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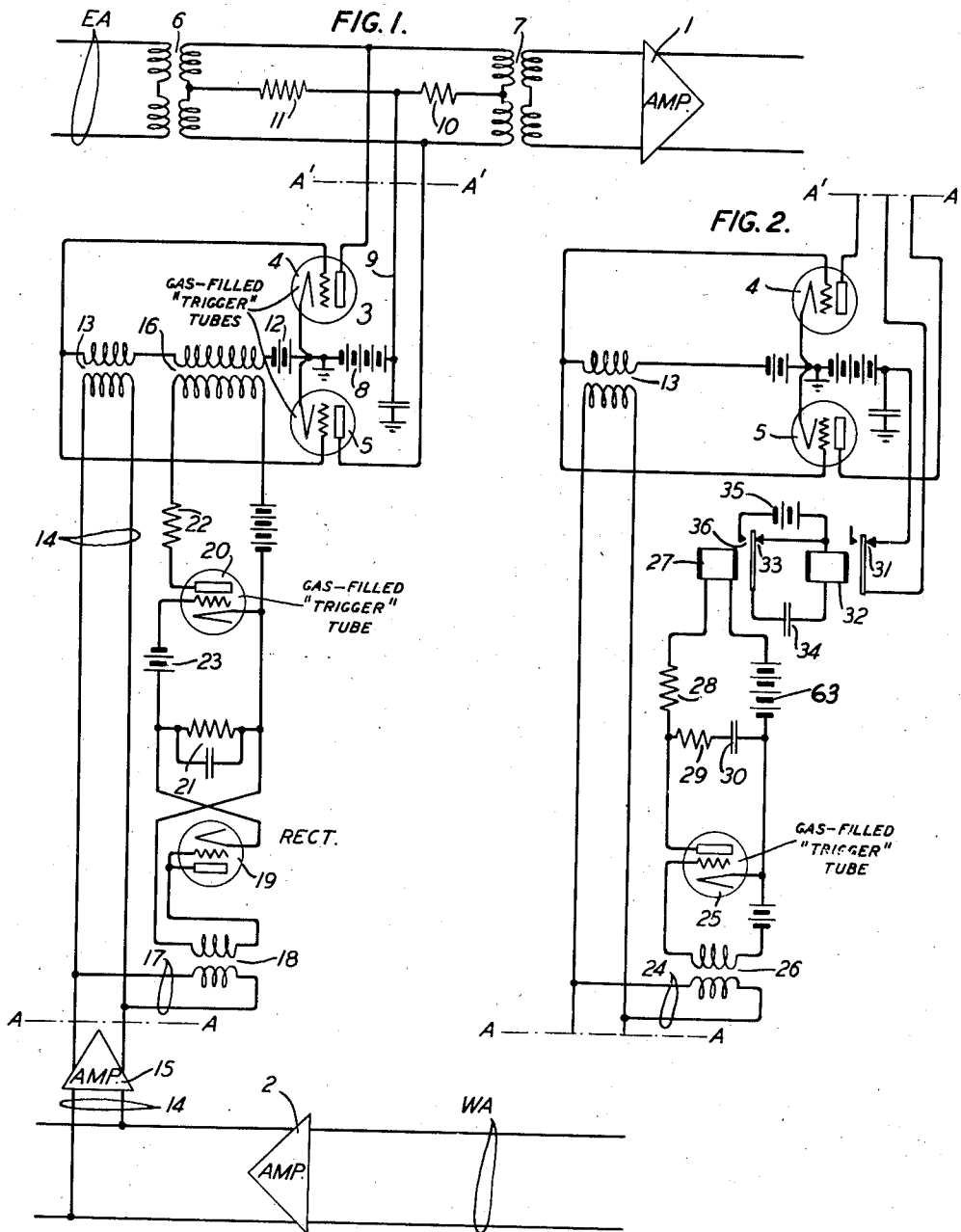
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GAS FILLED TUBE CIRCUIT

