

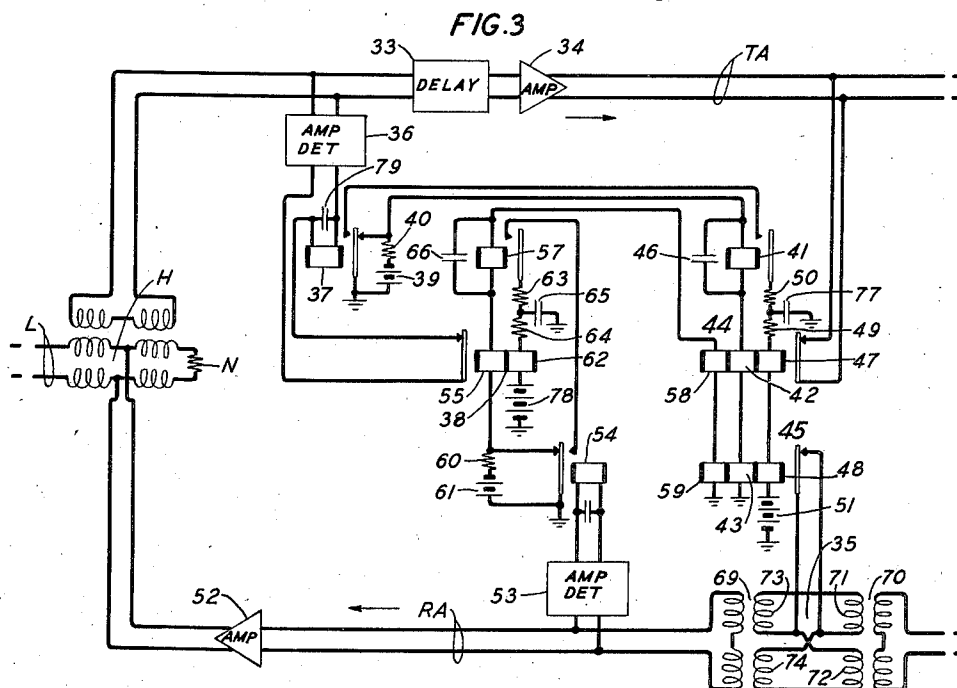
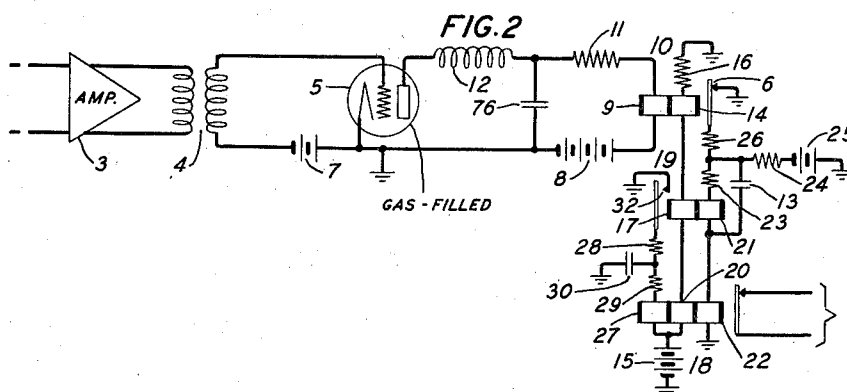
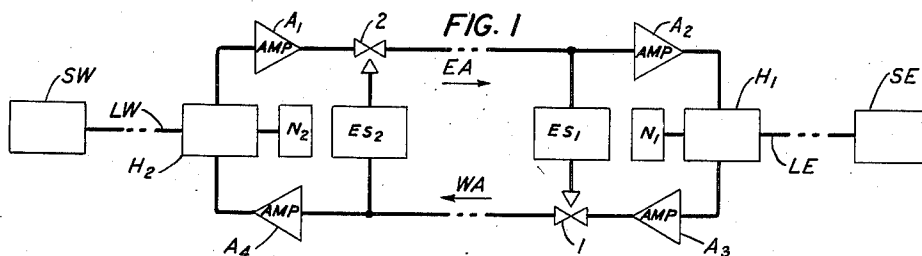
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TRANSMISSION CONTROL IN TWO-WAY SIGNALING SYSTEMS

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TRANSMISSION CONTROL IN TWO-WAY
SIGNALING SYSTEMS

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

5 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
10 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 in the opposite direction, so as to
15 prevent echoes or reflected current from being transmitted back to the transmitting end of the system and causing a disturbance or singing. These suppressors usually include an amplifier-rectifier circuit connected to a two-wire path for
20 each direction and responsive to signal transmission therein to control the operation of mechanical relays to insert a large loss in the signal transmission path for the opposite direction, as by short-circuiting it.

In one type of circuit the suppressor units are located approximately at the mid-point of the four-wire circuit and in another type of circuit the suppressor units are located at or near the terminals of the four-wire circuit. In both cases,
25 it is desirable to provide auxiliary means, the so-called hang-over circuit, for prolonging the operation of each suppressor unit the proper interval of time after the supply of controlling speech energy thereto ceases in order to completely suppress all echoes and to prevent false operation of the other suppressor unit. In the case of the receiving terminal type suppressor, it has been necessary in the past to use artificial transmission delay networks in the transmission
30 paths to prevent false operation of the suppressors by pre-echoes. Such electrical delay networks are relatively costly and often necessitate additional amplification to compensate for the loss they insert in the transmission paths. In the usual relay type of suppressor of the prior art, short transients (line noise) may cause complete false operation of the suppressor.

