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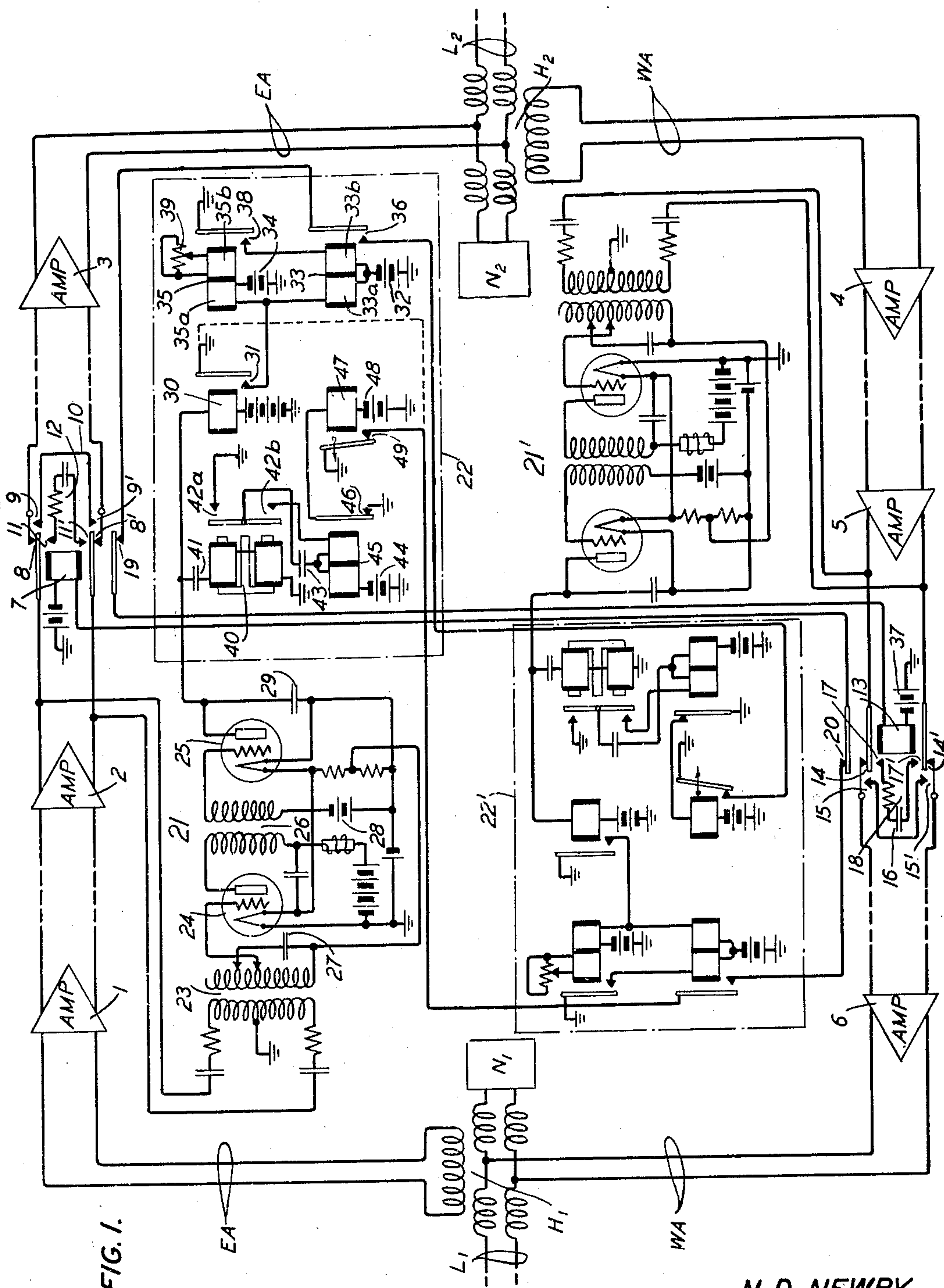
N. D. NEWBY ET AL