Filed Feb. 12, 1932

2 Sheets-Sheet 1



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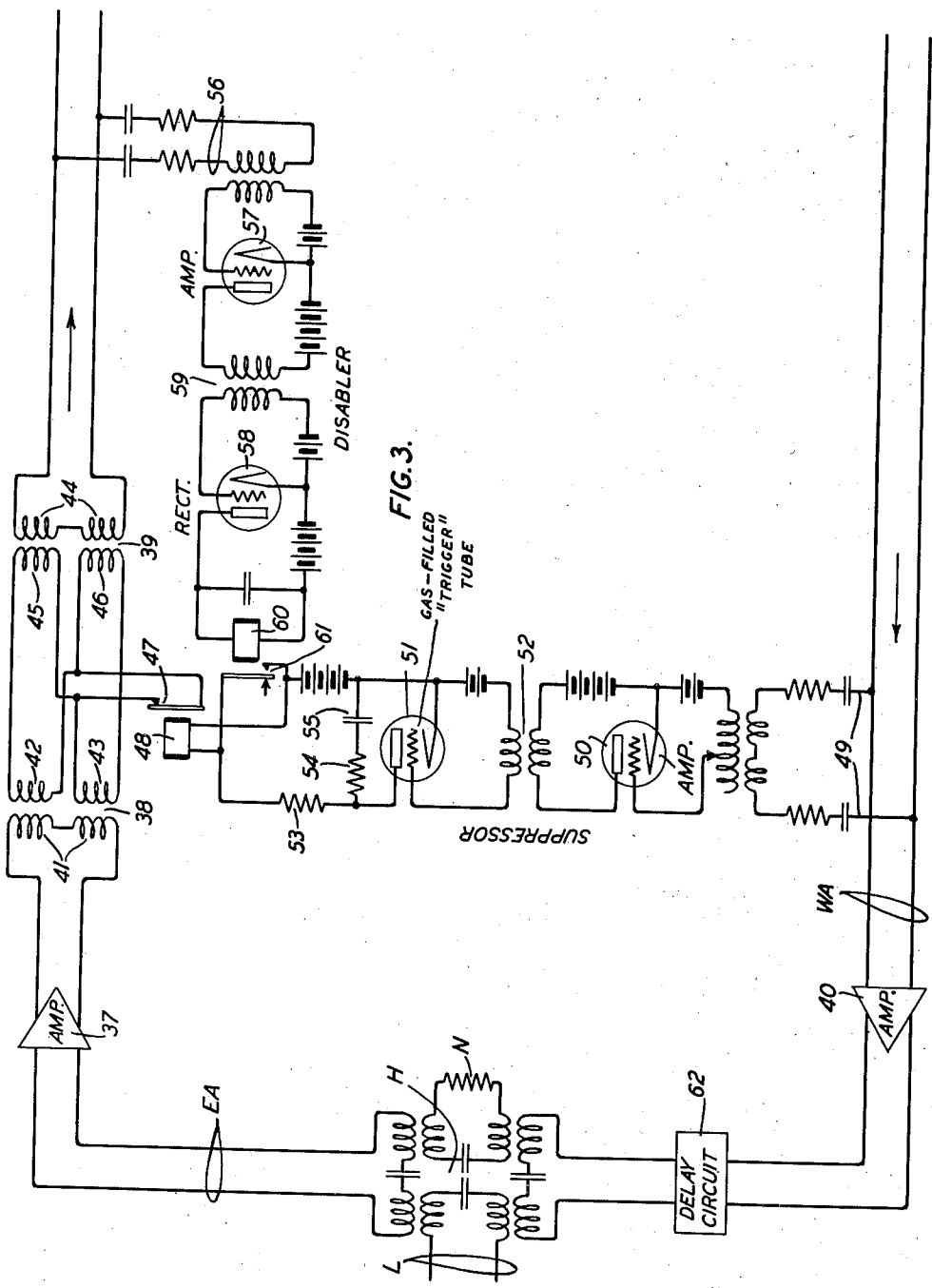
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GAS-FILLED TUBE CIRCUIT

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7 Claims. (Cl. 178-44)

This invention relates to circuits employing electric space discharge tubes and particularly gas-filled tubes.