In accordance with the present invention proper operation of terminal type suppressors is attained by circuits for delaying the application of
35 hang-over until the master relay of the suppressor has remained operated for a definite length of time. In one embodiment, the hang-over is not applied unless two or more impulses of substantially equal amplitude are received by

the suppressor a given time interval apart, such as would be found in continuously transmitted speech energy but not in the case of the usual line noise which comprises short impulses of infrequent occurrence. The circuits of the invention
5 do not require transmission delay networks in the repeating paths to obtain protection against pre-echoes.

The objects and advantages 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 which may be arranged in accordance with the invention;

Fig. 2 shows schematically an echo suppressor circuit representing one embodiment of the invention which may be utilized in connection with the system of Fig. 1; and

Fig. 3 shows schematically one terminal of a two-way radio telephone system employing transmission control circuits embodying the invention.

The diagram of Fig. 1 is not an actual circuit diagram, but rather a single line lay-out, each line indicating a transmission path. A normal make in a path is indicated in this diagram by contacting arrowheads. An arrow directed at a make point indicates that the path will be disabled at that point by operation of the associated control device (echo suppressor), represented by a box, in response to impressed signals.

The four-wire telephone circuit of Fig. 1 comprises a one-way path EA including the one-way
35 amplifying devices A₁ and A₂, for repeating telephonic currents in the direction from west to east between the two-way line LW connected to the west station SW and the two-way line LE connected to the east station SE, and the one-way path WA including the one-way amplifying devices A₃ and A₄, for repeating telephonic currents in the direction from east to west between the line LE and the line LW. The paths EA and WA may be connected in substantially conjugate relation with each other and in energy transmitting relation with the lines LW and LE in any suitable manner, for example, as indicated, by hybrid coil transformers H₁ and H₂ and associated balancing networks N₁ and N₂.

Connected to the path EA near its output is the input of an echo suppressor unit ES₁ which operates in response to signal waves transmitted over the path EA to disable or block the path WA at some point 1 near its input. Similarly, 55

connected to the path WA near its output is the input of an echo suppressor unit ES₂ which operates in response to signal waves transmitted over the path WA to disable the path EA at some point 2 near its input.

A preferred construction of the echo suppressor circuits ES₁ and ES₂ in accordance with the invention is shown in Fig. 2. As indicated, this echo suppressor comprises in its input an amplifying device 3, the output of which is coupled by transformer 4 to the input circuit of the three-electrode gas-filled detector tube 5. The grid of the tube 5 is negatively biased by the battery 7 so that normally the tube is in the de-ionized condition. Space current is supplied to the plate of the tube 5 by the plate battery 8 through the operating winding 9 of the mechanical relay 10, the resistance 11 and the radio frequency choke coil 12 in series. Connected across the plate circuit from a point between resistance 11 and choke coil 12 to the negative terminal of plate battery 8 is a condenser 16 which is normally charged by battery 8. The choke coil 12 is provided to prevent possible parasite radio oscillations from affecting the operation of tube 5.

The relay 10 has another winding 14 which acts in opposition to the operating winding 9 to bias the relay against operation. The winding 14 is supplied with biasing current from battery 15 through the biasing winding 20 of relay 18, the biasing winding 17 of relay 19 and resistance 16 in series. The relays 19 and 18 are also provided with operating windings 21 and 22, respectively, which are normally supplied with energizing current from battery 25 over a circuit extending from the positive terminal of the battery through ground, winding 22 of relay 18, winding 21 of relay 19, series resistances 23 and 24 to the negative terminal of the battery. The winding 22 of relay 18 and the winding 21 of relay 19 in series are normally shunted by a circuit including the resistance 23, the resistance 26 and the normally closed armature and contact 6 of relay 10. The shunting effect of this circuit normally reduces the current in the operating windings 21 and 22 of relays 19 and 18, respectively, so that the biasing windings 17 and 20, respectively, of these relays prevail, and relays 19 and 18 are normally held unoperated. When relay 10 operates to open its armature and contact 6, this shunting circuit around winding 21 of relay 19 and winding 22 of relay 18 is broken, and the operating current from battery 25 flowing through these windings increases sufficiently to cause these windings to prevail over the biasing windings so that the relays 19 and 18 will operate. The condenser 16 and the resistance 23 connected around the winding 21 of relay 19 are provided to make the relay 19 slow-operating.

The relay 18 is also provided with a third winding 27 wound to assist the operating winding 22, which is adapted to be energized from battery 15 when relay 19 operates to close its armature and contact 32, over a circuit which may be traced from the positive terminal of battery 15 through winding 27 of relay 20, series resistances 29 and 28, closed armature and contact 32 of relay 19 and ground to the negative terminal of battery 15. A condenser 30 is connected between ground and the junction of resistances 28 and 29 for a purpose which will be brought out later in connection with the description of the operation of the complete circuit.

