June 5, 1934.

A. C. NORWINE

1,961,381

VOICE OPERATED CIRCUIT

Filed June 7, 1930

FIG. 1

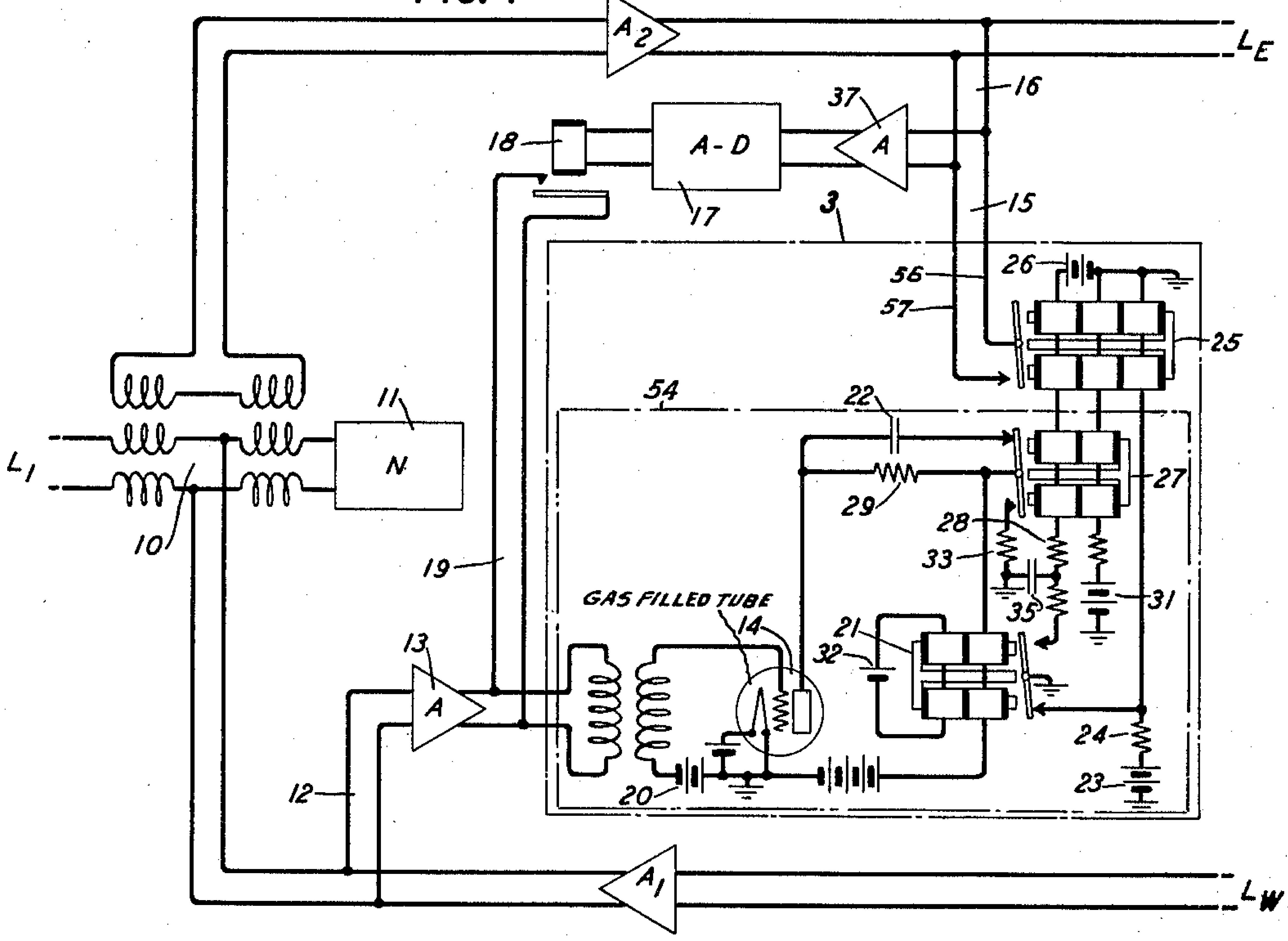


