input of the suppressor portion 4 of another transmitting terminal echo suppressor unit including the control device (amplifier-detector) 5 adapted to operate in response to signal waves impressed on its input from the path WA to adjust the loss pad VL₃ in the path EA from its normal low loss condition to a large loss condition. The adjustment of the pad VL₃ to the latter condition is also delayed for a time interval T after the signal waves are first impressed upon the control device 5, by any suitable means, for example, by the transmission delay circuit 6.

Connected across the path EA near the east terminal of the four-wire circuit and on the output side of the loss pads VL₂ and VL₃ is the input of the suppressor portion 7 of a receiving terminal echo suppressor unit, including the wave-operated control device (amplifier-detector) 8, which is arranged to respond to impressed signal waves from the path EA to adjust the variable loss pad VL₄ in the path WA from the normal low loss condition to the large loss condition, and simultaneously to adjust the variable loss pad VL₂ in

parallel with the pad VL₃ in the path EA from a normal large loss condition to the low loss condition.

Similarly, connected across the path WA at a point near the west terminal of the four-wire circuit and beyond the output side of the parallel variable loss pads VL₅ and VL₆ in that path is the input of the suppressor portion 9 of another receiving terminal echo suppressor unit including the wave-operated control device (amplifier-detector) 10, adapted to be operated in response to impressed signal waves from the path WA to adjust the variable loss pad VL₁ in path EA from its normal low loss condition to a large loss condition, and simultaneously to adjust the variable loss pad VL₆ in parallel with the pad VL₅ in the path WA, from the normal large loss condition to the low loss condition. The circuits 7 and 9 are arranged to operate quickly to adjust the loss pads controlled thereby, in comparison to the operation of the circuits 1 and 4 to adjust the associated loss pads, as indicated by the absence of delay circuits in the former circuits.

The suppressor portion 9 of the receiving terminal echo suppressor unit at the west terminal of the four-wire circuit serves also as the disabler portion of the transmitting terminal echo suppressor unit thereat, for the operation of the former to adjust pad VL₁ to insert a large loss in the input of the path EA effectively blocks the input to circuit 1 of the latter echo suppressor unit. Similarly, the suppressor portion 7 of the receiving terminal echo suppressor unit at the east terminal serves as the disabler portion of the transmitting terminal suppressor unit thereat, for operation of the former to adjust the pad VL₄ to insert a large loss in the input of the pad WA effectively blocks the input to the circuit 4 of the latter suppressor unit.

The suppressor portion 1 of the transmitting terminal suppressor at the west terminal serves as the disabler portion of the receiving terminal suppressor unit thereat, for the operation of the former to adjust the pad VL₅ to produce a large loss in the path WA in front of the point of connection of the circuit 9 of the latter echo suppressor unit thereto effectively blocks the input to circuit 9 when the pad VL₆ is in the large loss condition. Similarly, the suppressor portion 4 of the transmitting terminal echo suppressor unit at the east terminal of the four-wire circuit serves as the disabler portion of the receiving terminal echo suppressor unit thereat, for operation of the former to adjust the pad VL₃ to insert a large loss in the path EA in front of the point of connection of the suppressor portion 7 of the latter echo suppressor unit effectively blocks the input thereto when the pad VL₂ is in the large loss condition.

The operation of control circuit 9 or 7 in response to impressed signals, provides a low loss by-pass (through pad VL₆) around pad VL₅, and provides a low loss by-pass (through pad VL₂) around pad VL₃, respectively, and prevents subsequent false operation of circuit 1 from blocking path WA through pad VL₅, or subsequent false operation of circuit 4 from blocking path EA through pad VL₃.

Other details of the construction of the terminal echo suppressor circuits associated with the four-wire toll telephone circuit in the system of Fig. 1 will be clear from the following description of operation.

It will be first assumed that a subscriber associated with the two-way line LE at the east end

of the four-wire circuit starts to talk, and at that time the subscriber associated with the two-way line LW at the west end of the four-wire circuit is silent. The east subscriber's speech currents from the line LE will be impressed on the east to west repeating path WA at the east fork of the four-wire circuit, and will be transmitted thereover. East's speech waves in the path WA will be transmitted through the loss pad VL₄ with little attenuation because the latter pad is in its normal low loss condition, and will be amplified by the amplifying device A₃ at the east terminal.