1,927,133

TRANSMISSION CONTROL IN SIGNALING SYSTEMS

Filed March 10, 1931

3 Sheets-Sheet 1



INVENTORS
N. D. NEWBY
D. L. MOODY

BY

gr York

ATTORNEY

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N. D. NEWBY ET AL

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3 Sheets-Sheet 2

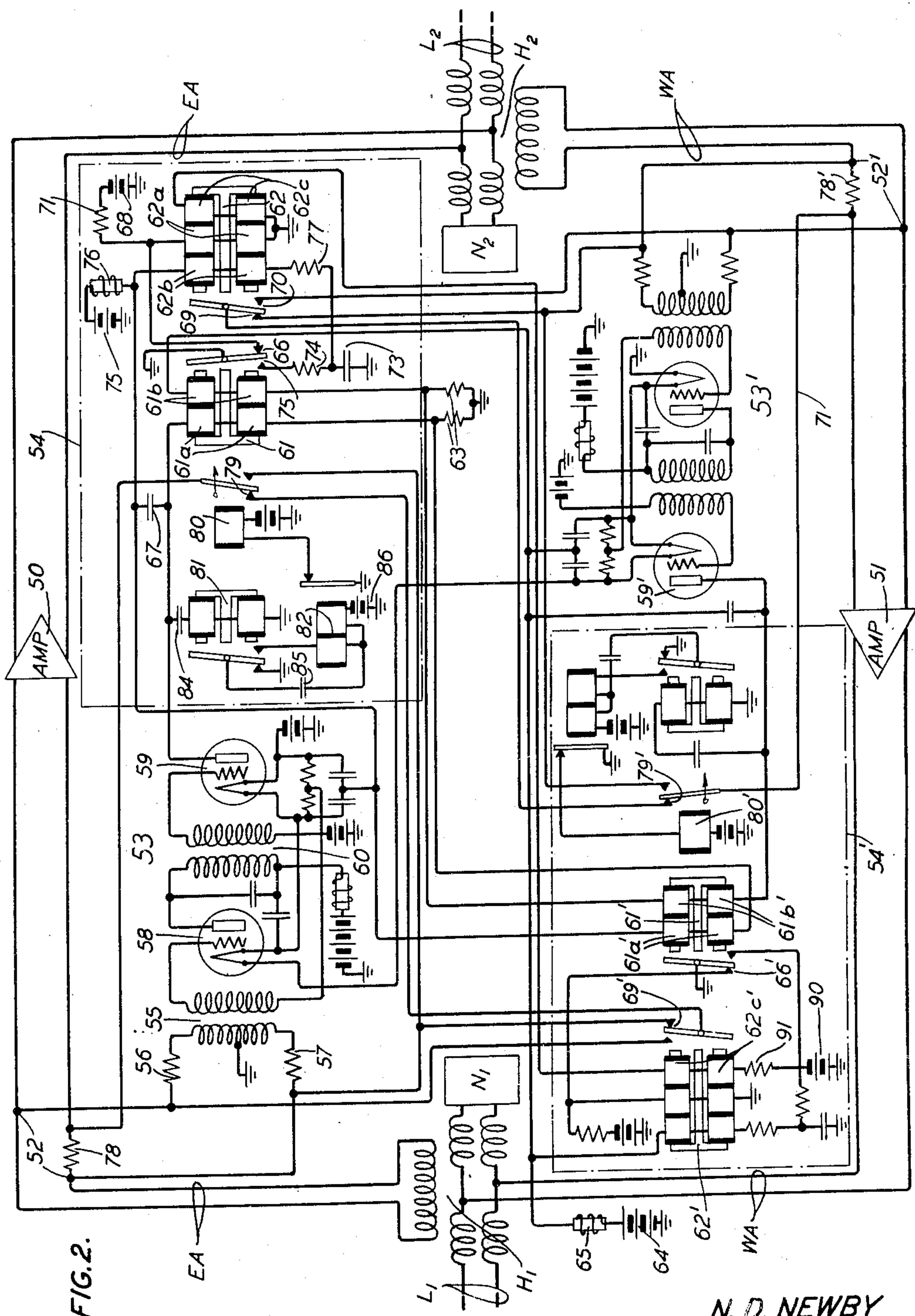


FIG. 2.

INVENTORS N. D. NEWBY
D. L. MOODY
BY

g e 70 4 c
ATTORNEY

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3 Sheets-Sheet 3

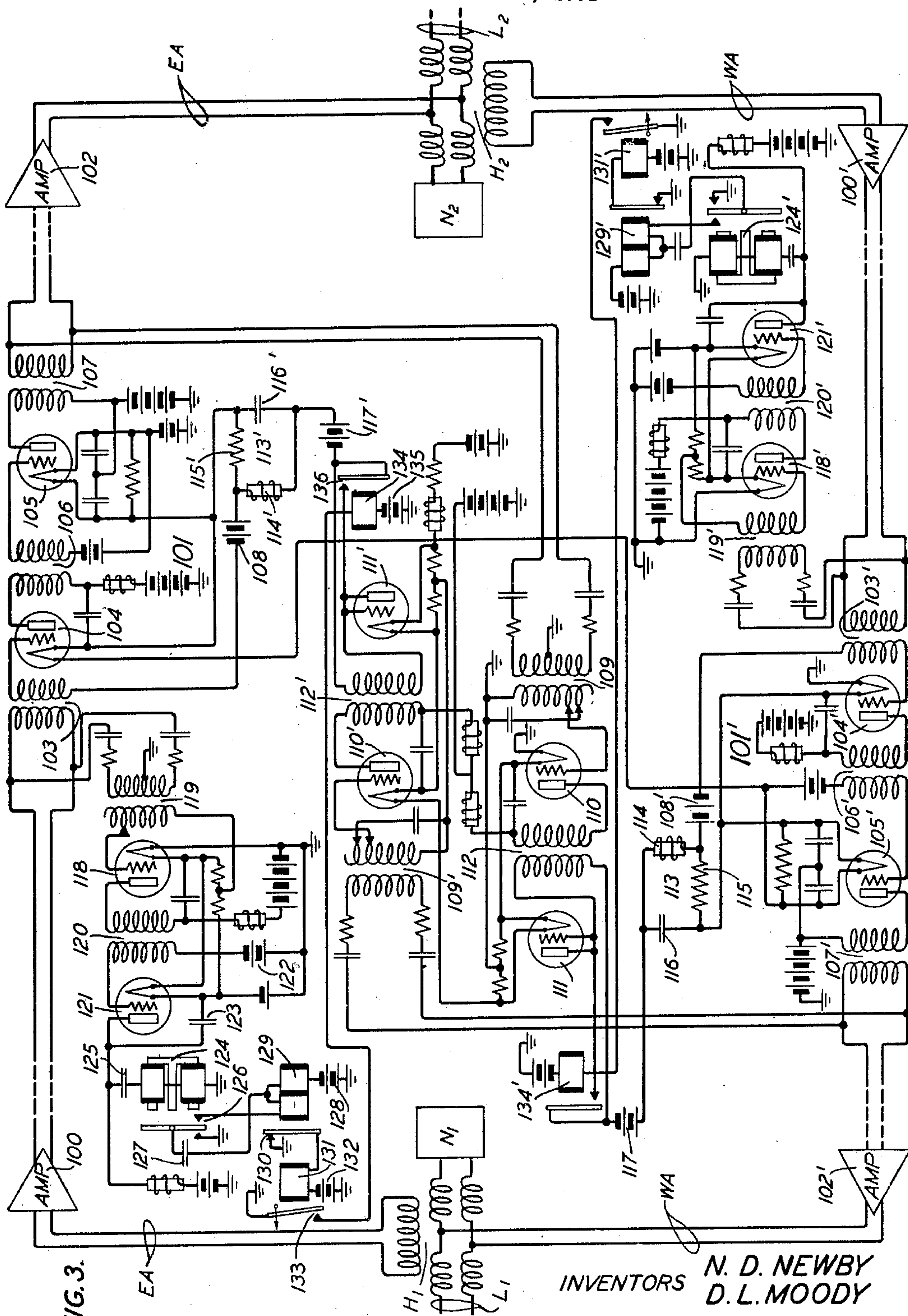


FIG. 3.

INVENTORS
BY

N. D. NEWBY
D. L. MOODY

gerfolk

ATTORNEY

UNITED STATES PATENT OFFICE

1,927,133

TRANSMISSION CONTROL IN SIGNALING SYSTEMS

Neal D. Newby, Woodbridge, N. J., and Dwight L. Moody, Hempstead, N. Y., assignors to American Telephone and Telegraph Company, a corporation of New York

Application March 10, 1931. Serial No. 521,586

11 Claims. (Cl. 179—170)

This invention relates to two-way signaling systems and particularly to two-way toll telephone systems equipped with voice-operated echo suppressors, and utilizing auxiliary alternating current signals for operating calling and supervisory apparatus at the ends of the signal transmission line.

The voice-operated echo suppressors of the prior art impose fundamental limitations on voice frequency signaling over toll telephone lines. One of these limitations is that the suppressors ordinarily will operate to prevent duplex signaling over the toll line. Another is that they will prevent signaling out over the toll line while speech or tones are coming in the reverse direction. These limitations do not prevent satisfactory operation on most toll lines in use at present in which the echo suppressors are operated by the so-called ring-down method which allows the operators to keep on signaling until the voice energy or tones coming in the reverse direction are interrupted long enough to permit the signals to get through. However, if it is desired to use some sort of automatic control of signaling on these toll lines, such as would be used, for example, with voice frequency, multi-channel, straightforward or dialing operation, echo suppressors of the present design could not be used unless more or less complicated and expensive auxiliary circuits are utilized for relaying the signals around the suppressors.

An object of the invention is to improve the operation of a two-way toll telephone system equipped with voice operated echo suppressors and employing auxiliary alternating current signals for controlling the calling and supervisory signal apparatus at the ends of the system.