FIG. 2

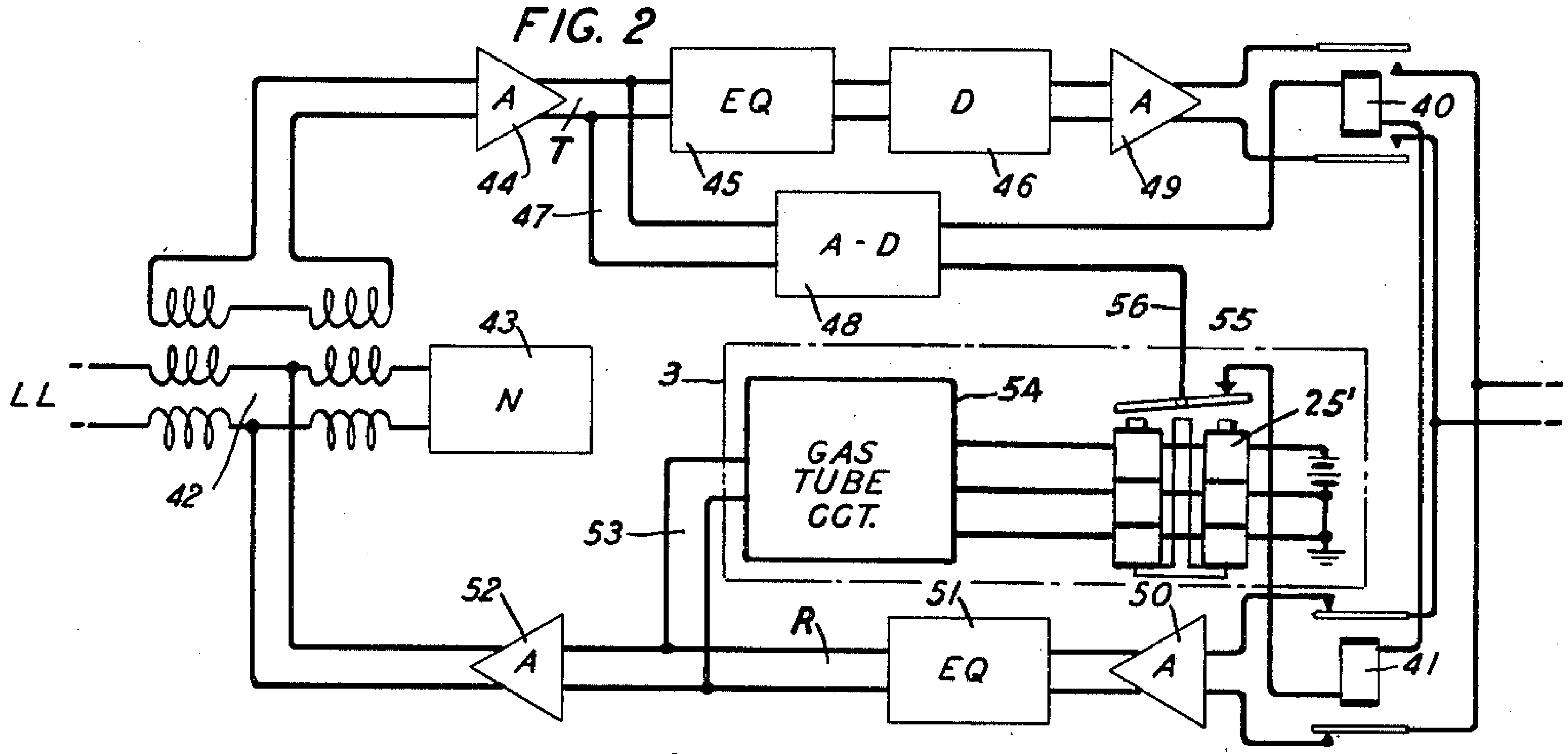
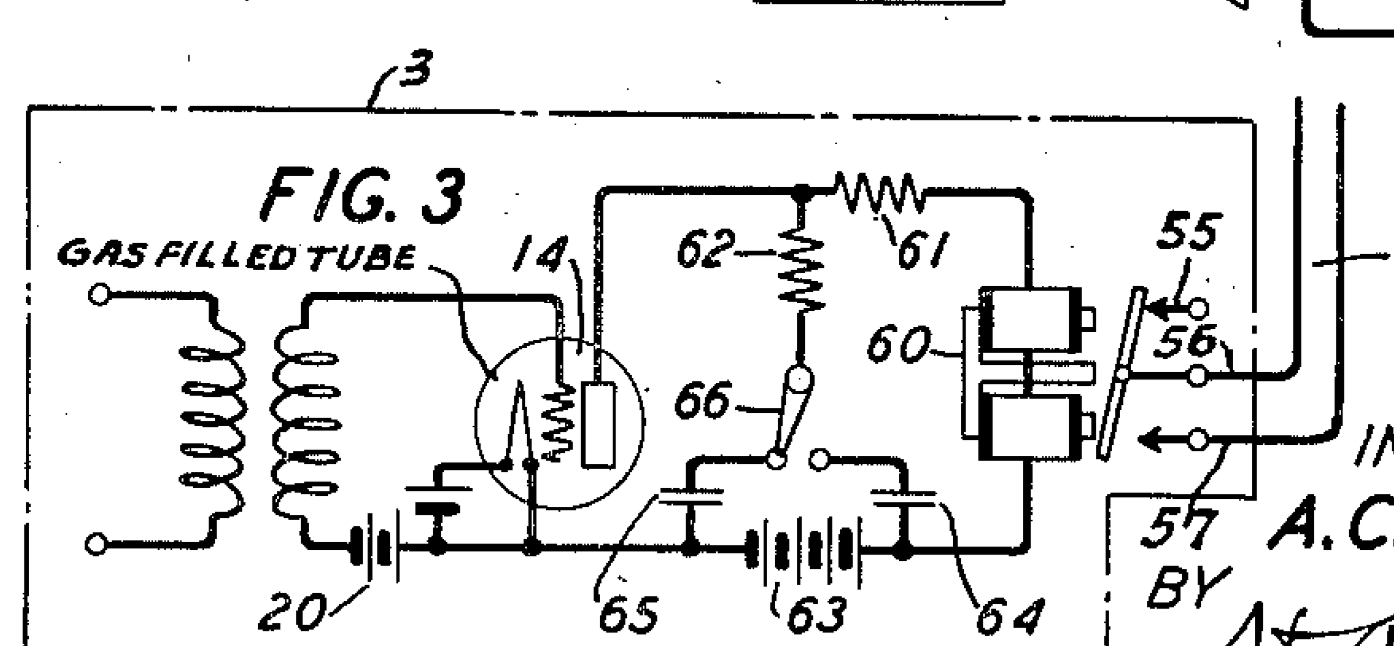