The armature and contact of relay 18 are nor-

mally in the closed condition and are opened by operation of the relay. The contact and armature of relay 18 are connected to the path WA or to the path EA in the system of Fig. 7, and are arranged in any suitable manner so that when in the closed condition, as indicated, they render the path WA operative at point 1 or the path EA operative at the point 2 depending on whether the circuit of Fig. 2 is used in echo suppressor ES₁ or in the echo suppressor ES₂; and so that when they (the armature and contact of relay 20) are opened by operation of the relay they disable the path WA at the point 1 in the case of echo suppressor ES₁ or disable the path EA at the point 2 in the case of echo suppressor ES₂.

The operation of the circuit of Fig. 2 when used for the echo suppressor ES₁ and for the echo suppressor ES₂ in the system of Fig. 1 will now be described.

It will be assumed that speech waves from a west subscriber associated with the west station SW is received by the four-wire circuit over the two-way line LW, and at that time no speech waves from a subscriber associated with the east station SE are being received over the two-way line LE.

The west subscriber's speech waves will be impressed by the hybrid coil H₂ upon the path EA and after amplification in the amplifier A₁ will be transmitted out over the path EA towards the east end of the four-wire circuit. At the east end of the four-wire circuit, the main portion of west's speech waves will be amplified by the amplifier A₂ and will be impressed by hybrid coil H₁ on the two-way line LE over which it will be transmitted to the east subscriber associated with the east station SE.

However, a small portion of west's speech waves in the output of the path EA will be diverted into the echo suppressor ES₁. Referring to Fig. 2, the diverted speech waves will be amplified by amplifier 3 and the amplified waves in the output thereof will be impressed by transformer 4 on the input circuit of the gas-filled detector tube 5 causing ionization therein and consequent flow of space current from battery 8 through the operating winding 9 of relay 10, the resistance 11, choke coil 12 and the space path of tube 5 in series. The condenser 16 will be simultaneously discharged through tube 5.

The energization of the winding 9 of relay 10 will cause immediate operation of that relay to open its armature and contact 6 breaking the shunting connection across the winding 21 of relay 19 and the winding 22 of relay 18 through series resistances 23 and 26, thus effectively increasing the amount of current flowing from battery 25 through the windings 21 and 22 of relays 19 and 18, respectively. Due to the increase in energizing current, the winding 22 of relay 18 will overcome the effect of the biasing winding 20 of the relay and will cause immediate operation of the relay to open its normally closed armature and contact. As stated above, the opening of the armature and contact of relay 18 will result in the path WA being disabled at the point 1.

The simultaneous increase in the flow of energizing current through winding 21 of relay 19 due to the operation of relay 10 will cause winding 21 to prevail over the biasing winding 17 so that relay 19 will operate to close its armature and contact 32. However, because of the effect of the condenser 16 and resistance 23 in shunt with

winding 21, the relay 19 is slow-operating so that the armature and contact 32 thereof will not be closed for an appreciable interval of time after relay 10 has operated and after relay 20 has operated to disable the path WA.

The closing of the armature and contact 32 of relay 19 completes an energizing circuit for the winding 27 of relay 18 from battery 15 over a circuit previously traced, causing the winding 27 to apply hang-over to the relay 18. However, this hang-over does not become effective until relay 19 releases to open its armature and contact 32 in consequence of the release of relay 10, as will be described below. Condenser 30 normally charged by battery 18 through winding 27 and resistance 29 is discharged to ground through the closed armature and contact 32 of relay 19 when relay 19 operates.

At the end of the speech impulse which caused operation of relay 10, detector tube 5, because of the large resistance 11 in its plate circuit, will restore to the deionized condition. Relay 10, however, will not immediately release, but will be held operated for a given hang-over interval while the normally charged condenser 76, which was discharged through the space path of tube 5 when that tube operated, is charged up again by current from battery 8 through winding 9 of relay 10 and resistance 11. If another speech syllable does not follow the first syllable within a given time interval, the relay 10 will release, closing its armature and contact 6.

A speech syllable is made up of a building-up period, a middle period in which the syllabic amplitude is a maximum and remains nearly constant, and a period of decay. In ordinary conversation, it has been found that within a time interval of about 1/90 of a second at least two vocal peaks of substantially the same amplitude will occur during the middle part of a syllable. By suitable design and selection of the values of the relay 10 and the circuit elements associated with tube 5, the relay 10 is arranged to stay operated to hold its armature and contact 6 closed on applied voltage peaks spaced 1/90 of a second, or less, apart, and thus to be maintained operated by the succeeding vocal peaks in ordinary speech syllables.

If, then, the west subscriber continues to talk, the relay 10 will be maintained operated long enough on every syllable to cause operation of relay 19 applying hang-over to relay 18 through winding 27. This hang-over on relay 18 becomes effective when relay 19 releases in response to the previous release of relay 10 when the west subscriber ceases talking or pauses for a sufficient interval of time. The relay 19 will not release until a given time after relay 10 releases due to the slow-release action provided by the resistance 23 and condenser 13 in shunt to the operating winding 23 of relay 19. When relay 19 finally releases, the normal energizing circuit for winding 27 of relay 18 from battery 15 is broken by the opening of the armature and contact 32 of relay 19. Although the current in the operating winding 22 of relay 18 due to the shunting effect of resistances 23 and 26 is now insufficient to hold the relay operated, that relay is maintained operated for an additional interval of time due to the assistance of winding 27 which winding is energized by the flow of charging current from battery 15 to the condenser 30 through that winding and resistance 29. The normally charged condenser 30 was discharged through the closed armature and con-

tact 32 of relay 19 to ground when relay 19 operated. By suitable selection of the values of condenser 30 and resistance 29, winding 27 and battery 15, the length of this hang-over interval is made sufficient so that the path WA is maintained disabled at point 1 after release of relay 10 due to cessation in west's speech for a time sufficient to allow all echoes of west's speech controlling the operation of echo suppressor ES₁ to reach the point 1 in path WA and to be substantially dissipated thereat before that path is again rendered operative.