The invention is a two-way toll telephone system in which the voice operated echo suppressor circuits are arranged so as to allow full or half-duplex direct transmission of alternating current calling or supervisory signals over the system at all times, even while speech waves or tones are coming in the reverse direction.

This is accomplished in a preferred embodiment by relay means associated with each echo suppressor and responsive to received calling and supervisory signals to render the suppressors ineffective thus allowing the signals to be freely transmitted over the toll line in either direction, while allowing the suppressors to function in the usual manner to suppress echoes or to prevent singing in response to transmitted speech waves or other signals when the calling or supervisory signals are not being transmitted.

The exact nature of the invention and its advantages will be understood from the following detailed description thereof when read in connection with the accompanying drawings in which:

Figure 1 shows the invention applied to a four-wire telephone circuit employing echo suppressors of the mechanical relay type;

Fig. 2 shows the invention applied to a two-wire telephone circuit employing echo suppressors of the mechanical relay type; and

Fig. 3 shows the invention applied to a four-wire telephone repeater circuit equipped with echo suppressors of the vacuum tube type.

Fig. 1 shows the invention applied to a four-wire telephone circuit employing echo suppressors. The telephone circuit comprises a one-way, two-wire path EA including the one-way amplifying devices 1, 2 and 3 adapted for repeating in amplified form telephone currents received from a west two-way telephone line section L₁ to an east two-way telephone line section L₂, and a one-way repeating path WA including the one-way amplifiers 4, 5 and 6 adapted for repeating in amplified form telephone currents received from the east two-way line section L₂ to the west two-way line section L₁. The input of the repeating path EA and the output of the repeating path WA are connected in energy transmitting relation with the west line section L₁ and in substantially conjugate relation with each other by means of the three-winding transformer or hybrid coil H₁ and associated balancing network N₁, and the output of the repeating path EA and the input of the repeating path WA are connected in energy transmitting relation with the east line section L₂, and in substantially conjugate relation with each other by means of the three-winding transformer or hybrid coil H₂ and associated balancing network N₂, in well known manner.

Both the repeating path EA and the repeating path WA in the absence of signal transmission thereover are normally operative.

The normally deenergized mechanical relay is adapted when energizing current is supplied to its winding to open the normally closed contacts 8, 8' in the repeating path EA to disconnect the east portion of the path EA from the west portion thereof, to close normally open contacts 9, 9' to connect the short-circuiting connection 10 across the east portion of the path EA, and to close normally open contacts 11, 11' to connect a suitably designed balancing network 12 to the west portion of the amplifying path EA.

Similarly, adjacent the amplifying path WA is a normally deenergized mechanical relay 13 adapted, when energizing current is supplied to its winding, to open the normally closed contacts 14, 14' in the path WA, to disconnect the east portion of the path WA from the west portion thereof, to close normally open contacts 15, 15' to connect the short-circuiting connection 16 across the west portion of the path WA, and to close normally open switches 17, 17' to connect a suitably designed balancing network 18 across the east portion of the amplifying path WA.

Also, the relay 7 when energized opens the normally closed contact 19 in the energizing circuit for relay 13, and the relay 13 when energized opens the normally closed contact 20 in the energizing circuit for relay 7.

Connected across the one-way amplifying path EA between the point of connection therein of the normally closed contacts 8, 8' and the hybrid coil H₁ and preferably in the output of an amplifier in that portion of the path EA is the input of the suppressor controlling transmission in the path WA, which will be referred to hereinafter as the west suppressor. It comprises the vacuum tube circuit 21, the input of which is connected across the path EA, and the chain of relays shown within the dot-dash box 22 in the output of the circuit 21 and controlled thereby. Connected across the one-way amplifying path WA between the point of connection of the normally closed contacts 14, 14' therein and the hybrid coil H₂, and preferably in the output of an amplifier in that portion of the path WA, is the input of the suppressor controlling transmission in the path EA, which will be referred to hereinafter as the east suppressor. It comprises the vacuum tube circuit 21', the input of which is connected across the path WA, and the chain of mechanical relays shown within the dot-dash box 22', in the output of the circuit 21' and controlled thereby.

The chain of mechanical relays within the dot-dash box 22 controls the operation of the mechanical relay 13 adjacent the amplifying path WA and the energizing circuit for relay 7, and the chain of relays within the box 22' controls the operation of the relay 7 adjacent the path EA and the energizing circuit for the relay 13, in the manner which will be described below.

The vacuum tube circuit 21' and the relay chain 22' in the east suppressor is similar to the vacuum circuit 21 and the relay chain 22, respectively, in the west suppressor and operates in similar manner. Only the latter, therefore, will be described in detail. In the following description the apparatus in the circuit 21' and in the box 22' in the east suppressor will be identified by the same characters as the corresponding apparatus in the west suppressor, but followed by a prime (') mark.

The input of the vacuum tube circuit 21 is designed to offer a high impedance to the portion of the repeating path EA to which it is connected so that it will not appreciably affect the direct transmission of telephone waves over the path EA. The power taken from the path EA by the associated echo suppressor is therefore relatively small, requiring amplification in order that it may control the operation of the relay chain within the dot-dash box 22. The vacuum tube circuit 21 comprises the input transformer 23 and the two three-electrode vacuum tubes 24 and 25 connected in tandem through the interstage transformer 26. The input transformer 23

is broadly tuned by the condenser 27 in shunt to its secondary winding and by the capacity introduced by the transformer windings and the input capacity of the tube 24 so as to transmit efficiently to the tube 24 incoming currents within the voice frequency signaling range, but to be inefficient for transmitting other frequencies, particularly those below 500 cycles per second. Some protection is thereby secured against operation of the tube 24 by low frequency noise currents received from the path EA. Input transformer 23 has taps as shown by which the voltage applied to the grid of the tube 24 and consequently the sensitivity of the vacuum tube circuit 21 can be readily adjusted.

The three-electrode vacuum tube 24 is arranged to function as an amplifier, and the tube 25 is arranged to function as a combined amplifier and C bias detector the output current of which controls the operation of the relays shown within the box 22. The coupling circuit between the tubes 24 and 25 and including the interstage transformer 26 is designed to provide maximum transmission efficiency in the range of important voice frequencies. The grid of the detector tube 25 is supplied by the grid battery 28 with a relatively large negative potential so as to reduce the space current of the tube to zero, or nearly so, when no alternating current voltage is supplied to the input electrodes of the tube 25 through the interstage transformer 26. When voice currents are being transmitted over the repeating path EA in the direction from west to east, a portion thereof will be impressed by the input transformer 23 of the vacuum tube circuit 21 on the input of the amplifying tube 24 and amplified thereby. The amplified voice waves in the output of the amplifier 24 will be impressed by the interstage transformer 26 upon the input electrodes of the detector 25. The instantaneous values of the alternating voltage impressed upon the grid of the detector 25 which make the grid more negative produce no effect on the output current of that tube, but instantaneous values of the impressed voltage which makes the grid of the tube 25 more positive cause pulses of current to be produced in the plate circuit of the detector tube. The small condenser 29 shunted across the output of the detector tube 25 is provided for the purpose of smoothing out the resulting output current of the tube.