FIG. 3



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1,961,381

VOICE OPERATED CIRCUIT

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14 Claims. (Cl. 179—170)

The present invention relates to transmission control, particularly to the control of a circuit by the signals being transmitted to disable the circuit or render it in condition to transmit.

An object of the invention is to decrease the delay of actuation without sacrifice of positive operation.

The invention will be described with particular reference to speech transmission, but it will be understood that where speech currents are mentioned, other types of signal currents may equally as well be used and the invention is not limited to speech transmission.

Typical instances of voice operated circuits are found in the so-called singing prevention and the so-called echo suppressor circuits. In the former, speech traversing a circuit conditions that circuit for transmission, as by removing a disabling element in the circuit so as to permit the speech to continue. In the latter, speech in traversing one circuit, say a westward circuit, disables the opposite or eastward circuit, (or a singing suppressor associated therewith) so as to prevent mutual lockout between subscribers or the return of echoes produced at points along the line.

The invention has particular application to the latter class of devices, that is, to echo suppressors and especially to terminal echo suppressors. In a terminal echo suppressor, incoming speech waves in the receiving branch must disable the transmitting branch input, to prevent operation of the latter by any of the received speech that might find its way into the transmitting branch due to unbalance or otherwise. It is a requirement of the echo suppressor that it be fast acting so as to effect the disabling of the transmitting branch at some point before the received speech reaches that point. Where the echo suppressor itself is not sufficiently rapid in its action, delay circuits may be and have been used to retard the speech until the echo suppressors have had time to operate, but it is preferable in many cases to avoid introduction of any unnecessary delay into the system.

The present invention provides a fast-acting echo suppressor circuit, which at the same time is positive in its operation. The invention is, of course, also applicable to singing prevention and various other types of speech or signal controlled circuits.