A portion of the amplified waves in the output of the amplifying device A₃ will enter circuit 4 of the transmitting terminal echo suppressor at the east terminal and will cause operation of the control device 5 therein after a delay of T provided by delay circuit 6, to adjust the loss pad VL₃ in the path EA from the normal low loss to the large loss condition. Meanwhile, the main portion of east's speech waves will be transmitted from the output of amplifier A₃ out over the path WA to the west terminal of the four-wire circuit.

At the west terminal, east's speech waves will be impressed on the loss pads VL₅ and VL₆ in parallel. The pad VL₆ is in its normal large loss condition, but the pad, VL₅, if the west subscriber associated with the line LW has not spoken for a time T preceding this, will be in its normal low loss condition, and east's speech waves will be transmitted through the latter pad with little attenuation. The main portion of east's speech currents in the output of the pad VL₅ will be amplified by the amplifying device A₄ and the amplified waves impressed on the line LW over which it will be transmitted to the west subscriber.

A portion of east's speech waves transmitted through the pad VL₅, however, will be diverted into the suppressor portion 9 of the receiving terminal echo suppressor unit at the west terminal of the four-wire circuit, and will cause operation of control device 10 to immediately adjust the pad VL₁ in the input of the path EA from the normal low loss condition to the large loss condition effectively blocking the input of path EA and simultaneously to adjust the loss pad VL₂ in the path WA to change it from the normal large loss condition to the low loss condition. The advantage of the latter action will be discussed later.

Part of east's speech energy impressed on the line LW from the path WA is returned from the line LW and is transmitted through the west fork of the four-wire circuit to the input of the path EA in the form of an echo. It is assumed that the usual hybrid coil arrangement is used at the west fork, as well as at the east fork, of the four-wire circuit, although not shown in this particular diagrammatic illustration. If the pad VL₁ under control of the east subscriber's speech currents through the control device 10 is not adjusted fast enough to the high loss condition, a part of the echo transmitted into the path EA, due to east's first word or syllable, will pass through the pad VL₁ without appreciable attenuation. This unsuppressed portion of the first part of a word has been called "pre-echo". The echo due to the later parts of the word or syllable will be suppressed by the pad VL₁ for its adjustment to the large loss condition will, by the time the echo reaches VL₁, have been completed. By suitable adjustment of the control circuit 10 or its associated apparatus the suppressor portion 9 of the receiving terminal echo

suppressor is made to have a small hangover h in operation sufficiently long to insure that the echoes due to the weak endings of each word will be suppressed by pad VL₁.

The pre-echo transmitted through the pad VL₁ will be amplified by the amplifying device A₁ and the amplified echo divided between the outgoing portion of the line EA and the input of the suppressor portion 1 of the transmitting terminal echo suppressor at the west terminal. The portion of the pre-echo transmitted into the circuit 1, if it is strong enough, will cause operation of the control device 2 and after a delay of T provided by the delay circuit 3 will tend to cause the adjustment of the pad VL₅ to the high loss condition, but this adjustment will be only momentary inasmuch as the following portion of the echo, due to the high loss it encounters in the then adjusted pad VL₁, will be of too low level to hold the control device 2 operated.

The other portion of the pre-echo will be transmitted out over the path EA to the east terminal of the four-wire circuit, and will be impressed on the loss pads VL₂ and VL₃ in parallel thereat. The loss pad VL₂ will then be in its normal large loss condition, and the loss pad VL₃ is also in the large loss condition due to its adjustment in response to operation of the control device 5 of the transmitting terminal suppressor at the east terminal by east's speech current at a time T after they are first impressed on the latter device. The pre-echo therefore will be suppressed at this point, and, as the later portions of the echo of each word will be suppressed by the large loss produced by the pad VL₁ at the west terminal, no echo of east's speech waves while he continues to talk, will be transmitted back to him.

It will be noted that east adjusted pad VL₃ in the path EA at the east terminal at a time T after he started speaking due to the delayed action of the transmitting terminal suppressor provided by the delay circuit 6, and that east's first word traveled to the west terminal and the first part thereof returned as a pre-echo arrived at the loss pad VL₃ over the path EA after a time interval of 2T after east first started to talk.