The pulses of current in the plate circuit of the detector tube 25 due to the positive portions of the amplified voice waves impressed on the input circuit thereof pass through the winding of the normally deenergized relay 30, which is the first relay in the chain shown within the dot-dash box 22, energizing that winding. The energization of the winding of relay 30 causes that relay to operate to close the normally open contacts 31 to close an energizing circuit from the source of direct current 32 through one operating winding 33a of the relay 33, and to close an energizing circuit from the source of direct current 34 through the operating winding 35a of the hang-over relay 35. Relay 33 will then operate to close the normally open contacts 36 to close an energizing circuit from battery 37 to the winding of relay 13. Relay 13 will then operate to open the normally closed contacts 14, 14' in the repeating path WA, disconnecting the west portion of that path from the east portion thereof, to close normally open contacts 15, 15' to connect the short-circuiting connection 16 across the west portion of the path WA, and to close

the normally open contacts 17, 17' to connect the balancing network 16 across the east portion of the repeating path WA.

The hang-over relay 35 in response to the energization of its winding 35a, will operate simultaneously with the relay 33, to close the normally open contacts 38 to close an energizing circuit from the source of direct current 32 through the hold-over winding 33b of relay 33, thus holding that relay operated.

The function of the hang-over relay 35 is to hold the relay 33 and therefore the relay 13 operated until all the echo currents in the path WA due to the speech currents being transmitted in the repeating path EA are dissipated in the short-circuiting connection applied to the east portion of the repeating path WA by operation of the relay 13. This is accomplished as follows:

When the input voltage to the vacuum tube circuit 21 ceases due to the cessation of the transmission of speech currents in the direction from west to east over the repeating path EA, the detector vacuum tube 25 returns to its normal zero space current condition causing relay 30 to release. The release of relay 30 opens the contacts 31 causing the energizing current for the operating windings 33a and 35a of the relay 33 and the hang-over relay 35, respectively, to be interrupted. Relay 33, however, cannot release at once because it is still held operated by the current in its hold-over winding 33b under control of the hang-over relay 35 the opening of the contacts 38 of which is delayed by the effect of a circulating current in the hang-over winding 35b of relay 35. This circulating current is produced through induction when the current through the operating winding 35a is interrupted due to the release of relay 30. The time which elapses between the termination of the input voltage to the vacuum tube circuit 21 due to cessation of the transmission of the speech currents in the repeating path EA, and the release of the relay 33 depends on the value of the resistance 39 in series with the hang-over winding 35b of the hang-over relay 35. The greater the value of the resistance 39, the smaller the circulating current; therefore, the more quickly the release of relay 33 will take place. By means of various combinations of the regulating resistance 39, various hang-over times may be secured. At the end of this interval, the hang-over relay 35 releases to open the contacts 38 so as to interrupt the energizing current for hold-over winding 33b of relay 33 thus causing the release of the relay 33 and the consequent release of the relay 13, causing the short-circuiting connections across the repeating path WA to be removed so as to allow transmission of speech current thereover.

The method of operation of the system when speech current signals alone are being transmitted over the repeating paths has been described above. The method of operation of the system when supervisory or ringing signals consisting of voice frequency carrier interrupted at the proper signaling rate, say, 20, 30 or 45 times per second, are also transmitted over the repeating path will now be described.

The carrier is amplified and detected by the vacuum tubes 24 and 25 in the vacuum tube circuit 21. The interrupting frequency of the carrier, therefore, appears in the plate circuit of the detector tube 25 and flows through the winding of the relay 30 and the winding of a polarized relay 40 connected in a circuit in parallel with relay 30, causing their operation. The condenser

41 in series in the circuit containing the windings of polarized relay 40 tunes that circuit broadly enough to receive the interrupting frequencies of the carrier. The periodic reversal of the current in the windings of the polarized relay 40 causes its armature to periodically and alternately make and break contact with contacts 42a and 42b so as to alternately charge the condenser 43 with current from the battery 44 and discharge it through the windings of the relay 45. Relay 45 then operates and is maintained operated as long as the polarized relay 40 is energized, to open the normally closed contact 46 to break the normal energizing circuit for slow-release relay 47 from battery 48. The slow-release time of relay 47 is provided to prevent the opening of its contacts 49 due to the momentary opening of the contacts 46 of relay 45 caused by the application of voice currents to the chain of relays 40 and 45. The relay chain consisting of relays 40 and 45 is arranged by any suitable means so as to operate on the interrupting frequency. The release of relay 47 opens the normally closed contacts 49 in the energizing circuit for relay 7 and thereby prevents subsequent operation of that relay in response to the voice currents in the repeating path WA through operation of the east echo suppressor. The normally closed contacts 8, 8' in the repeating path EA remained closed, therefore, so that the interrupted signaling current, as well as any voice currents which may be received from the two-way circuit L₁ may pass over the path EA to the two-way line section L₂. In other words, whenever properly interrupted signaling currents are impressed on either side of the suppressor, or on both sides simultaneously, these currents themselves prevent the suppressor from short-circuiting them. In this manner, therefore, the echo suppressor permits full duplex, multi-channel voice frequency signaling. It should be noted that relays 13 or 7 in addition to short-circuiting the adjacent repeating path when speech currents are being transmitted over the other repeating path, permit the echo suppressor associated with the short-circuited repeating path, to remain bridged thereacross to receive signals in the opposite direction at any time. For example, relay 7 accomplishes this by opening the path EA and placing a termination, the properly designed balancing network 12, on the side of the path which is not short-circuited. Therefore, when properly interrupted signaling currents are received by the repeating path EA from the circuit L₁ at the time relay 7 is operated, the energizing circuit for relay 7 will be broken by the operation in sequence of relays 40 and 45 causing the release of relay 47 to open the contacts 49. The release of relay 7 removes the short circuit on the repeating path EA by causing the contacts 9, 9' and 11, 11' to open, and closes the open circuit in the path EA by causing the contacts 8, 8' to return to their normal closed condition.

It will be seen that with the arrangement described supervisory or ringing signals will always be permitted to pass over either repeating path between the two-way line sections L₁ and L₂ regardless of whether the echo suppressor associated with the oppositely directed repeating path is already operated and regardless of the direction of signaling. Thus, full-duplex multi-channel signaling is insured.

In order to avoid interference between the voice currents and the ringing or supervisory

signals, the signaling frequencies which are used to interrupt the carrier should be preferably chosen outside the syllabic frequency range.

Although the suppressor is not functioning as such when interrupted signaling currents are passing over both sides of the circuit simultaneously, if the double carrier, duplex signaling system is used, (different carrier frequencies in opposite directions), the echo must pass over the circuit twice before reaching a ringer which it may affect, that is, a ringing signal which is sent from a west station associated with the line section L_1 passes over the repeating path EA and line section L_2 to an east station associated with the line section L_2 where it actuates a ringer. The echo of that ringing signal passes back over the repeating path WA to the west station. The ringer at the west station is adjusted for a different ringing frequency, that of the ringing signal originating at the east station, and is, therefore, not affected by the echo. The echo may be again reflected at the west station and passed over the repeating path EA to the east station again. It should be noted that since this echo is passed over the circuit twice its level will be materially lower than that of the ringing signal itself and should not, therefore, affect the ringer at the east station.