The invention has particular application to signal transmission systems in which the transmission characteristics of the signal transmission paths are controlled by signals transmitted over the system. In systems of this type in the prior art it has been common to utilize a portion of the speech or other signaling energy transmitted over the system to control operation of an amplifier-detector circuit employing high vacuum tubes. The amplifier-detector circuits in turn control the actuation of electromagnetic relays, or control directly a variable loss element associated with a signal transmission path so as to control the transmission efficiency of the path in the desired manner. In systems of this character among the important factors determining proper operation, there may be mentioned the operate time, sensitivity and uniformity of response of the signal-operated control circuits. Heretofore, it has been found that the use of gas-filled space discharge tubes in connection with control circuits of the above mentioned type enables a more uniform response, a reduction in the operate time and greater sensitivity to be attained without unduly complicating these circuits or increasing their cost.

An object of the invention is to improve the operation of circuits employing gas-filled tubes. A related and more specific object is to improve the construction and operation of signal-controlled, circuit-control apparatus in which gas-filled tubes are used.

In one embodiment of the invention applied to a circuit for suppressing echoes and preventing singing in a two-way signal transmission system, the output of a gas-filled space discharge device is connected to a signal transmission path in such manner that the low alternating current output impedance of the device when operated under control of signals from an associated signal path, effectively disables the first path. A feature of this circuit is the use of an auxiliary circuit for applying a high negative voltage to the input of the gas-filled device when the operating voltage is removed therefrom so as to cause the device to quickly return to its normal unoperated condition.

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

Fig. 1 shows schematically a portion of a four-wire telephone repeating circuit embodying the invention;

Fig. 2 shows schematically a circuit which may be used to replace a portion of the circuit of Fig. 1, embodying a different modification of the invention; and

Fig. 3 shows schematically a portion of a four-wire toll telephone circuit employing terminal echo suppressors embodying the invention.

Fig. 1 shows the invention embodied in an echo suppressor applied to a four-wire repeating circuit, only a portion of the circuit being shown. The four-wire repeating circuit comprises a one-way transmission path EA including the one-way amplifying device 1 for repeating signals in the direction from west to east, and the one-way transmission path WA including the one-way amplifying device 2 for repeating signals in the direction from east to west. The one-way amplifying paths EA and WA may be connected at each end in energy transmitting relation with the two-way transmission circuits between which signals are to be repeated (not shown) and in substantially conjugate relation with each other by hybrid coil transformers and associated balancing networks such as are well known in the art or by any other suitable means.

Connected effectively in shunt of the path EA at any suitable point therein, for example, in the input of the amplifying device 1 therein, is the loss device 3 comprising two gas-filled space discharge devices 4 and 5 connected in push-pull relation. Each of the gas-filled devices 4 and 5 comprises a tube containing a small amount of gas, such as argon, a cathode or filament, a control electrode or grid and an anode or plate. The gas in the tubes gives it a peculiar grid-plate current characteristic. As long as the potential of the grid with respect to the cathode remains under a certain critical value, no plate current will flow and the anode-cathode impedance is very high. However, as soon as the input voltage exceeds the critical value, the tube breaks down, plate current starts to flow and the anode to cathode impedance of the tube becomes very low.

The two anodes of the gas-filled tubes 4 and 5 are connected respectively to opposite sides of the transmission path EA between repeating coils 6 and 7. Space current is supplied in common to the plates of tubes 4 and 5 from the plate battery 8. The space current for tube 4 passes from the positive terminal of battery 8 through conductor 9, then in parallel through a circuit comprising resistance 10, upper half of the pri-

mary winding of repeating coil 7 and upper wire of path EA, and a circuit comprising resistance 11, upper half of the secondary winding of repeating coil 6 and upper wire of path EA, then through the space path of tube 4 to the negative terminal of battery 8. Space current for tube 5 passes from the positive terminal of battery 8 through conductor 9, then in parallel through a circuit comprising resistance 10, lower half of the primary winding of repeating coil 7 and lower wire of path EA, and a circuit comprising resistance 11, lower half of the secondary winding of repeating coil 6 and lower wire of path EA, and then through the space path of tube 5 to the negative terminal of battery 8.

The battery 12 supplies negative biasing potential in common to the grids of tubes 4 and 5. The value of the negative potential is made sufficient to hold the tubes 4 and 5 unoperated but insufficient to return these tubes to their normal unoperated condition after the input voltage thereto is removed. The resistances 10 and 11 are provided to limit the plate current in the gas-filled tubes. The push-pull arrangement of the tubes 4 and 5 is provided for balancing out D. C. click.