The hang-over time of each echo suppressor unit preferably should be made slightly longer than the total transmission time over the output of the repeating path from the point of connection of the suppressor thereto through the hybrid coil at the receiving end of the four-wire circuit, and back over the echo path to the disabling point, in order to suppress echoes due to the weak endings of speech syllables which may not be of sufficient amplitude to hold the suppressor operated.

If the impulse causing the ionization of detector tube 5 is only of short duration, and is not immediately repeated, as is usual in the case of line noises (transients) which come at irregular intervals, relay 10 and consequently relay 18 will remain operated only a short time. The relay 19, however, is made sufficiently slow-operating by suitable selection of the values of condenser 13 and resistance 23 associated with its operating winding 21, so that such short transient voltage peaks will not completely operate it, and hang-over will not be applied to the disabling relay 18. Noise impulses of longer duration may cause operation of relay 19 to apply hang-over to the disabling relay 18, but because such noise impulses will be of infrequent occurrence, will result in only a small degradation of the transmission performance of the system.

It is seen, that the deferred application of hang-over to the disabling relay of the echo suppressor provided by making the relay 19, which controls the application of hang-over, slow-operating, prevents undue false operation of the echo suppressor by line noise and without necessitating a reduction of the sensitivity of the echo suppressor as regards operation by speech.

The description hereinbefore given covers the condition wherein by assumption the west station SW was the transmitting station and the east station SE the receiving station. The action is similar in the case of transmission from east to west, that is, from station SE to station SW. In this case, east's voice currents received over the two-way line LE are impressed by hybrid coil H₁ on the path WA, and after amplification by the amplifiers A₃ and A₄ therein, will be impressed by hybrid coil H₂ on the two-way line LW over which they will be transmitted to the west subscriber associated with station SW. However, a small portion of the east's voice currents will be diverted near the output of the path WA into the echo suppressor ES₂. As the echo suppressor ES₂ is identical with the echo suppressor ES₁ previously described, it operates in a manner similar to the latter echo suppressor to block transmission at the point 2 in the path EA and thereby prevents the sending of an echo back over the path EA to the originating station SE.

Prior to my invention, it was the practice to arrange echo suppressors so that the same hang-over was applied every time the suppressor operated. On a very short operating impulse, the

same hang-over was applied as for a sustained succession of impulses. As a result of this situation, unless expensive artificial delay networks were inserted in the transmission paths between the input point of the suppressor and the point of suppression, an initial short impulse of current would cause an initial echo and operate the suppressor associated with the transmitting end of the system and this operation with its associated hang-over would result in a blocking of transmission from the sending end. With the deferred hang-over feature of my invention, it is unnecessary to use delay networks to prevent operation by initial echoes since the false operation of the suppressor by the short initial echo current is only momentary, as only a short hang-over would be applied in this case.

In Fig. 3 is shown another embodiment of the invention utilized for directionally controlling transmission in a two-way signaling system of the type employing a two-way transmission link intermediate between terminals, for example, a two-way radio telephone system.

As the two terminals of the system are identical, only the west terminal of the system is illustrated. As indicated, the input of a one-way transmitting-amplifying circuit TA and the output of a one-way receiving-amplifying circuit RA are connected in substantially conjugate relation with each other and in energy transmitting relation with the two-way line L leading to a west subscriber's station by the hybrid coil transformer H and associated balancing network N in well-known manner. The transmitting circuit TA and the receiving circuit RA would be extended on the right to radio transmitting apparatus including a transmitting antenna and to radio receiving apparatus including a receiving antenna, respectively (not shown).

The circuit EA includes, as indicated, a delay circuit 33, an amplifier 34, and the receiving circuit RA includes the loss pad 35 and the amplifier 52 near its output. Connected across the input of the transmitting circuit TA in front of the delay circuit 33 is the input of a control circuit comprising the wave-operated control device (amplifier-detector) 36 and the master relay 37 connected across the output of the device 36. Connected across the output of the path RA at some point in the output of the loss pad 35 is the input of a control circuit including the wave-operated control device (amplifier-detector) 53 and the mechanical relay 54 connected across the output of the device 53. The first-mentioned control circuit is responsive to outgoing speech signals in the transmitting circuit TA to control through a relay circuit the loss characteristics of the transmitting circuit TA and the receiving circuit RA, and the second-mentioned control circuit is responsive to incoming signals in the circuit RA to control a relay circuit to disable the first control circuit in a manner which will be described in detail below in connection with the complete description of the operation of the system of Fig. 3.