Fig. 2 shows a modified form of the invention applied to a two-wire repeater circuit equipped with echo suppressors of the mechanical relay type. The repeater circuit comprises a normally operative one-way path EA including the one-way amplifying device 50 for repeating in amplified form telephonic currents in the direction from west to east between a west two-way line section L_1 and an east two-way line section L_2 , and a one-way amplifying path WA including the one-way amplifier 51 for repeating in amplified form telephonic currents in the direction from east to west between the east line section L_2 and the west line section L_1 . The input of the amplifying path EA and the output of the amplifying path WA are connected in energy transmitting relation with the two-way line section L_1 , and in substantially conjugate relation with each other by means of the hybrid coil H_1 and associated balancing network N_1 , and the output of the repeating path EA and the input of the repeating path WA are associated in energy transmitting relation with the line section L_2 , and in substantially conjugate relation with each other by means of the hybrid coil H_2 and associated balancing network N_2 , in well known manner.

Connected across the repeating path EA at the points 52 in the input of the amplifier 50 therein is the input of the west echo suppressor comprising the vacuum tube circuit 53 and the chain of mechanical relays controlled thereby shown within the dot-dash box 54. Connected across the repeating path WA at the points 52' in the input of the amplifier 51 therein is the input of east echo suppressor comprising the vacuum tube circuit 53' and the chain of mechanical relays controlled thereby shown within the dot-dash box 54'.

As the elements in the east suppressor are identical with those in the west suppressor and similarly arranged, it will be only necessary to describe in detail those in the former. In the following description apparatus in the east echo suppressor corresponding to that in the west echo suppressor will be identified by the same characters, but with a prime (') mark following.

The vacuum tube circuit 53 in the west echo

suppressor is connected across the repeating path EA at the points 52 through the input transformer 55 which is arranged to provide a high voltage step-up. The resistances 56 and 57 of suitable value are connected in series with the primary winding of the input transformer 55 for the purpose of reducing the bridging loss of the input impedance of the suppressor on direct transmission through the repeating path EA. The vacuum tube circuit 53 comprises the three-electrode vacuum tube 58 operating to amplify the voice energy taken from the input of the repeating path EA, and the three-electrode vacuum tube 59 acting as a combined amplifier and detector to convert the amplified voice energy into pulsating unidirectional current suitable for operating relays. The vacuum tubes 58 and 59 are connected in tandem through the interstage transformer 60 which is designed to give a high voltage step-up for transmitted waves of frequencies in the neighborhood of 1000 cycles per second so that the vacuum tube circuit as a whole provides maximum transmission efficiency at this frequency and somewhat less efficiency at other frequencies, particularly below 500 cycles per second. This provides some protection from low frequency noise currents, and makes the vacuum tube circuit more sensitive at frequencies where the power in the direct transmission is strong.

The vacuum tubes 58 and 59 in the vacuum tube circuit 53 have the usual filament heating, grid biasing and space current supply batteries. Negative grid potential for the amplifier tube 58 is obtained from a portion of the voltage drop in the filament circuit of the tubes. The circuit is designed so that a sufficient negative biasing potential is applied to the grid of the detector tube 59 to insure that no plate current will flow through the relays in the plate circuit when no voltage is applied to the input of the vacuum tube circuit 53 from the repeating path EA.

In the relay chain controlled by the vacuum tube circuit 53 and shown within the dot-dash box 54 is a polarized relay 61, which will be referred to hereafter as the detector relay as it is connected in the plate circuit of the detector tube 59 so as to be operated directly by impulses therefrom, and a polarized relay 62 acting as a hang-over relay. The detector relays 61 and 61' of the two suppressors are connected in a differential arrangement. One winding 61a of the detector relay 61 is connected to the corresponding winding 61a' of the detector relay 61' in the other suppressor in such manner that when a current impulse is produced in the plate circuit of the detector tube of one suppressor, for example, in the plate circuit of the detector tube 59 in the west echo suppressor, causing the winding 61a of the detector relay 61 to be energized, the same energizing current flows also through the winding 61a' of the detector relay 61' in the east echo suppressor in such direction as to put strong bias on that relay, tending to prevent it from being falsely operated by reflected current due to irregularities in the repeating paths.

Plate battery of the detector tubes 59, 59' is fed through the two detector relays as shown, and between the two windings of these relays a resistance 63 to ground is placed. Plate current is supplied to the plate of the detector tubes 59', from the plate battery 64 through retard coil 65, the windings 61b, 61b' of the detector relays and resistance 63 thus biasing the relay 61 so that when the suppressors are in the non-operated condition, the armature of the relay is held

against the back contacts 66. In a similar manner plate current is supplied to the plate of detector tube 59 from battery 75 through retard coil 76 and windings 61a' and 61a and resistance 53 thus properly biasing relay 61'.

The negative grid potential applied to each detector tube 59, 59' reduces its space current to zero or nearly so when no voltages are being impressed on the input of the vacuum tube circuits 53, 53'. Consequently the detector relays 61, 61' are normally in a released condition with the armatures held to their back contacts 66, 66' by biasing current from batteries 64 and 75. When voice currents are being transmitted over the repeating path EA a portion is impressed on the input of the vacuum tube circuit 53 of the west suppressor through the input transformer 55. The impressed voice currents are amplified by the vacuum tube amplifier 58 and the amplified alternating voltages are impressed upon the grid of the detector tube 59 through the inter-stage transformer 60. Instantaneous values of this voltage which make the grid of tube 59 more negative, produce no effect on the space current of the tube, but instantaneous values of the impressed voltage which make the grid more positive cause corresponding pulses of current to appear in the plate circuit of tube 59 and pass through the winding 61a of the detector relay 61 causing that relay to operate and the winding 61a' of detector relay 61' biasing the latter relay against operation. The condenser 67 is utilized to by-pass the alternating current component of the rectified current in the plate circuit of the detector tube 59 from the detector relays so as to prevent chatter.

Now, if the alternative voltage due to speech transmission in path EA, applied to the input of the vacuum tube circuit 53 is of sufficient magnitude, the resultant plate current in the detector tube 59 is of sufficient value to cause the operation of the detector relay 61 and to cause a strong bias to be placed on the corresponding winding of the detector relay 61' in the east echo suppressor. The armature of relay 61 will leave its back contact 66. As soon as the armature of relay 61 has moved from the contact 66, short-circuiting ground is removed from winding 62a of relay 62 allowing current to flow from battery 68 through resistance 71 through the winding 62a of the hang-over relay 62. This causes hang-over relay 62 to operate, the armature thereof moving from the back contact 69 to the front contact 70 closing a short-circuiting connection 71 across the repeating path WA in the input of the amplifier 51 thereby preventing transmission of speech currents over that path until the short circuit has been removed. Meanwhile, the armature of the detector relay 61 will have moved from the back contact 66 to the front contact 72 discharging the condenser 73 through a resistance 74 to ground, and at the same time will cause current to flow from the grounded battery 75 through retardation coil 76, the winding 62b of the hang-over relay 62 through resistance 74 and 77 to ground. The current flowing through the winding 62b of the relay 62 will assist in maintaining the hang-over relay 62 in its operated condition.