In the detailed specification to follow, an example of the invention as applied to a terminal echo suppressor shown in Fig. 1 of the drawing will first be described, after which an application of the invention to a circuit employing both a singing prevention circuit and an echo suppressor, shown in Fig. 2 will be described. Fig. 3 shows an alternative and somewhat simpler type of control circuit using a gas-filled tube.

In Fig. 1, a two-way line L_1 is shown connected by means of the usual hybrid coil 10 and balancing network 11 to an eastward one-way line LE and a westward one-way line LW.

Circuit 12 is branched from the line LW and leads to the echo suppressor comprising the amplifier 13 and gas-filled tube 14 with its associated relays to be described later. The purpose of this circuit as a whole is to disable the line LE and the amplifier detector associated therewith by closing the short circuit 15 in a manner to be described.

Circuit 16 is branched from the line LE and leads to the amplifier detector 17 which controls a relay 18 to disable the echo suppressor circuit by placing a short circuit across the input to the gas-filled tube 14 by closing circuit 19.

The operation will be more fully understood by tracing the operational steps, which are as follows.

Assuming no transmission in the line LE, speech arriving on line LW is amplified at A_1 and impressed through the hybrid coil on the line L_1. A portion of the speech energy is diverted in circuit 12, amplifier 13 and impressed on the input or grid circuit of the gas-filled tube 14.

This tube has its grid normally biased negatively by a considerable amount due to battery 20. When this grid bias is opposed by positive lobes of speech waves of sufficient amplitude, however, so that the threshold value is exceeded, a rush of current passes through the tube between the filament and the plate, causing energization of relay 21. The initial rush of current passes in large part through condenser 22 which is provided in the circuit to enable relay 21 to be energized quickly.

When relay 21 attracts its armature, this armature at its lower back contact removes a normal shunt to ground from battery 23 through resistance 24 allowing current from battery 23 to flow through the right-hand winding of relay 25 to ground, causing that relay to attract its armature and close the shunt circuit 15 which disables the line LE and amplifier detector 17.

When the armature of relay 21 completes its stroke and closes its upper contact, a circuit is closed from battery 26, winding of relay 25, winding of relay 27, resistance 28, armature of relay

21 to ground causing relay 27 to become energized and open the normally closed connection of condenser 22 with the tube 14 and winding of relay 21. Relay 21 remains energized, however, by space current from tube 14 which now flows entirely through resistance 29. The armature of relay 27 also closes at its lower contact a circuit to ground through high resistance 33 which is in parallel with the space path of tube 14 and permits a small additional current to flow through the energizing winding of relay 21. Battery 31 supplies biasing current for biasing windings of relays 27 and 25 as indicated. Relay 21 is also supplied with biasing current from battery 32 as shown, all three relays 21, 25 and 27 being polarized.

So long as speech continues on the line LW without interruption, the relays 21, 25 and 27 remain energized as above described. Upon the cessation of speech in the line LW, the grid of tube 14 assumes its normal high negative voltage due to battery 20 and the space current is quickly reduced to zero, allowing relay 21 to release. The armature of relay 21 in opening its upper contact breaks the D. C. circuit from battery 26 through windings of relays 25 and 27 but it will be noted that a condenser 35 is provided which now becomes charged from battery 26 by current flowing through windings on relays 25 and 27 and through a portion of resistance 28 condenser 35 and to ground. This current maintains relays 25 and 27 energized until condenser 35 becomes charged. The duration of energization of relays 25 and 27 is controlled by the constants of this circuit, particularly the capacity of condenser 35 and the magnitude of resistance 28. The armature of relay 21 upon closing its lower contact puts a shunt as previously described across the energizing winding of relay 25 so that relay 25 now remains under the sole control of the holding circuit above traced, extending through condenser 35. When the current in this holding circuit is sufficiently reduced, relays 25 and 27 both release their armatures. Relay 25 opens the disabling circuit 15 for the line LE and relay 27 again connects condenser 22 into the energizing circuit of relay 21.

Speech incoming over line L_1 for transmission into the line LE is amplified at A_2 and a portion of the amplified speech energy passes into circuit 16, amplifier 37, amplifier detector circuit 17 and causes relay 18 to attract its armature, and close circuit 19. Thus after speech has once begun to be transmitted from line L_1 into line LE, any energy arriving over line LW, whether it be due to speech from a distant terminal, echoes or other causes, is prevented from operating tube 14 and associated relays.