The loss pad 35 may be of any suitable type which would normally provide a low loss to transmitted waves and which is adapted to be changed to the high loss condition by operation of a mechanical relay. The particular type of pad illustrated is disclosed and claimed in H. C. Silent Patent 1,749,851, issued March 11, 1930. As indicated, it comprises the two transformers 69 and 70 connected in tandem in the circuit RA. The transformer 70 has one primary winding and two

secondary windings 71 and 72, and the transformer 69 has one secondary winding and two primary windings 73 and 74. The upper terminals of the windings 71 and 73 are connected together and likewise the lower terminals of the windings 72 and 74. The lower terminal of the winding 73 is connected to the upper terminal of winding 72, and the lower terminal of winding 71 is connected to the upper terminal of winding 74. These connections taken by themselves are such that the windings 71, 72, 73 and 74 effectively oppose each other so as to prevent transmission over the circuit RA through the transformer network 35. However, as indicated, a normal cross-connection made through the normally closed armature and contact of relay 45 ties together the lower terminals of the windings 71 and 73 and the upper terminals of the windings 72 and 74, so that, in effect, two series aiding circuits are established through transformers 70, 69, and transmission through the transformer network 35 over the circuit RA is normally permitted. When the relay 45 operates to open its armature and contact, the windings 71, 72, 73 and 74 are connected in opposing relation so that transmission through the transformer network 35 is substantially prevented.

The operation of the system of Fig. 3 is as follows:

It will be assumed that speech waves for transmission in the direction from west to east are being received over the two-way line LW from a west subscriber, and at that time, no speech waves from a subscriber associated with the distant east terminal of the system (not shown) are being received in the receiving circuit RA.

The west subscriber's speech waves will be impressed by the hybrid coil H on the input of the transmitting circuit TA and will be divided between the input of the delay circuit 33 and the input of the control circuit connected to the transmitting circuit TA in front of the delay circuit 33. The portion of west's speech currents diverted into the control circuit will be amplified and detected in the amplifier-detector 36 and will cause immediate operation of the master relay 37 to shift its armature from the back to the front contact thereby removing a normal short circuit around battery 39 and series resistance 40. This completes an energizing circuit for the winding of relay 41, the winding 42 of relay 44 and the winding 43 of relay 45 over a circuit which may be traced from the positive terminal of battery 39 through ground to winding 43 of relay 45, winding 42 of relay 44, winding of relay 41 and resistance 40 to the negative terminal of battery 39. The resultant energization of winding 42 of relay 44 and winding 43 of relay 45 will cause immediate operation of these relays. Relay 44 will operate to open its armature and contact removing the normal short circuit across the transmitting circuit TA in the output of amplifier 34, and relay 45 will simultaneously operate to open its normally closed armature and contact so as to connect windings 71, 72, 73 and 74 of the transformers 69, 70 in the loss network 35 in the receiving circuit RA in opposing relation thus inserting a high loss in the receiving circuit RA in the manner previously described.

Meanwhile, the main portion of west's speech currents in the circuit TA will be transmitted through the delay circuit 33 and then will be amplified by the amplifier 34. The delay circuit 33 is arranged to produce sufficient delay in the transmission of these speech currents so that they

will not arrive at the disabling point in the circuit TA until after relay 44 has operated to remove the short circuit across the circuit TA. West's amplified speech currents will then be transmitted out over the circuit TA to the radio transmitting apparatus from which they will be radiated to the distant terminal of the system to which the east subscriber is connected.

Due to the condenser 46 connected in shunt to its winding, the relay 41 is made slow-operating so that this relay does not operate for a predetermined interval of time after relays 44 and 45 have operated. When relay 41 finally operates, it closes its armature and contact completing an energizing circuit for the winding 47 of relay 44 and the winding 48 of relay 45 over a circuit extending from the positive terminal of battery 51 through winding 48, winding 47, resistances 49 and 50, closed armature and contact of relay 41, closed front contact and armature of relay 37 and ground to the negative terminal of battery 51, and causing the condenser 77, which is normally charged up from battery 51 through winding 48 of relay 45, winding 47 of relay 44 and resistance 49, to be discharged to ground through the closed armature and contact of relay 41 and closed back contact and armature of relay 37. Winding 47 of relay 44 and the winding 48 of relay 45 are wound so as when energized by operation of relay 41 as described, they assist the operating windings 42 and 43 of the respective relays to maintain the relay armatures and contacts open, and to produce a hang-over in the operation of these relays when master relay 37 releases when west ceases talking.

As long as west continues to talk substantially continuously, the switching circuits at the west terminal will remain in the operated condition just described so that the transmitting circuit TA is operative to transmit and the receiving circuit RA is disabled by the high loss inserted therein in front of the input of the receiving control circuit by the loss pad 35.

The operation of the switching circuits at the east terminal of the two-way signaling system, which are identical with the switching circuits at the west terminal illustrated, in response to west's speech waves will be clear by reference to the corresponding receiving switching circuits at the west terminal shown. That the switching circuits to be referred to are those located at the east terminal and not the west terminal will be made evident in the following description by referring to the circuits at the east terminal with the same characters as the corresponding circuits at the west terminal followed by a prime (') mark.