The common portion of the input circuits of tubes 4 and 5 is coupled by a transformer 13 to the output of control circuit 14 including the one-way amplifying device 15 having its input bridged across the path WA preferably in the output of the amplifying device 2 therein. The common portion of the input circuits of tubes 4 and 5 is coupled by transformer 16 to the output of a second control circuit 17 having its input connected across the control circuit 14 in the output of the amplifying device 15 therein by transformer 18. The control circuit 17 comprises an equivalent two-electrode space discharge rectifying device 19 having its input connected to the secondary winding of transformer 18, and a three-electrode gas-filled "trigger" space discharge device 20, similar to the devices 4 and 5, having its input connected to the output of the rectifying device 19 across the circuit 21 comprising a condenser in parallel with a resistance, and its output connected to the primary winding of transformer 16. A high resistance 22 is provided in the plate-filament circuit of the gas-filled tube 20 to enable that tube to return quickly to its unoperated condition after it has been operated under control of a voltage applied to its input terminals.

The operation of the system of Fig. 1 will now be described. In the absence of transmission of signal currents over the path WA the push-pull gas-filled tubes 4 and 5 are in their normally unoperated condition so that their plate-filament circuits which are connected effectively in shunt with the path EA, have such a high impedance as to insert little or no loss in the transmission path EA. The path EA is therefore normally operative to transmit signals to the amplifying device 1.

Now let it be assumed that signals are being transmitted over the path WA. A portion of the amplified signals in the output of the amplifying device 2 in that path will be diverted into the control circuit 14, and will be amplified by the amplifying device 15 therein. A portion of the amplified waves in the output of the amplifying device 15 will be impressed by the transformer 13 on the input circuit of the tubes 4 and 5 in the loss device 3 causing a positive voltage to be applied to the grids of the tubes 4 and 5 of such value as to overcome the negative biasing poten-

tial applied by grid battery 12 causing the tubes to be rendered operative.

The amplified signal voltage impressed upon the input circuits of the gas-filled tubes 4 and 5 causes the gas therein to be ionized and thus their space paths to become conductive to transmit space current substantially instantaneously. The anode to cathode impedances of the two tubes are thus immediately reduced to a very low value effectively short-circuiting the transmission path EA through the now conductive space paths of the two tubes.

The characteristic of gas-filled tubes is that they are not normally self-restoring when the voltage applied to their inputs is removed. In accordance with the present invention, the restoration of the gas-filled tubes 4 and 5 to their normally inoperative condition when the signal input thereto ceases is accomplished by the control circuit 17 in the following manner:

The portion of the amplified signal currents in the output of the amplifying device 15 diverted into control circuit 17 is impressed on the rectifying device 19 by transformer 18. The gas-filled "trigger" tube 20 is normally maintained inoperative by a negative polarizing potential applied to the grid thereof by the battery 23. The rectified signal voltage in the output of the rectifying device 19 will be impressed across the condenser-resistance circuit 21 on the input electrodes of the tube 20 and will charge the condenser through the resistance in such a direction as to apply a positive potential to the grid of the tube 20 opposing the negative potential provided by the battery 23. This positive potential will cause the gas in the gas-filled tube 20 to be ionized and thus the space path of that tube to become conductive to transmit space current substantially instantaneously. The resulting current flowing through the primary winding of transformer 16 will cause the voltage to be applied to the input circuits of the tubes 4 and 5 in such direction as to reinforce the positive voltage applied thereto by the transformer 13 thus helping to maintain the tubes 4 and 5 in the operative condition initiated by the currents impressed thereon through transformer 13.

Now, if signal currents cease to flow in the path WA, the signal potential applied through transformer 13 to the input circuits of tubes 4 and 5 will be removed without restoring the tubes 4 and 5 to their normally inoperative condition. However, the removal of the rectified signal potential applied to the primary winding of transformer 16 with cessation in the flow of signal currents in the path WA will cause a "kick" of negative voltage to be applied to the grids of tubes 4 and 5. By suitable design of the transformer 16, this momentary negative voltage applied to the grids of tubes 4 and 5 may be made sufficiently high as to render the gaseous path within the tubes 4 and 5 non-conducting thereby immediately restoring the anode to cathode impedances of these tubes to their normal high value thus removing the low impedance shunt from the path EA rendering that path again operative to transmit signal currents.