If now, the input of speech currents from the repeating path EA to the input of the west suppressor ceases, the space current in the detector tube 59 will be reduced to zero, causing detector relay 61 to release and its armature

will fall back from its front contact 72 to its back contact 66 to short-circuit the energizing circuit for winding 62a of hang-over relay 62 reducing the current therein to zero by grounding the battery 68 through resistance 71, and removing the ground from winding 62b of the hang-over relay 62. However, the armature of the hang-over relay 62 will not immediately fall back since current from the battery 75 will continue to flow through the winding 62b of this relay and resistance 77 until the condenser 73 is fully charged. The length of time that this current will flow depends upon the value of resistance 77 and the capacity of the condenser 73. At the end of this time interval, the hang-over relay 62 will release moving its armature from contact 70 to contact 69 and thus producing an open circuit in the connection 71 short-circuiting the path WA. The path WA is now operative so as to transmit speech waves thereover from the line section L₂ to the line section L₁ in the direction from east to west. Current from battery 90 through resistance 91 flows through windings 62c and 62c' of relays 62 and 62' to bias these relays so that the armature normally closes contacts 69 and 69'.

So far, the resistance 78 in series in one line wire of the path EA in the input of amplifier 50 and the corresponding resistance 78' in the input of amplifier 51 in repeating path WA have not been mentioned. Their function is to prevent the input of an echo suppressor from being short-circuited when the associated repeating path is short-circuited. The resistance 78 is normally short-circuited through the front contact 79 of the normally energized, slow-release relay 80 in the west suppressor and the back contact 69' of the hang-over relay 62' in the east suppressor so that its presence does not affect transmission over the repeating path EA. Similarly, the resistance 78' is normally short-circuited through the front contact 79' of slow-release relay 80' in the east suppressor and the back contact 69 of hang-over relay 62 in the west suppressor so that its presence does not affect transmission over the repeating path WA. When the repeating path WA is short-circuited by operation of the west echo suppressor in the manner described above, the short-circuiting connection around the resistance 78' in the path WA is removed so that incoming speech currents in that path received from the line section L₂ flow through the resistance 78' produce a voltage drop in the resistance which is proportional to the speech voltage applied to the input of the west suppressor. Resistance 78 in repeating path EA in similar manner when speech currents are received from the line section L₁, serves to apply the speech currents to the west echo suppressor when the associated repeating path is short-circuited by operation of the east echo suppressor.

Relays 80, 81 and 82 and their associated leads, in the west echo suppressor, and the corresponding relays 80', 81' and 82' and their associated leads in the east echo suppressor, provide means for rendering the suppressors ineffective as long as calling or supervisory alternating current signals of certain characteristics such as a voice-frequency carrier interrupted at the proper signaling rate, say 20, 30 or 45 times per second, is impressed on either side of the suppressor. The frequency of interruption should be well above the syllabic frequency if possible. The conditions under which relays 80, 81 and 82 operate

and the manner of their operation are similar to that described above for the corresponding relays 40, 45 and 47 in connection with the system of Fig. 1.

5 A portion of the interrupted voice-frequency carrier transmitted over the repeating path EA is impressed upon the input of the vacuum tube circuit 53 and is amplified and detected by the two tubes 58 and 59. The interrupted frequency of the carrier, therefore, appears in the plate circuit of the detector tube 59 and causes the operation of polarized relay 81 and polarized relay 82 connected thereto. The condenser 84 in series with polar relay 81 tunes the circuit in which it is connected broadly enough to receive the interrupting frequencies of the carrier. The operation of relay 81 causes condenser 85 to be charged and discharged through the windings of relay 82 by current from the battery 86 at the signaling frequency. Relay 82 is thereby operated and causes the release of the slow-release relay 80. The slow release of this relay may be necessary in order to guard against false operation thereof in response to voice current impressed on circuit 53. The relay chain consisting of relays 82 and 81 is arranged to operate only on the interrupting frequency. If, at the time relay 80 releases, no signals or voice currents are being impressed on the east echo suppressor from the repeating path WA, the only change in the circuit resulting is that the resistance 78 in the path EA is short-circuited through the back contact of relay 80 instead of through the make contact 79 thereof and the back contact 69' of relay 62'.

35 If the repeating path EA has been previously short-circuited by the operation of relay 62' in response to transmission of speech currents in the repeating path WA, the release of relay 80 removes the short circuit on the repeating path EA by opening its make contact 79, and short-circuits resistance 78 by the closing of the back contact of relay 80. The repeating path EA is thereby opened to allow the calling or supervisory signals to pass from line section L₁ to line section L₂ regardless of whether or not speech or signal currents are flowing in path WA. It is apparent that this action can take place in both sides of the echo suppressor simultaneously and that duplex signaling is, therefore, possible.

50 Fig. 3 shows the invention applied to a four-wire repeater circuit equipped with signal controlled echo suppressors of the vacuum tube type. The repeating circuit comprises the one-way amplifying path EA adapted for repeating in amplified form in the direction from west to east, signals received from the two-way line section L₁ to the two-way line section L₂, and the one-way amplifying path WA adapted for repeating in amplified form in the direction from east to west signals received from the two-way line section L₂ to the line section L₁. The input of the repeating path EA and the output of the repeating path WA are connected in energy transmitting relation with the two-way line section L₁, and in substantially conjugate relation with each other by means of the three-winding transformer or hybrid coil H₁ and the associated balancing network N₁. Similarly, the output of the path EA and the input of the path WA are connected in energy transmitting relation with the two-way line section L₂, and in substantially conjugate relation with each other by means of the three-winding transformer or hybrid coil H₂ and associated balancing network N₂, in well known manner.

75 The repeating path EA comprises the one-way

amplifier 10 in the input of the path, the one-way vacuum tube amplifier 101 near the center of the path and the one-way amplifier 102 near the output of the path. The vacuum tube amplifier 101 in repeating path EA comprises the input transformer 103, the three-electrode vacuum tube amplifying devices 104 and 105 connected in tandem through interstage transformer 106, and output transformer 107. The vacuum tubes 104 and 105 have the usual filament heating, grid biasing and space current supply batteries. The grid electrode of the first amplifying tube 104 in the amplifier 101 receives a normal negative bias from the grid biasing battery 108 of such value as to make the tube 104 normally operative, to repeat signals impressed upon its input by the input transformer 103. The vacuum tube amplifying device 105 in the second stage of the amplifier 101 is also normally biased so as to be operative to repeat signal waves impressed upon its input by the interstage transformer 106.