In the preferable arrangement, the suppressor portion of each transmitting terminal echo suppressor, and thus the disabler portion of each receiving terminal echo suppressor, is arranged to have substantially no hangover in operation. In the alternative arrangement, the hangover of the suppressor portion of each transmitting terminal suppressor would be equal to T plus a small additional time interval h to take care of weak endings of syllables, etc. For the pad VL₃, with no hangover to suppress the pre-echo, it is apparent that either east's first impulse must have continued for a time T or else it must have been followed immediately by another impulse which would adjust the pad VL₃ to the large loss condition at the right time to suppress the first impulse. Fortunately, this relation is satisfied in almost all cases by the characteristic of English speech and the transmission time over most four-wire toll telephone circuits now in existence. That is, few four-wire circuits now have a one-way transmission time greater than 0.1 second, and few single words or sounds are shorter in duration than 0.1 second except those immediately followed by other sounds. Higher velocity four-wire circuits will further improve this relation.

In the event that west starts to speak after

east has started to speak but before east's speech waves reach the west terminal, west's speech waves will enter the input of the path EA from line LW, and the variable loss pad VL₁ still being in its normal low loss condition, will be transmitted therethrough with little attenuation. Then the transmitted speech waves after amplification in the amplifying device A₁ will be divided between the outgoing portion of the path EA and the input of the suppressor portion 1 of the transmitting terminal echo suppressor unit at the west terminal. The portion transmitted out over the path EA at the east terminal will be suppressed by the parallel loss pads VL₂ and VL₃, both being in the large loss condition because of the previous operation of the suppressor portion of the transmitting terminal suppressor unit at the east terminal in response to east's speech waves.

The portion of west's speech waves diverted into the control circuit 1 at the west terminal will cause the operation of the control device 2 therein which after a delay of T provided by the delay circuit 3 will result in the variable loss pad VL₅ in the path WA at the west terminal being adjusted to the large loss condition. If, however, before this happens, east's speech energy has entered the control circuit 9 at the west terminal and causes the operation of the control device 10 therein and consequent adjustment of the pad VL₆ in the path WA to the low loss condition, the subsequent adjustment of the pad VL₅ to the large loss condition in response to west's speech waves will have no effect for east's speech energy will continue to be transmitted through the now low loss pad VL₆ forming a by-pass around the large loss pad VL₅. In a sense then, the variable loss pad VL₆ may be said to disable the pad VL₅, and likewise, at the east terminal the pad VL₂ may be said to disable the pad VL₃.

If west and east should both start talking at about the same time, the one who starts to talk first should gain complete control of the switching circuit by blocking the opposite direction of transmission with substantially simultaneous operation of the suppressor portion of the transmitting terminal echo suppressor unit at the terminal of the four-wire circuit nearest him and the suppressor portion of the receiving terminal echo suppressor unit at the far terminal or, what is the same thing, the disabler portion of the transmitting terminal suppressor at the far terminal.

In practice, principally because of line and equipment variations, it is difficult to maintain synchronous action of the suppressors at opposite ends of a four-wire circuit if they are controlled by speech currents. With both subscribers starting to talk about the same time it is possible for any or all of the suppressors to operate falsely momentarily. The most probable combination, other than successful speech transmission in one direction or the other is (1) the pads VL₃ and VL₅ may be simultaneously adjusted to a condition other than normal, or (2) pads VL₁ and VL₄ may be adjusted simultaneously from the normal condition. In case (1) transmission lock-out will occur, that is, both subscribers may be talking and neither can hear the other. This condition can persist until one of the talkers pauses allowing the other to seize control of the system. Inasmuch as in the system of the invention, as shown in Fig. 1, the switching circuits controlling the adjustment of

loss pads VL₃ and VL₅ are operated with zero hangover, intersyllabic pauses are usually sufficient to terminate the lock-out. In practice, the effect of this momentary lock-out is extremely small.

In case (2) partial lock-out of transmission will result, that is, each subscriber will succeed in transmitting a very short impulse of speech to the other, and the two impulses will cause both directions of transmission to be blocked momentarily. In practice, this condition very rarely lasts for more than half a second and, as in the case of the condition of (1) it will hardly be noticeable to the subscribers.

It will be noted that in the system of the invention as shown in Fig. 1, there can be no possible combination of operations of the several echo suppressor units which will permit signal transmission between the subscribers in both directions at the same time.

Fig. 2 shows in more detail a preferred construction of the echo suppressor circuits of the invention which may be used at each terminal in the system of Fig. 1, and which have been operated successfully in practice. The figure shows only the echo suppressor circuits at the west terminal of the system, the elements therein corresponding to those at the west terminal in the system of Fig. 1 bearing the same reference characters. Identical apparatus would be used at the east terminal of the system (not shown).