Fig. 2 shows schematically an alternative circuit which may be used for restoring the gas-filled tubes 4 and 5 in the system of Fig. 1 to their inoperative condition when the transmission of signal current in the path WA ceases. The circuit of Fig. 2 would be substituted for that portion of the system of Fig. 1 included within the dot and dash lines AA and A'A'.

As indicated in Fig. 2 the auxiliary control circuit 17 of Fig. 1 would be replaced by an auxiliary circuit 24.

In the control circuit 24, the input of the 5 three-electrode gas-filled "trigger" discharge tube 25, similar to the gas-filled tubes 4, 5 and 20 in the system of Fig. 1, is connected across the control circuit 14 in the output of the amplifying device 15 therein by transformer 26. 10 The winding of a mechanical relay 27 in series with a high resistance 28 and a plate battery 63 is connected between the plate and filament of the gas-filled tube 25. The high resistance 28 is provided to enable the gas-filled tube 25 to restore quickly with cessation in the supply of signaling voltages to its input. A circuit comprising a low resistance 29 and a condenser 30 15 in series is connected directly across the plate and filament of the tube 25 effectively in shunt with the high resistance 28 and the winding of relay 27 so that condenser 30 is normally charged by current from the plate battery 63. The normally closed switch contacts 31 in the common portion of the output circuits of the gas-filled tubes 4 and 5 are adapted to be opened by 20 operation of relay 32. The winding of mechanical relay 32 is normally short-circuited through the normally closed switch contacts 33 and condenser 34 in series so that the relay 32 is normally unoperated. A source 35 of direct current is arranged to be connected across the winding of relay 32 in series with the condenser 34 by the closing of normally open switch contacts 36, and, when the normal short circuit around 35 the winding of relay 32 is removed by the opening of switch contacts 33 the current from the source 35 will charge up the condenser 34 through the winding of relay 32 causing the latter to be energized in such direction as to hold the contacts 31 40 more firmly closed. When the contacts 36 are opened to break the energizing circuit from battery 35 and the switching contacts 33 return to their normally closed condition, the condenser 34 will discharge through the winding of relay 32 in such direction as to cause its operation to open the normally closed switch contacts 31. 45 The opening of switch contacts 33 and the closing of switch contacts 36 is controlled by relay 27 in the manner which will be described.

Let it be assumed that signals are being transmitted over the path WA. A portion of these waves in the output of the amplifying device 2 will be diverted into the control circuit 14 and will be amplified by the one-way amplifying device 15 therein. A portion of the amplified 55 signal waves in the output of the amplifying device 15 will be immediately impressed upon the common portion of the input circuits of the push-pull, gas-filled tubes 4 and 5 by transformer 13 causing operation of the tubes 4 and 5 effectively to short circuit the path WA through the conductive space paths of the tubes 4 and 5 in the manner described in detail in connection with Fig. 1. 60

Another portion of the amplified signal waves in the output of the amplifying device 15 in control circuit 14 is diverted into the control circuit 24 and impressed by the transformer 26 on the input electrodes of the gas-filled "trigger" tube 25. The amplified signal voltages impressed 70 upon the input of the tube 25 will cause the gas therein to be ionized and thus the space path of the tube becomes conductive to transmit space current from battery 63 substantially instantaneously. The resulting output current of tube 25

will flow through the high resistance 28 and through the winding of relay 27, and will cause operation of the latter relay to open switch contacts 33, removing the short circuit from the winding of relay 32, and then to close switch contacts 36 causing condenser 34 to be charged up by current from battery 35 through the winding of relay 32. 80

The winding of relay 32 is so wound that the switch contacts 31 will be maintained more firmly closed in response to current from battery 35 transmitted through the winding of relay 32 during the period in which the gas-filled tube 25 is maintained operated in response to the impressed signal voltages. 85 90