Fig. 1 shows but one terminal of the 4-wire circuit comprising lines LE and LW. The opposite terminal would be similarly arranged except that the circuit 12 and its associated elements will at that station be connected to the line LE, while circuit 16 and its associated elements will be connected to the line LW. By virtue of these connections, the 4-wire connection is placed under the control of the speech which first arrives at the receiving end of the 4-wire circuit.

It will be noted that the relay system in the echo suppressor makes for fast operation because relay 25 operates upon movement of armature of relay 21 away from its back contact. The time of travel of the armature of relay 21 is therefore eliminated from the operate time. Tube 14 being a gas-filled tube of the hot-cathode type responds practically instantaneously and uniformly to all voltages in excess of the threshold value so that uniform response characteristic is obtained for initially weak or initially strong speech.

The fact that the space current of tube 14 when once started builds up to its full value also makes for positive operation of the circuit. If a high vacuum tube were used at 14 or one in which the space current rises to a value depending upon the grid voltage, it is seen that speech energy of slowly rising characteristic might give non-uniform operating characteristics to relay 21. The immediate rise of current in tube 14, however, to maximum value when once the threshold value is reached by the input wave removes any such non-uniformity or uncertainty of response.

One function of resistance 33 in providing a holding current for the relay 21 as already described, is to prevent chatter at the make contact due to the tendency of the tube 14 to produce oscillations of the frequency range from about 80 to 200 cycles per second, depending on the amplitude of the input waves. These frequencies so produced bear little if any relation to the frequency of the input waves. The removal of condenser 22 from the plate circuit of the tube 14 also reduces the production of these slow oscillations in the gas-filled tube. If a large condenser were placed around the winding of relay 21 sufficient to eliminate the chatter, this condenser would need to be so large that the relay would be materially retarded in its operation. Chatter could be minimized by reduction of the plate resistance of tube 14 but the ability of the grid to stop the gaseous discharge is directly dependent upon the amount of current being passed. The plate resistance should be just great enough so that the tube 14 operates and releases for practically the same value of input voltage.

The design and construction of the gas-filled tube 14 itself may be varied within wide limits. A preferred construction is disclosed and claimed in U. S. patent to A. L. Samuel 1,921,004 issued August 8, 1933. The tube in general may be the usual high vacuum type of tube filled with an inert gas at low pressure. The maximum filament potential drop must not exceed the ionizing potential of the gas used. The grid must not emit electrons and the grid must shield the whole cathode from the anode since the amplification factor depends entirely on the size of the largest effective hole in the grid structure. A suitable gas to be used is argon at a pressure of 0.1 mm. although other gases, e. g., mercury, neon, etc., may be used, or a mixture of gases, including mercury and argon.

In the circuit of Fig. 1 that has been described above, the amplifier detector 17 may be of the usual prior art type, including a two-element rectifier, or any suitable rectifier for converting speech waves in the input circuit 16 into direct current suitable for operating relay 18.

With the circuit of the invention used in the echo suppressor as above described in connection with Fig. 1, the speed of operation is increased without increasing the sensitivity of the circuit thus retaining the same protection against false operation by noise. The high speed of operation insures that the relay 25 operates before incoming speech on line LW finds its way across hybrid coil 10 and into line LE where it might operate relay 18 but for the closing of disabling circuit 15.

Referring now to Fig. 2, land line LL is shown connected through a transmitting branch T and receiving branch R with another two-way line CL which may be a transoceanic telephone cable or any other suitable circuit, such as another land line or a two-way input circuit to a radio transmitter and receiver. Instead of the single terminating line CL, two terminating branches formed as extensions of the transmitter branch T and receiver branch R respectively, may be used leading respectively to a radio transmitter and a radio receiver.

In the circuit of Fig. 2 the transmitting branch T is normally disabled at the open armature contacts of relay 40 and the receiving branch R is normally in condition to receive on account of the normally closed armature contacts of relay 41.