In Fig. 2, the input of the west to east repeating path EA and the output of the east to west repeating path WA are coupled in conjugate relation and in energy transmitting relation with the two-way telephone line LW by a hybrid coil H and a balancing network N in well-known manner.

The variable loss pad VL₁, and the variable pads VL₅ and VL₆, are connected in the input of the path EA and in the output of the path WA, respectively, by transformers, as indicated. Each pad comprises two series branches and two parallel shunt branches. The two series branches are respectively connected effectively in series with the upper and lower conductors of the transmission path, and each consists of two copper-oxide rectifying elements C₁ in series, the elements in one series branch being poled in opposition to the elements in the other series branch. The two parallel shunt branches are connected effectively in shunt with the transmission path at points in the pad intermediate the two series rectifiers C₁ in the two series arms, and each comprises two oppositely poled copper-oxide rectifying elements C₂ in series. The junction point of the two copper-oxide rectifying elements C₂ in each shunt branch of the pad is connected to a midpoint of the secondary winding and primary winding, respectively, of the transformers coupling the pad in the transmission path. The rectifying elements in the pad are so connected in balanced form to prevent transients being set up in the transmission path due to the controlling currents sent through the elements by the biasing voltage applied by the associated transmission control circuit across the two junction points of the oppositely poled elements C₂ in the two shunt arms in the manner which will be described later.

The control device 2 in the control circuit 1 of the echo suppressor circuit connected across the path EA in the output of the amplifying device A₁ comprises a single screen grid amplifying vac-

uum tube 11 having its input circuit tuned by input transformer 12 and shunt condenser 13 to 1000 cycles, and its gain suitably controlled by adjustment of the variable resistance 14 in its control grid-cathode circuit, and a bridge circuit R of copper-oxide rectifying elements C₃, C₄, C₅ and C₆, arranged to form a full wave rectifier such as is well known in the art. The input terminals A—B of the bridge circuit R are connected to the output of the amplifying tube 11 by the transformer 15, and the output terminals C—D of the bridge circuit are connected through the series potentiometer resistance 19 across the input terminals of the delay circuit 3 providing a transmission delay of T, where T is the one-way transmission time over the four-wire circuit between terminals.

The delay circuit 3, as indicated, may be a multi-section low pass electrical filter, as indicated, each section consisting of a series inductance and a shunt condenser, the filter having the proper cut-off to provide the necessary delay action, and the number of sections used depending on the value of the transmission delay time T required.

The output terminals of the delay circuit 3 are connected across the junction point between the oppositely-poled copper-oxide rectifying elements C₂ in the two shunt branches of the variable-loss pad VL₅ connected in the transmission path WA in parallel with the variable loss pad VL₆. Potentiometer resistance 18 and resistance 20 in series are connected directly across the output terminals C—D of the rectifier bridge R.

With no output from the rectifier R, a small biasing direct current is supplied from battery 17 to the copper-oxide rectifying elements in the pad VL₅ through potentiometer resistances 18 and 19, resistance 20, and the conductors of delay circuit 3 in series. By proper relative poling of the battery 17 and the rectifying elements C₁, C₂ in the pad, and selection of the proper values for the battery and associated resistances, the biasing current is made of such value and to flow in such direction as to reduce the impedance of the series copper-oxide rectifying elements C₁ to a low value and to maintain the impedances of the shunt copper-oxide rectifying elements C₂ high, resulting in a low loss through the pad VL₅. In a practical case, battery 17 was a 24-volt battery, resistance 19 was equal to 25 ohms and the resistance 20 was about 6000 ohms. The value of the resistance 19 is maintained low enough to prevent any current from going through the copper-oxide rectifying elements C₃, C₄, C₅, and C₆ in rectifier R, and therefore prevents the loss pad VL₅ from being shunted by the rectifier R producing an unstable condition.

A signal input applied to the control circuit 1 from the path EA will be amplified by the amplifying device 11 and rectified by the copper-oxide rectifier bridge R, and the rectified signal currents will flow through the delay circuit 3 and the copper-oxide rectifying elements in the pad VL₅ in opposition to the initial biasing current supplied from battery 17. The rectified signal currents will be sufficiently large to reverse the voltage across the rectifying elements in the pad, the series elements C₁ thus becoming high in impedance and the shunt elements C₂ becoming low in impedance, so that the loss of pad VL₅ is changed from its normal low loss condition to a large loss condition thus effectively blocking the path WA and suppressing echoes of the signals therein.