Now, if the flow of signal currents in the path WA ceases, the operating voltage applied to the tubes 4 and 5 through transformer 13 will be removed. Because of the inherent nonself-restoring characteristics of the gas-filled tubes 4 and 5, the tubes 4 and 5 would be still maintained operated to short circuit the path EA through their conductive space paths were it not for the action of control circuit 24. 95

As soon as the signal voltage is removed from 100 the input electrodes of the gas-filled tube 25 in control circuit 24, because of the high resistance 28 in its output circuit, the tube 25 will be immediately rendered inoperative and the energizing voltage supplied to the winding of relay 27 during the operation of the tube 25 will be removed. Then, the condenser 30 which has been discharged during the operation of tube 25 will be charged by current from battery 63 through the resistances 29 and 28 and the winding of relay 27 maintaining the relay operated for the desired hang-over interval. When condenser 30 110 has been charged to its normal value, flow of current through the winding of relay 27 will cease and the relay will release causing switch contacts 36 to be returned to their normal open condition and switch contacts 33 to be returned to their normal closed condition. The opening of contacts 36 will break the energizing circuit for relay 32 from battery 35, and the closing of switch 120 contacts 33 will cause the winding of that relay to be short circuited through condenser 34. Condenser 34 will then discharge through the winding of relay 32 in such direction as to operatively energize its winding. Relay 32 will then immediately operate to open the normally closed switch contacts 31 common to the output circuits of the tubes 4 and 5 thus disabling the space current paths of the tubes 4 and 5 so that the latter will return immediately to their unoperated condition. The loss circuit 3 then acts as a high impedance shunt across the path EA, and, therefore, will have little or no effect on the transmission of signal currents over the path EA. 125 130 135

Fig. 3 shows schematically one terminal, the west terminal, of a two-way signaling system employing echo suppressors of the terminal type embodying the invention. 140

The two-way signaling system comprises a one-way transmission path EA comprising near the west terminal shown a one-way amplifying device 37 for repeating signals in the direction from west to east, and the repeating coils 38 and 39, and a one-way transmission path WA including near the west terminal shown a one-way amplifying device 40 for repeating signals in the direction from east to west. The input of the path EA and the output of the path WA are connected in substantially conjugate relation with each other, and in energy transmitting relation with 145 150

a two-way telephone circuit L by means of the usual hybrid coil transformer H and associated balancing network N in well known manner.

The transformer 38 in the path EA has a single primary winding 41 and two secondary windings 42 and 43 while the transformer 39 in the path EA has a single secondary winding 44 and two primary windings 45 and 46. The upper terminals of secondary winding 42 and primary winding 45 are connected directly together, and likewise the lower terminals of the secondary winding 43 and the primary winding 46 are connected directly together. The lower terminal of primary winding 45 is, however, connected to the upper terminal of secondary winding 43 while the upper terminal of primary winding 46 is connected to the lower terminal of secondary winding 42. These connections are such that taken by themselves, the windings would be opposed so as to prevent transmission over the path EA. However, the switch contacts 47 are so connected that when closed they cross-connect and thereby tie together the lower terminals of windings 42 and 45 and the upper terminals of windings 43 and 46 so that, in effect, two series aiding circuits are established through transformers 38 and 39 to permit transmission to take place over the path EA. As shown in Fig. 3, the switch contacts 47 are normally in the closed condition so that the transmission path EA is normally operative. The opening of the switch contacts 47 under control of the relay 48 in the manner which will be described, causes the windings of the transformers 38 and 39 to be balanced against each other so as to prevent transmission over the path EA.

The above described transformer arrangement per se is not the invention of applicant having been disclosed and claimed in the U. S. Patent to H. C. Silent, No. 1,749,851, issued March 11, 1930.

Branched across the transmission path WA near the west terminal of the four-wire circuit is the input of a control circuit 49 comprising first the vacuum tube amplifier 50, the three-electrode gas-filled "trigger" space discharge device 51, similar to the devices 4, 5 and 25 in the systems of Figs. 1 and 2, having its input connected to the output of the amplifier 50 by transformer 52, and the winding of mechanical relay 48 connected to the output of the gas-filled tube 51. The high resistance 53 is provided in the output circuit of the gas-filled device 51 in series with the winding of relay 48 to enable the device 51 to restore quickly to its unoperated condition on the removal of an operating voltage applied to its input. A circuit comprising low resistance 54 in series with a condenser 55 is connected across the plate and filament of the device 51 effectively in parallel with the winding of relay 48. The control circuit 49 in combination with the transformer arrangement in the path EA comprises the suppressor portion of the terminal echo suppressor.