West's speech currents on arrival at the east terminal will be received by the receiving antenna and after detection in the radio receiving circuits thereat will be transmitted into the receiving circuit RA'. The loss pad 35' at the east terminal in the receiving circuit RA' being in the normal low loss condition, west's speech waves will be transmitted therethrough with little attenuation and then will be divided between the input of the amplifier 52' in the output of the circuit RA' and the input of the amplifier-detector 53' in the receiving control circuit. The portion of west's speech currents received by the amplifier 52' will be amplified thereby and the amplified waves impressed by the hybrid coil H' on the two-way circuit L' over which it will be transmitted to the receiving circuits of the east subscriber.

A portion of west's speech currents diverted into

the receiving control circuit will be amplified and detected in the amplifier-detector 53' and then will energize the winding of the receiving master relay 54' causing that relay to operate to shift its armature from the back to the front contact. This will remove the normal short circuit around battery 61' and resistance 60' in series so as to cause energizing current from battery 61' to be supplied to the operating winding 55' of relay 38', the winding of relay 57', the winding 58' of relay 44' and the winding 59' of relay 45' through resistance 60'.

Relay 38' will immediately operate to break its normally closed armature and contact effectively disconnecting the transmitting master relay 37' from the amplifier-detector 36' in the transmitting control circuit at the east terminals so as to prevent thereafter storage of energy in condenser 79' shunting the winding of relay 37'. Thus, while west continues to talk, false operation is prevented of the transmitting master relay 37' by any echoes of west's speech currents which may be transmitted into the transmitting control circuit TA' at the east terminal through hybrid coil H', or by any speech currents of the east subscriber subsequently received over the two-way line L' and impressed on the transmitting circuit TA' at the east terminal.

The winding 58' of relay 44' and the winding 59' of relay 45' energized simultaneously with the winding 55' of relay 38' are arranged when energized to oppose the action of the operating windings 42' and 43' of the respective relays, and thus serve to produce a heavy bias against operation of these relays. Therefore, even if the transmitting master relay 37' and the receiving master relay 54' are simultaneously operated in response to speech waves from the east subscriber received over the line L' and the speech waves from the west subscriber incoming in the receiving circuit RA', respectively, operation of the transmitting circuit enabling relay 44' and the receiving circuit disabling relay 45' by east is prevented by the bias on the latter relays. Thus, it is seen that if a subscriber associated with either terminal of the two-way system starts to talk and his speech currents are received in the transmitting circuit of the terminal to which he is connected at the same time or after speech currents of the distant subscriber are received at the receiving circuit of that terminal, the former subscriber cannot get control of the switching circuits at his own terminal, and the distant subscriber, so long as he continues to talk, will control the switching circuits at both terminals.

The winding of relay 57' is supplied with energizing current at the same time as the winding 55' of relay 38', but, because of the condenser 66' in shunt with the winding of the former relay, it is slow-operating and will not operate until a given time after the receiving master relay 54' has operated in response to the incoming speech currents.

When relay 57' finally completely operates, it closes its armature and contact thus causing energizing current to be supplied to the hang-over winding 62' of relay 38' over a circuit extending from the positive terminal of battery 78' through winding 62' of relay 38', series resistances 64' and 63', the closed armature and contact of relay 57', the closed front contact and armature of relay 54' and ground to the negative terminal of battery 78'. Although hang-over is thus applied to the relay 38' through the hang-over winding 62', this hang-over does not become effective until

relay 54' releases in response to cessation of or an appreciable pause in the west subscriber's speech currents, as will be described later.

Now, let it be supposed that the west subscriber ceases talking or pauses for a sufficient interval of time to allow the transmitting master relay 37 at the west terminal to release. The armature of relay 37 is then shifted from the front to the back contact reconnecting the normal short circuit around battery 39 and breaking the energizing circuit therefrom to the winding of relay 41, winding 42 of relay 44 and winding 43 of relay 45 through resistance 40, and also breaking the energizing circuit for the winding 47 of relay 44 and winding 48 of relay 45 from battery 51 through the front contact and armature of relay 37.

Relay 41, because of the slow-release action provided by condenser 46, will release a given time after relay 37 has released. Relays 44 and 45 will not release immediately due to the deenergization of winding 42 and winding 43, respectively, but will be maintained operated for a hang-over interval while condenser 77, which had been discharged when relay 41 operated, is charged up from battery 51 through winding 48, the winding 47 and resistance 49 in series. By proper selection of the values of the elements in the hang-over circuit just described, the relay 44 will be maintained operated to disable the transmitting circuit TA until all of west's speech waves, which meanwhile are delayed in delay circuit 33, have passed the disabling point in the circuit, thus preventing loss of any of west's speech; and so that relay 45 will be maintained operated to block the receiving circuit RA through loss pad 35 for a sufficient length of time to prevent false operation of relay 54 in the receiving control circuit by any delayed echoes of west's speech waves returned from the other terminal.

At the end of this hang-over interval, relays 44 and 45 will return to the unoperated condition in which the transmitting circuit TA is disabled by the short circuit closed by the armature and contact of the former relay, and in which the receiving circuit RA is operative due to the low loss condition of the loss network 35 caused by the closed condition of the armature and contact of relay 45.