Condenser 21 connected across the input of the delay circuit 3 is a hangover condenser which is charged by the rectified current from the output of rectifier R when signals are being applied to control circuit 1, and discharges when the signal input ceases through the copper-oxide rectifying elements in pad VL₅ in such direction as to maintain the loss of the pad high for a given hangover interval. In the usual case, zero hangover would be required for the transmitting terminal echo suppressor in which case the condenser 21 would be omitted, but in the case of certain types of circuits, it may be of some advantage to provide some hangover and the condenser will furnish this in the manner described.

Control circuit 9 connected to the path WA on the output side of the parallel loss pads VL₅ and VL₆, which controls the loss conditions of the variable loss pad VL₁ in the path EA and the variable loss pad VL₆ in the path WA, is similar to the control circuit 1 except for the omission of the delay circuit 3, as indicated by the use of similar reference characters for identifying its constituent elements. In the case of circuit 9 the corresponding reference characters are followed by a prime (') mark.

In circuit 9, the normal biasing current from the battery 17' and the rectified signal output of rectifier R' flow through the rectifying elements in the pad VL₁ and the rectifying elements of pad VL₆ in series. The normal biasing current flows through the copper-oxide rectifying elements in the loss pad VL₁ in the path EA in such direction as to make the series rectifying elements C₁ therein of low impedance to alternating current and the shunt rectifying elements C₂ therein of high impedance to alternating current, thus effectively making the loss of the pad VL₁ normally low, and flows through the rectifying elements in pad VL₆ in such direction as to make the series elements C₁ of high impedance to alternating current, and the shunt rectifying elements C₂ of low impedance to alternating current, thus making the loss inserted by the pad VL₆ in path WA normally high. This complementary loss condition of the pads VL₁ and VL₆ is attained, as indicated, by a reversal of the two current supply leads to the pad VL₆, but may be obtained in any other suitable way, for example by reversing the poling of the copper oxide rectifying elements in the pad VL₆ from that shown.

Signals applied to the input of the control circuit 9 from the path WA are amplified by amplifier 11' and rectified by rectifier R' and the rectified signal current in the output of rectifier R' flows through the copper-oxide rectifying elements in the pads VL₁ and VL₆ in opposition to the initial biasing current flowing therethrough from battery 17', which rectified current will be large enough to reverse the voltage across the copper-oxide rectifying elements in the two pads. The series rectifying elements C₁ in the pad VL₁ then become of high impedance to alternating currents and the shunt elements C₂ become low in impedance, so that the pad VL₁ is changed from the normal low loss condition to a large loss condition. The series rectifying elements C₁ in the pad VL₆ will become of low impedance to alternating current and the shunt elements C₂ of high impedance to alternating current, thereby causing the loss pad VL₆ to introduce a low loss to alternating current signals in the path WA.

When the rectified signals are applied to the pads VL₁ and VL₆ in the manner just described, the effect of the condenser 21' connected across the output of the rectifier R' in retarding the

change of loss in the pads is relatively small because the impedance of the rectifier R' is very low. When the signals are removed from the rectifier R' with cessation in the supply of signaling current to the input of control circuit 9, the rectifier R' becomes high in impedance, and the condenser 21', which has been charged up by the flow of rectified current, will discharge through the rectifying elements C₁, C₂ in the pads VL₁ and VL₂ in such direction as to maintain their impedances substantially in the condition initiated by the rectified signaling current for a hangover time interval the length of which depends on the size of the condenser 21'. As the discharge of the condenser 21' grows less, the impedance of the elements C₁, C₂ in the pads will slowly change until at the end of the discharge their impedance values are returned to the conditions provided by the flow through them of the normal biasing current from battery 17' only. The pad VL₁ is thus returned to the normal low loss condition and the pad VL₂ to the normal high loss condition. As pointed out in connection with the description of operation of the system of Fig. 1, the hangover in the loss condition of the pads VL₁ and VL₂ would be small but sufficient to take care of the weak endings of words.

Other elements having a non-linear voltage current characteristic may be substituted for the copper-oxide rectifiers as the controlling elements in the loss pads in the circuits of the invention, for example, vacuum tube devices or elements of the material commercially known as thyrite which is disclosed in the patent to McEachron No. 1,822,742, issued September 8, 1931. Also, mechanical relay circuits, such as are commonly used in connection with echo suppressors or voice-operated anti-singing devices in the prior art, may be used in place of the particular elements illustrated and described for controlling the loss condition of the transmission paths. Other variations in the system 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. In a two-way signal transmission system comprising at each terminal an incoming and an outgoing one-way path, an echo suppressor unit at each terminal of said system comprising one switching circuit connected to the outgoing path and responsive to outgoing signals therein to disable the incoming path, and a second switching circuit connected to said incoming path and responsive to incoming signals to disable said outgoing path, said one switching circuit having a delay in operation in response to impressed signals substantially equal to the one-way transmission time between terminals of the system and substantially no hangover in operation with cessation in the controlling signals, and said second switching circuit being comparatively quick operating and having a small hangover in operation.