Associated with the path EA at a point east of the transformer 39 but near the west terminal of the four-wire circuit is what is usually called the disabler or interlocker portion of the terminal echo suppressor. The disabler comprises a control circuit 56 having its input connected across the path EA and including a vacuum tube amplifier 57, a three-electrode vacuum tube rectifier 58 connected to the output of the amplifier 57 by transformer 59 and the winding of a mechanical relay 60 connected across the output of the rectifier 58. The normally open switch contacts 61 are adapted to be closed by relay 60 to

close a short-circuiting connection across the winding of relay 48 when the winding of relay 60 is energized in response to operation of the rectifier 58.

The operation of the system of Fig. 3 will now be described. In the absence of incoming signals received over the path WA, the switch contacts 47 associated with the windings of transformers 38 and 39 in the path EA are in the normally closed condition. If, now, signals are received over the circuit L at the west terminal of the four-wire circuit, these signals will be impressed by hybrid coil H upon the input of the path EA and will be amplified by the amplifying device 37 in that path. The amplified signals in the output of the amplifying device 37 will be then transmitted freely through the transformer arrangement comprising transformers 38 and 39 and the connections therebetween. The main portion of the amplified signals will then be transmitted out over the path EA towards the east terminal of the four-wire circuit. A small portion of the signals in the output of the transformer 39 in the path EA will be diverted into the control circuit 56 and will be amplified by the amplifier 57 and rectified by the rectifier 58 therein. The rectified signals in the output of the rectifier 58 will cause the operation of the relay 60 to close the normally open switch contacts 61 thereby short-circuiting the winding of relay 48 and thus preventing subsequent false operation of that relay in response to later operation of the gas-filled device 51 by signals received over the path WA.

Now let it be supposed that signals from the subscriber associated with the east terminal of the four-wire circuit are received over the path WA and impressed upon the input of the control circuit 49 associated therewith before signals are received in the path EA from the west subscriber associated with the circuit L. The portion of the east subscriber's signals diverted into the control circuit 49 will be amplified in the amplifier 50 and the amplified signals impressed upon the input of the gas-filled tube 51 causing its immediate operation in the manner described in connection with the gas-filled tubes in the previous figures, to cause quick operation of the relay 48. The operation of the relay 48 will open the normally closed switch contacts 47 associated with the windings of repeating coils 38 and 39 causing these windings to be connected in opposing relation so as to disable effectively the path EA.

Due to imperfections in the balance of the hybrid coil network H there is a possibility that currents due to the east subscriber's signals may be transmitted from the output of the path WA to the input of the path EA. To prevent this leakage energy from being transmitted to the input of the disabler circuit 56 and thus later causing false operation of relay 60 to disable the suppressor circuit 49, a delay circuit 62 may be used in the output circuit of the path WA to delay the transmission of these leakage currents to the disabling point in the path EA until after that path has been disabled by the opening of switch contacts 47 in response to operation of relay 48. Because of the inherent quick operating characteristics of the gas-filled tube 51 and the fact that the disabling of the path EA is accomplished almost instantaneously with operation of relay 48 because it depends only on the opening of contacts, it is probable that the delay circuit 62 may be dispensed with in the path WA.

In the event that the talking party associated

with the line L has begun to speak before speech arrives over the path WA at the west terminal shown in Fig. 3, the suppressor portion 49 of the terminal echo suppressor will not be effective to disable the path EA. It will be understood, of course, that at the remote terminal the suppressor portion of the terminal echo suppressor thereat will be associated with the path EA, which at that terminal is the receiving branch, and the disabler portion of the echo suppressor thereat corresponding to the control circuit 56 will be associated with the path WA. It is seen therefore that the speaker whose voice currents reach the far terminal before the disabler relay 60 thereat becomes energized by the other subscriber's voice currents, will obtain control of the entire circuit.