Speech incoming on the line LL, which is provided with hybrid coil 42 and balancing network 43, passes in part into the transmitter branch T, through amplifier 44, equalizer 45 and into the delay network 46. A portion of this speech energy is taken off by circuit 47 leading to the amplifier detector 48. This amplifier detector controls relays 40 and 41, causing both of them to be energized in response to the speech waves in circuit 47. Relay 41 on energizing severs the connection between the line CL and the receiving branch R. Relay 40 in attracting its armatures connects the transmitting branch T through to the cable circuit CL. By the time relays 40 and 41 are fully operated, the speech that was applied to delay circuit 46 is passed on through power amplifier 49, contacts of relay 40 and into the cable circuit CL.

Upon the cessation of speech in the branch T, the circuit restores to the condition shown in the drawing.

Speech incoming from the cable circuit CL passes through the normally closed contacts of relay 41, amplifier 50, equalizer 51, amplifier 52, and into the land line LL. A portion of the speech energy in receiving branch R passes into circuit 53 leading to the gas-tube echo suppressor indicated in this figure by the rectangle 54. This echo suppressor circuit may be, and preferably is, of the type disclosed in Fig. 1 within the broken line enclosure 54 of Fig. 1. Relay 25′ is the same relay as relay 25 of Fig. 1, except that in the case of the circuit of Fig. 2, the back contact, rather than the front contact of this relay, is used. The back contact is normally closed, placing relays 40 and 41 under control of amplifier detector 48. Speech energy applied to the input circuit 53, however, immediately causes relay 25′ to attract its armature and remove relays 40 and 41 from the control of the amplifier detector 48. Thus, when the circuit of Fig. 2 is in receiving condition, the initial speech upon passing into receiving branch R disables the singing prevention circuit 48 and prevents any false operation which might otherwise take place by some of the received speech getting across hybrid coil 42 and into the input side of transmitting branch T.

The delay circuit 46 may be of any suitable type, either electrical, mechanical or acoustical, examples of each type being known in the prior art. The equalizers 45 and 51 are primarily to equalize for non-uniform attenuation of the speech at different speech frequencies although these may include also any volume control or volume expansion circuits, as may be found necessary. Equalizer 45 at one station together with equalizer 51 at the opposite station should just compensate for the wave distortion produced by all of the apparatus included between them, that is, the line CL together with the terminal apparatus that is used between the equalizers. In this way the speech waves applied to input 47 and those applied to input 53 have the characteristics of normal speech rather than speech which is purposely distorted as is the case at other points between the sending and receiving equalizer networks.

While the echo suppressor circuit of Fig. 1 is the preferred form, it may be replaced by the alternative form shown in Fig. 3. This may be done by substituting the circuit of Fig. 3 in the system of either Fig. 1 or Fig. 2 in place of the apparatus within the broken line enclosure 3.

If the circuit of Fig. 3 is substituted in the Fig. 1 system, terminals 56 and 57 of Fig. 3 will be used, these being connected to circuit 15 as shown. When making the substitution in the Fig. 2 circuit, terminals 55 and 56 will be used since the relay 25′ of Fig. 2 which relay 60 is to replace, has its back contact normally closed.

In Fig. 3 the gas-filled tube 14 may be identical with that of Fig. 1 and its input circuit may be the same as Fig. 1. The output circuit, however, includes a single relay 60 together with resistances 61 and 62, plate battery 63 and a condenser 64 or 65, one or the other of which is connected in circuit by the switch 66. The front contact or the back contact of relay 60 or both may be used for control purposes, the front contact being used in the system of Fig. 1 and the back contact being used in the system of Fig. 2, as above described.

With the switch 66 in the position shown in Fig. 3, condenser 65 is normally charged from battery 63, but relay 60 is deenergized. When speech waves are applied to the input circuit, tube 14 breaks down and its normal high plate resistance drops to a very low value, permitting condenser 65 to discharge through the space path of the tube and also causing current to flow from battery 63 through the winding of relay 60 through the resistance 61 and across the space path of the tube resulting in energization of relay 60. The tube 14 has a much lower resistance after breakdown than a high vacuum tube, and the current in the relay rises more rapidly than when a high vacuum tube is used because a higher ratio of resistance to inductance is permissible in the circuit. At the cessation of the applied speech waves, tube 14 is restored to the normal non-conducting, high impedance condition. Relay 60 is not immediately deenergized, however, since a charging current for condenser 65 now begins to flow from battery 63 through the winding of relay 60 and resistances 61 and 62. Condenser 65 thus provides a hangover effect, the timing of which is controlled by adjusting the magnitudes of the resistances and of the capacity of condenser 65.