2. In a two-way signaling system including a four-wire circuit comprising oppositely directed two-wire paths for the signals in opposite direction, an echo suppressor unit at each terminal of the four-wire circuit, comprising one switching circuit connected to the outgoing path at the terminal and a second switching circuit connected to the incoming path at the terminal, said one switching circuit being responsive to outgoing signals in the outgoing path to disable said incoming path in front of the point of connection of said second switching means thereto, said second

switching circuit being responsive to incoming signals in the incoming path to disable the outgoing path in front of the point of connection of said one switching means thereto, said one switching means having a delay in operation in response to impressed signals substantially equal to the one-way transmission time between terminals of said four-wire circuit and substantially no hangover in operation, said second switching circuit being comparatively quick operating, and means to prevent said incoming path from being disabled after said second switching means has once operated.

3. In a two-way signal transmission system comprising at each terminal an incoming and an outgoing one-way signal transmission path, an echo suppressor unit of the transmitting terminal type and an echo suppressor unit of the receiving terminal type associated with the incoming and one-way paths at each terminal of said system, the transmitting terminal echo suppressor unit including a suppressor portion responsive to signal transmission in the outgoing path to disable the incoming path at the terminal, the receiving terminal suppressor unit including a suppressor portion responsive to signal transmission in said incoming path to disable the outgoing path, said suppressor portion of said transmitting terminal unit having a delay in operation in response to impressed signals substantially equal to the one-way transmission time over said system between terminals and substantially no hangover in operation, said suppressor portion of said receiving terminal suppressor being comparatively quick operating.

4. In a two-way signal transmission system comprising at each terminal an outgoing and an incoming one-way signal transmission path, an echo suppressor unit at each terminal comprising one switching means connected to the outgoing path and responsive to outgoing signals therein, only in the absence for a given time of prior incoming signals in the incoming path to insert a large disabling transmission loss in said incoming path substantially at the time of arrival of said outgoing signals at the other terminal, and responsive substantially immediately to cessation of flow of said outgoing signals in said outgoing path to remove said large loss from said incoming path, a second switching means connected to said incoming path on the output side of the point of insertion of said large loss therein and operatively responsive substantially immediately to impressed incoming signals to insert a large disabling loss in said outgoing path in front of the point of connection of said one switching means thereto, and other means responsive to operation of said second switching means to prevent subsequent insertion of said large loss in said incoming path from being effective to disable said incoming path.

5. In a two-way signal transmission system including a four-wire circuit comprising oppositely directed two-wire transmission paths for the signals in opposite directions, an echo suppressor unit associated with the transmission paths at each terminal of the four-wire circuit, each unit comprising one variable attenuation pad in the outgoing path, two variable attenuation pads in parallel in the incoming path, said one pad and one of said parallel attenuation pads normally being adjusted to provide a small transmission loss in the path in which connected, and the other of said parallel pads normally being adjusted to provide a large transmission loss in shunt with the normal low loss provided by said one pad, in

said incoming path, one wave-controlled switching circuit connected to the outgoing path on the output side of said one attenuation pad therein, and a second wave-controlled switching circuit connected to the incoming path on the output side of the parallel attenuation pads therein, said one switching circuit being responsive to outgoing signals in said outgoing path when the attenuation pad therein is in its normal low loss condition, to change the one of the parallel attenuating pads in the incoming path normally providing a small loss to a large loss condition, said second switching circuit being responsive to incoming signals in the incoming circuit when said one of said parallel pads therein is in its normal low loss condition, to change said one

pad in said outgoing path from the normal low loss condition to a large loss condition, and simultaneously to change said other parallel pad in said incoming path from its normal large loss condition to a low loss condition.

6. The system of claim 5, in which said one switching means includes means for delaying its operation in response to impressed outgoing signals for a time interval substantially equal to the one-way transmission time between terminals of said four-wire circuit, and has substantially no hangover in operation with cessation in the controlling signals, and said other switching means is comparatively quick operating.

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