At the east terminal of the system, the cessation of the supply of west's speech currents to the amplifier detector 53' in the receiving control circuit associated with the receiving circuit RA' at that terminal will cause relay 54' to release shifting its armature from the front to the back contact and thus reapplying the normal short circuit around battery 61' and series resistance 60' and breaking the energizing circuit for winding 62' of relay 38' from battery 73' through the armature and front contact of relay 54'. The short-circuiting of battery 61' will cut off the supply of energizing current to the operating winding 55' of relay 38', the winding of relay 57', the winding 58' of relay 44' and the winding 59' of relay 45'. The large bias which had been applied to relays 44' and 45' through windings 58' and 59', respectively, is thereby immediately removed so that relays 44' and 45' are in condition for immediate operation by east if he now starts to talk.

Relay 38', however, will not be immediately released due to the deenergization of its winding 55' but will be held operated for an additional hang-over interval while condenser 65',

which was discharged when relay 57' operated, is being charged up from battery 78' through winding 62' of relay 38' and series resistance 64'. At the end of this hang-over interval, the contact and armature of relay 38' will close reconnecting the master relay 37' to the output of the amplifier-detector 36' and thus conditioning the transmitting control circuit at the east terminal for immediate operation by east when he starts to speak. The slow-operating and thus slow-releasing relay 57' will also release to open its armature and contact a given time interval after the receiving master relay 54' has released. The switching circuits at both terminals are now in their normal condition as indicated at the west terminal shown in Fig. 3 with the transmitting circuit blocked due to the unoperated condition of the transmitting circuit enabling relay 44 or 44', and with the receiving circuit operative due to the low loss condition of the network 35, 35' with the receiving circuit disabling relay 45, 45' unoperated.

The interlocks between the transmitting and controlling circuit at each terminal in the system as shown in Fig. 3 provided by the biasing windings on the transmitting control relays and the immediate disabling of the transmitting master relay under control of the receiving control circuit are such as to prevent false operation on initial echoes without the use of expensive artificial delay circuits in the transmission paths.

The delay in application of the hang-over to the relay in the receiving control circuit which causes the disabling of the transmitting control circuit, that is, relay 38 or 38', provided by making the relay 57, 57' slow-operating serves to reduce the number of false operations by noise with full hang-over, and thus allows greater sensitivity of the receiving amplifier-detector 53, 53' and higher received volume. This is because the noise peaks are usually of short duration and of infrequent occurrence so that they will not hold the receiving master relay operated long enough to complete operation of the relay 57, 57' controlling the application of hang-over if the operating time of the latter relay is properly selected by suitable choice of the shunting condenser.

A complication which may result if the principle of delayed hang-over is applied to the receiving side alone is that there is a possibility of the false operation of the transmitting master relay 37, 37' by delayed noise echoes. The chances are that the original narrow static peak operating the receiving master relay would be considerably reduced in amplitude when it returns as an echo. This false operation is not harmful when the local party is talking, but would interfere with the received speech if returned at the moment when the controls were returned to normal. The effect of this possible false operation of the transmitting master relay is minimized in the system of Fig. 3 by also applying the principle of delayed hang-over to the transmitting side by making the relay 41, 41' which supplies the hang-over to the enabling and disabling relays 44, 44' and 45, 45', respectively, slow-operating to the required degree. By proper choice of the value of the condenser shunting the latter relay, its operating time may be made so slow that the transmitting master relay 37, 37' will not be maintained operated long enough by the noise peaks which are usually of short duration and of infrequent occurrence to complete the operation of the latter relay. In this

case, there should be no reduction in speech sensitivity because a voice operated anti-singing circuit (vodas) such as shown in the system of Fig. 3 is set more sensitive than an echo suppressor, to avoid excessive speech clipping, and the weaker syllables operate the transmitting master relays before they reach their maximum amplitudes. If it is deemed essential to have the transmitting master relay peak operated, it could be provided with a hang-over by suitable choice of the value of the shunting condenser sufficient to cover the vocal period (about .01 second) and the application of the full hang-over (0.15 second) would have to be delayed at least this length of time. Such an arrangement might also lessen the effect of false operation by line noise.

Various modifications of the circuits illustrated and described which are within the spirit and scope of the invention will occur to persons skilled in the art. The invention is to be limited only in accordance with the appended claims.

What is claimed is:

1. In a two-way signal transmission system comprising at least near the terminals thereof one-way paths for transmitting the signals in opposite directions, switching means connected to one one-way path near one terminal of the system, and responsive to transmission of signals in said one path to disable the other one-way path, means for producing a hang-over in the operation of said switching means so that said other one-way path will remain disabled a desired interval of time after cessation in the supply of controlling signals to said switching means, and means for preventing said hang-over becoming effective unless said switching means has been continuously operated by the signals for a given time.

2. In a two-way signal transmission system comprising at least near the terminals thereof one-way paths for transmitting the signals in opposite directions, switching means connected to one one-way path near a terminal of the system, and responsive to signal transmission therein to disable the other one-way path, means for producing a hang-over in the operation of said switching means so that said other one-way path will remain disabled a desired interval of time after cessation in the supply of controlling signals to said switching means, and means for deferring the application of the hang-over to said switching means until the latter has been continuously operated for a given time.

3. The system of claim 1, and in which said desired interval of time for which said other one-way path will remain disabled is at least equal to the time of transmission over said one-way paths from the point of connection of said switching means to said one one-way path through the terminal connected to the output of said one-way path, and said given time for which the switching means must be operated to cause said hang-over to become effective is determined by the maximum time interval between peaks of substantially equal amplitude in said signals.