It may be desirable to provide a certain amount of hang-over in the operation of the suppressor relay 48 to prevent premature closing of the switch contacts 47 when the input of speech currents to the suppressor circuit 49 ceases. Also it may be desirable to provide a certain amount of hang-over in the operation of the disabler relay 60 when the supply of signal current to the input of the control circuit 56 ceases to prevent premature opening of the switch contacts 61. These hang-overs are provided by suitable design of the condensers and resistances shunting the respective relay windings, the operation being similar to that described above for condenser 30 in the system of Fig. 2.

For simplicity of disclosure the filament circuits of the various discharge tubes in the systems of Figs. 1, 2 and 3 have been shown open. In practice, they will, of course, be supplied with filament heating batteries or the equivalent.

In the circuits of the invention which have been illustrated and described, echo suppressors of the type which operate to insert a loss in or remove a loss from a transmission path in response to signals in another transmission path are employed. It is apparent that the circuits of the invention are applicable as well to other types of echo suppressors well known in the art.

Other modifications which may be made in the circuits illustrated and described within the scope and spirit of the invention will be apparent to persons skilled in the art. The invention is to be limited only within the scope of the appended claims.

What is claimed is:

1. In combination, a normally unoperated gas-filled electric discharge device having an input circuit, a source of alternating current signals, a transmission element, means for impressing a portion of the signals from said source on said input circuit in such manner as to cause operation of said device, means for simultaneously rectifying another portion of said signals and for utilizing the rectified signals to cause the energization of said transmission element, and means responsive to deenergization of said transmission element with cessation in the supply of signals from said source to restore said device to its normal unoperated condition.

2. In combination, a gas-filled electric discharge device having an input and an output circuit, said device being normally inoperative, means for impressing alternating current signals on said input circuit in such manner as to render said device operative, and means responsive to cessation in the supply of alternating current sig-

nals to said input circuit to apply momentarily a negative voltage thereto sufficient to restore said device to its normal inoperative condition.

3. In combination, a normally inoperative gas-filled electric discharge device comprising a cathode, an anode and a control electrode, an input circuit connected to said cathode and control electrode, a source of alternating current signals, means for impressing a portion of said signals on said input circuit in such manner as to render said device operative, means for simultaneously rectifying another portion of said signals, a transformer for impressing the rectified signals on said input circuit, said transformer being so designed and poled that removal of the rectified signal voltage therefrom with cessation in the supply of signals from said source will cause said control electrode to be negatively biased sufficiently to restore said device to its normal inoperative condition.

4. In combination, a wave transmission path, a gas-filled electric discharge device having its output connected effectively in shunt with said path, said device normally having a high output impedance, means to apply alternating current signals to the input of said device in such manner as to reduce the output impedance thereof to a low value and means responsive to cessation in the supply of said signals to apply momentarily to the input of said device such a voltage as to restore the output impedance of said device to its normal high value.

5. In combination, two signal transmission paths, a gas-filled electric discharge device having an input circuit and having its normally high impedance output circuit connected effectively in shunt with one of said paths, means responsive to transmission of alternating current signals in the other of said paths to apply alternating current voltages to said input circuit in such manner as to decrease the value of the impedance of said output circuit, and means responsive to cessation in the transmission of said signals in said other path, to momentarily apply to the input of said device such a voltage as to restore the output impedance of said device to its normal high value.

6. In combination, a normally unoperated gas-filled electric space discharge device having an input circuit and an output circuit, a source of alternating current signals, means to impress a portion of said alternating current signals on the input circuit of said device so as to cause operation thereof, means to charge a condenser during transmission of said signals from said source, and means controlled by the discharge of said condenser when the transmission of said signals ceases to disable the output circuit of said device so as to restore said device to its normal unoperated condition.

7. In combination, a normally unoperated gas-filled electric discharge device having an input circuit, a source of alternating current signals, a condenser, means for impressing signals from said source on said input circuit in such manner as to cause operation of said device, means also responsive to the signals from said source for charging up said condenser, and means responsive to the discharge of said condenser with cessation in the supply of said signals from said source to restore said device to its normal unoperated condition.

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