The apparatus in the repeating path WA is identical with that in the repeating path EA. The apparatus in the path WA corresponding to that in the repeating path EA is designated by similar characters followed by a prime (') mark.

Connected across the repeating path EA in the output of the amplifier 101 therein is the input of the west echo suppressor comprising the input transformer 109, the three-electrode vacuum tube amplifier 110 and the three-electrode vacuum tube rectifier 111 having its grid and plate electrodes strapped together, coupled in tandem by the interstage transformer 112, and the filter 113 comprising the retardation coil 114, the resistance 115 and the condenser 116, connected between the output of the rectifier 111 and the grid circuit of the vacuum tube 104' in the vacuum tube amplifier 101' in the repeating path WA.

Connected across the output of the amplifier 101' in repeating path WA is the input of the east suppressor comprising the same elements as specified above for the east suppressor, the elements therein as stated above being identified with the same characters as the corresponding elements in the west echo suppressor, except that they are followed by a prime (') mark. In the east echo suppressor, the filter 113' is connected between the output of the vacuum tube rectifier 111' and the grid of the vacuum tube 104 in the first stage of the amplifier 101 in the repeating path EA. Other important elements in the echo suppressor circuits will be referred to in the following description of the operation of the west echo suppressor in blocking the repeating path WA in response to speech signals transmitted over the repeating path EA.

The speech waves received over the two-way line section L₁ are impressed upon the input of the repeating path EA by the hybrid coil H₁ and are amplified by the normally operative one-way amplifiers 100 and 101 therein. The main portion of the amplified speech waves in the output of the amplifier 101 are transmitted to the input of the one-way amplifying device 102 and are amplified thereby and the amplified waves impressed by the hybrid coil H₂ upon the two-way line section L₂. A portion of the speech waves in the output of the amplifier 101 is impressed upon the input of the west echo suppressor by the input transformer 109. The resistances and condensers in series with the primary winding of the input transformer 109 are provided for the purpose of reducing the bridging loss produced in the repeating path EA by the

transformer 109. The speech waves impressed on the echo suppressor circuit by input transformer 109 are amplified by the amplifier 110 and are then impressed upon the input circuit of the rectifier 111 by interstage transformer 112 and are rectified thereby. The grid and plate of the rectifier tube 111, which are strapped together, are normally biased by current from the battery 117 so that normally no current flows through the rectifier tube 111.

When the speech waves are amplified by the amplifier 110 and impressed on the rectifying circuit of tube 111, the positive half of the waves causes current to flow through the circuit which may be traced as follows. The circuit passes from ground through the filament of tube 111, the electronic path between the filament and the plate and grid tied together of the tube 111, the secondary winding of the interstage transformer 112, battery 117, retardation coil 114, resistance 115 to the filament of tube 104' of the amplifier 101' in repeating path WA to ground. This pulsating current is filtered by the retardation coil 114 and the condenser 116 so that practically steady D. C. current flows through resistance 115. The voltage drop caused by this current flowing through resistance 115 gives the grid of the repeater tube 104' to which the resistance 115 is connected, a further negative bias. The negative bias on the grid of tube 104' in repeater 101' in the repeating path WA is now great enough to prevent operation of that tube in response to speech currents impressed thereon through input transformer 103'. The tube 104' will remain blocked and therefore the repeating path WA will remain inoperative to transmit speech currents from two-way line section L₂ to the two-way line section L₁ as long as the speech waves transmitted over repeating path EA maintain the west echo suppressor operated to supply the additional negative potential to the grid of tube 104'. When the input of speech waves from the repeating path EA to the west suppressor ceases, the rectified current passing through the resistance 115 will cease to flow so as to reduce the negative potential on the grid of tube 104' to its normal value at which the tube becomes operative for the transmission of speech currents over the path WA.

The west echo suppressor associated with the output of the repeater 101' in the repeating path WA operates in a similar manner to that of the east echo suppressor just described in response to speech waves impressed thereon to apply a negative bias to the grid of tube 104 in the amplifier 101 in repeating path EA blocking that tube and thus preventing subsequent transmission of speech currents over the path EA between the line sections L₁ and L₂.

To render the echo suppressors ineffective to block the repeating paths when calling or supervisory signals, such as a voice frequency carrier interrupted at the proper signaling rate, say, 20, 30 or 45 times per second, is to be transmitted between the two-way line sections L₁ and L₂, the circuits connected across the input of the amplifier 101 in repeating path EA and across the input of the amplifier 101' in the repeating path WA, respectively, are used. As the apparatus in these two circuits are identical and operate in similar manner, only the one associated with the input of the amplifier 101 in repeating path EA will be specifically described.

It will be assumed that the interrupted signals are being transmitted over the repeating path EA

from line section L₁ to line section L₂. These currents, as well as any speech currents which may be on the repeating path EA at the time, are impressed upon the three-electrode amplifying tube 118 by the input transformer 119. The resistances and condensers in series with the primary winding of the input transformer 119 are provided to reduce the bridged loss across the path EA caused by the input transformer 119. After amplification by the amplifier tube 118, the interrupted signals, or the interrupted signals and speech currents, are impressed by the interstage transformer 120 on the grid of the three-electrode vacuum tube combined amplifier and vacuum tube detector 121 the grid of which has a high negative bias provided by the grid battery 122 so that normally no current flows in the plate circuit of the rectifier tube 121. However, each positive portion of the wave impressed upon the input circuit of the rectifier 121 through interstage transformer 120 causes a pulse of current to flow in the plate circuit of the rectifier tube 121. The voice-frequency component of this current is shunted to the filament of tube 121 by condenser 123, leaving the interrupting frequency of the carrier in the plate circuit. This current of frequency say 20, 30 or 45 cycles per second flows through and causes the operation of the polarized relay 124, the condenser 125 in series therewith tuning the circuit broadly enough to receive the interrupting frequency of the carrier.

The periodic operation of polarized relay 124 causes its armature to continuously make and break connection with the contacts 126 causing the condenser 127 to be alternately charged with current from battery 128 through the windings of relay 129 and discharged through those windings at the signaling frequency. Relay 129 is thereby operated to open the normally closed contact 130 causing the release of slow-release relay 131 normally energized by current from battery 132. The release of relay 131 causes its armature to slowly fall back and finally make contact with contact 133 thereby closing an energizing circuit for the winding of relay 134 from battery 135. The slow-release time of relay 131 may be made by any well known means sufficient to prevent closing of the contact 133 in response to voice currents. Relay 134 then operates to close contact 136 thereby short-circuiting the secondary winding of interstage transformer 112' in the east echo suppressors. The short-circuiting of the secondary winding of interstage transformer 112' will prevent subsequent operation of the rectifier 111' in response to speech waves received from the repeating path WA, and therefore will prevent the application of any additional grid bias to the grid of tube 104 in the amplifier 101 in repeating path EA to block that amplifier. Therefore, whether or not voice-frequency currents are being impressed upon the east echo suppressor, the tube 104 will remain operative thus allowing the interrupted signals to be amplified by the amplifier 101 and transmitted over the output of that path to the line section L₂. Signals interrupted at the proper rate transmitted over the repeating path WA from line section L₁ will similarly cause operation of amplifier 118' and rectifier 121' to control the chain of relays 124', 129', 131' and 134' to disable the east echo suppressor connected to the output of the amplifier 101 in the repeating path EA so as to prevent the disabling of the amplifier tube 104' in the amplifier 101' in the repeating path WA, so as to permit

signals interrupted at the proper rate to be transmitted over that path between line sections L₂ and L₁.