4. In a two-way telephone transmission system, a four-wire repeating circuit comprising two oppositely-directed one-way circuits for repeating telephonic signals in opposite directions between two two-way lines, a wave-operated switching device connected to each one-way circuit near its output and responsive to waves received therefrom to disable the other one-way

circuit near its input, hang-over means associated with each switching device and responsive to operation thereof to prolong the disabling of said other one-way circuit for a given time after cessation in the supply of controlling signal energy to said switching device, and means for preventing the hang-over means from becoming effective unless the associated switching device has been continuously operated for a predetermined interval of time.

5. In a two-way telephone transmission system, a four-wire repeating circuit comprising two oppositely directed one-way circuits for repeating telephonic signals in opposite directions between two two-way lines, a wave-operated switching means connected to each one-way circuit near its output and responsive to waves received therefrom to disable the other one-way circuit in its input, and hang-over means associated with each switching means for maintaining the other one-way circuit disabled for a given time after cessation in the supply of controlling wave energy to the switching means, said hang-over means being effective if the switching means has been previously operated by continuous voice energy but ineffective if the switching means has been previously operated by a noise peak.

6. The system of claim 4, in which said switching device comprises a wave-operated device arranged to be supplied with the wave-energy from the connected one-way circuit and a chain of mechanical relays energized by operation of said device, one of said relays when energized operating immediately to disable the other one-way circuit, said hang-over means comprises a hang-over winding on said relay energized by operation of another relay in said chain, and said means for preventing the hang-over from becoming effective comprises means for making said other relay slow-operating to the required degree.

7. A radio telephone system for transmitting telephonic signals in opposite directions between two two-way lines, comprising at each terminal a normally disabled transmitting circuit and a normally operative receiving circuit connected to one of said two-way lines, a wave-operated switching means connected to the transmitting circuit and responsive to initiation of signal transmission therein in the absence of simultaneous signal transmission in the receiving circuit to disable said receiving circuit and to render operative the transmitting circuit, a second wave-operated switching means connected to the receiving circuit and responsive to received signals when that circuit is operative to disable the first switching means, a hang-over circuit associated with the first switching means and responsive to its operation to produce a hang-over in the disabling of said receiving circuit and the operative condition of said transmitting circuit for a predetermined interval of time after cessation in the supply of controlling signal energy to said first switching means, and means for preventing the hang-over from becoming effective unless said first switching means is continuously operated for a given time interval.

8. The system of claim 7, in which said first switching means comprises a wave-operated device connected to said transmitting circuit and at least two relays energized by operation of said device, one of said relays when energized causing the disabling of said receiving circuit, and said hang-over circuit includes another of said relays, which, when operated, applies hang-over

to said one relay, and said means for preventing the hang-over from becoming effective comprises means for making said other relay slow-operating in response to its energization.

5 9. A radio telephone system for transmitting telephonic signals in opposite directions between two two-way lines, comprising at each terminal a normally disabled transmitting path and a normally operative receiving path coupled to one
10 of said two-way lines, wave-operated switching means connected to the transmitting path in front of the disabling point therein and responsive to outgoing signals to disable said receiving path and to render said transmitting path operative to transmit said signals, a second wave-
15 operated switching means connected to the receiving path and responsive to incoming signals when that path is operative to disable the first switching means, hang-over means associated with said second switching means and responsive
20 to its operation to produce a hang-over in the disabling of said first switching means a given interval of time after cessation in the supply of controlling signal energy to said second switching means, and means for preventing this hang-
25 over in operation becoming effective unless said second switching means is continuously operated for a predetermined length of time.

30 10. The system of claim 9, in which said second switching means comprises a wave-operated device connected to said receiving path and a chain of mechanical relays energized by operation of said device, one of said relays when energized operating to cause said first switching
35 means to be disabled, said hang-over means includes a second relay in said chain which, when operated, applies hang-over to said one relay,

and said means for preventing said hang-over from becoming effective comprises means for making said second relay slow operating in response to its energization.

11. A system for transmitting signals in op- 5
posite directions between two two-way lines comprising at least at each terminal thereof transmitting and receiving one-way signal paths coupled to a different one of said two-way lines, a first switching circuit connected to the trans- 10
mitting circuit and responsive to outgoing signals therein, in the absence of incoming signals simultaneously present in the receiving circuit, to condition the one-way paths so that the trans- 15
mitting circuit is operative to transmit and the receiving circuit is disabled, and a second switching circuit connected to the receiving circuit on the output side of the disabling point therein, and responsive to incoming signals, when the re- 20
ceiving circuit is operative, to immediately bias said first switching circuit against operation by signals and thereafter to completely disable said first switching circuit in its input.

12. The system of claim 11, in which said first switching circuit comprises a wave-operated de- 25
vice connected to said transmitting circuit and at least two mechanical relays energized by operation thereof, certain of said relays when operated properly conditioning said one-way cir- 30
cuits, and the means for biasing said first switching circuit against operation comprises biasing windings on said certain relays wound to oppose the operating windings thereof, which biasing windings are energized in response to operation
35 of said second switching circuit.

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