The circuit shown in Fig. 3 has been described for the case where the interrupting and calling signals to be transmitted over the repeating path comprise voice-frequency carrier interrupted at a certain rate. The circuit described, however, will operate satisfactorily if the calling or supervisory signals to be transmitted over the repeating path are steady frequencies, if the chain of relays operating on the interrupting frequencies are replaced with a sharply tuned circuit to receive the signal frequencies which will cause the operation of apparatus similar to that shown to disable the echo suppressor.

Many modifications in the circuits which have been illustrated and described may be made by persons skilled in the art without departing from the spirit and scope of the invention as defined by the appended claims.

One modification may consist in placing in the amplifier-detector circuit of the echo suppressor sharply tuned filters to block the band or bands of frequencies used for supervisory signals, say 950-1050 cycles, so that the echo suppressor will not be caused to function when these frequencies alone are impressed on the line. A second amplifier-detector circuit operating on these frequencies alone would be connected to the "disabling" relay chain. This arrangement would allow supervisory signals to pass over one side of the line, say the EA branch, and speech currents to pass over the other side WA simultaneously.

The above result may also be obtained by having the disabling relay means not only disable the control means on the opposite path but also the control means on the same side. This modification may be made in the system of Fig. 1 by causing ground to be supplied to the armature of relay 30 from the make contact of relay 47 as indicated by the dotted line between the ground connection to the armature of relay 30 and the make contact of relay 47.

What is claimed is:

1. A two-way signal transmission system comprising stations, two normally operative one-way paths for respectively transmitting signals in opposite directions between said stations, control means connected to each one-way path and responsive to transmission of signals of certain characteristics therein to disable effectively the other one-way path, and means responsive only to transmission of signals of other characteristics in one of said one-way paths to render the control means connected to the other one-way path ineffective to disable said one-way path.

2. The system of claim 1 and in which the last-mentioned means comprises means controlled by the control means connected to said one one-way path when the signals of said other characteristics are impressed thereon from said one one-way path, to break effectively the circuit of the control means connected to said other one-way path.

3. The system of claim 1 in which the signals of said certain and said other characteristics differ on a frequency basis, and in which the last-mentioned means comprises a circuit comprising a chain of mechanical relays responsive to operation of the control means connected to said one one-way path when signals of said other characteristics are impressed thereon, to break effectively the circuit of the control means connected to the other one-way path, said relays having such operate and release times as to make the

relay circuit unresponsive to operation of the control means by the frequencies of signals of said certain characteristics.

4. The system of claim 1 in which the signals of said certain characteristics are voice frequency signals and said signals of said other characteristics are lower frequency signals, and in which the last-mentioned means comprises a circuit comprising a chain of mechanical relays controlled by the control means connected to said one one-way path, operating to disable the control means connected to said other one-way path in its output, said relays having such operate and release times as to make the relay circuit unresponsive to operation of the control means by voice frequency signals but responsive to operation of the control means by said lower frequency signals.

5. In a two-way signaling system, one-way paths for the transmission of signals between stations in opposite directions, wave-controlled means connected to each path and responsive to signal transmission thereover for effectively disabling the other one-way path so as to prevent transmission thereover between said stations, and means controlled by the wave-controlled means connected to each path only when signal waves of certain characteristics are impressed thereon to render the wave-controlled means connected to the oppositely directed transmission path ineffective to prevent free transmission of said signal waves of said certain characteristics between said stations over the first-mentioned path, while allowing the operation of the wave-controlled means connected to said oppositely directed path in response to signals of other characteristics transmitted thereover to disable said first-mentioned path when signals of said certain characteristics are not being transmitted over said first-mentioned path.

6. A two-way telephone transmission system comprising stations, a source of telephonic waves and a source of other signal waves of frequencies within the telephonic frequency range, interrupted at a certain rate, at each station, two one-way paths for respectively transmitting said telephonic and other signal waves in opposite directions between said stations, a control circuit connected to each path and responsive to transmission of waves within the telephonic frequency range over that path for effectively disabling the oppositely directed path, means connected to each control circuit and operative only when said interrupted signals are impressed thereon from the associated one-way path for rendering the control circuit connected to the other path ineffective thus permitting direct transmission of said interrupted signal waves between said stations over said one-way paths at all times.

7. The system of claim 1 and in which said means responsive to transmission of signals of said other characteristics in said one one-way path, to render the control means connected to the other one-way path ineffective, is connected to the input of said one one-way path whereas said control means for disabling said other one-way path is connected to the output of said one one-way path.

8. The system of claim 1 and in which the means responsive only to transmission of signals of said other characteristics in said one one-way path to render the control means connected to the other path ineffective and the control

means connected to said one one-way path are independent.

9. In a two-way signal transmission system, one-way paths including amplifying means for
5 respectively repeating signals between stations in opposite directions, wave-controlled means connected to each one-way path and responsive to transmission thereover of signals within the voice frequency range for effectively disabling
10 the oppositely directed one-way path, said means comprising relay means adapted when operated to short-circuit said oppositely directed path and a vacuum tube amplifier-rectifier circuit having its input connected across said one one-way
15 path and responsive to said signals within the voice frequency range to operate said relay means, and means controlled by the vacuum tube amplifier-rectifier circuit connected to one path in response only to impressed signals outside the voice frequency range for preventing
20 the relay means controlled by the vacuum tube amplifier-rectifier circuit connected to the other one-way path from short-circuiting the first one-way path.

25 10. In a two-way signaling system, two normally operative one-way transmission paths each including a space discharge amplifying device including a grid electrode, for respectively re-

peating signals in opposite directions between stations, control means connected to the output of the space discharge amplifying device in each one-way path and responsive to amplified signals of certain characteristics therein, for so biasing
80 the grid electrode of the space discharge device in the other one-way path so as to block transmission therein, and means connected to each one-way path in the input of the space discharge device therein and responsive only to signals of
85 other characteristics in said one-way path to prevent the blocking of transmission therein in response to signals in the other one-way path, and thereby enabling transmission of signals of
90 said other characteristics over said one-way paths between said stations at all times.

11. The system of claim 10 and in which the last-mentioned means comprises a vacuum tube circuit having its input connected to the one-way path transmitting signals, and a chain of relays
95 controlled by said vacuum tube circuit when the signals of said other characteristics are impressed thereon and unresponsive to the signals of said certain characteristics impressed on said vacuum tube circuit, to disable the control means con-
100 nected to the other one-way path, in its output.

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