With switch 66 in its alternative position, substantially the same action takes place, the difference being that in this case condenser 64 is normally discharged but receives a charge when tube 14 operates, the space current at first dividing between condenser 64 and winding of relay 60. Upon cessation of applied speech waves, condenser 64 discharges through resistances 61 and 62 and winding of relay 60 providing a hangover effect.

The invention is capable of various modifications in circuit structure, number and arrangement of relays used, number and arrangement of gas-filled tubes, etc. The circuits that have been shown and described are to be taken as illustrative rather than limiting, the scope of the invention being indicated in the claims.

What is claimed is:

1. In a signaling system, a signal transmission circuit including a disabling element capable of interrupting transmission, a circuit for controlling said element to permit or prevent transmission of signals through the circuit, comprising a gas-filled space discharge tube having an electron-emitting cathode, an anode and a control element or grid, means to impress some of the signal voltage across the cathode and grid of said tube in excess of the threshold value of grid voltage whereby the discharge current thus initiated is carried by gas ionization to substantially its maximum amplitude independent of the amplitude of positive grid swing so long as it is in excess of the threshold value, and means utilizing the resulting discharge current to actuate said disabling element.

2. In a voice operated circuit, a hot-cathode gas-filled electric discharge tube, including an anode and a grid or control element, a circuit for applying speech waves to the cathode-grid circuit causing said tube to break down with consequent abrupt lowering of its anode-cathode impedance, means in the anode-cathode circuit for effecting circuit control, and a condenser associated with the anode-cathode circuit the charge on which is controlled by the anode-cathode impedance, for producing a hangover effect in said circuit control means.

3. In a signaling system, two oppositely directed one-way transmission paths, means to transmit signals into the first path and to receive signals from the second path, a signal-operated device controlled from the first path, a second signal-operated device controlled from the second path, and containing a gas-filled hot-cathode electric discharge tube, means including a discharge control member or grid to which said signals are applied for causing said tube to pass substantially maximum amplitude discharge current in response to positive grid swings in excess of a predetermined minimum whereby initial discharge current of substantially maximum value is produced and means controlled by the gaseous discharge current of said tube for disabling the first path and the signal-operated circuit controlled therefrom.

4. In combination, a signal transmission path, a gas-filled hot-cathode electric discharge tube, a circuit for applying signal voltages to the input circuit of said tube, the anode-cathode of said tube including a current-operated device for controlling said path, and means biasing the grid negative with respect to the cathode, the external anode-cathode impedance being so high that the ratio of the input voltages at which said current-operated device operates and releases respectively are substantially unity.

5. In a voice operated circuit, a gas-filled hot-cathode electric discharge tube, means to apply speech waves to the input circuit of said tube, said tube and associated circuit elements having a tendency to produce oscillations, a relay in the cathode-anode circuit of said tube, and a circuit controlled by said relay for altering the constants of the cathode-anode circuit after space current flow takes place, to reduce the oscillating tendency of said tube circuit.

6. In a voice operated circuit, a gas-filled hot-cathode electric discharge tube, means to apply speech waves to the input of said tube, the cathode-anode circuit including an electromagnetic relay having an armature, and means controlled by said armature for establishing a holding circuit for said relay upon its energization, while still keeping the release of said relay under control of the space current of said tube.

7. In a two-way speech transmission system, a transmitter and a receiver, a voice operated circuit controlled by each and controlling the other, and means for increasing the speed of operation of the voice operated circuit controlled by the receiver without increasing its sensitivity comprising a gas-filled hot-cathode electric discharge tube having its input circuit coupled to said receiver and its output circuit connected to control said transmitter said tube having a grid or discharge control member and operating by gas ionization to pass substantially maximum amplitude discharge current in response to positive grid voltage swings in excess of the minimum voltage required to initiate discharge.

8. In a voice-operated circuit, a space discharge device having cathode, anode and control elements and containing gas such that the discharge between cathode and anode takes place principally by gas ionization, means to apply speech variations to the input of said device to initiate discharge, a relay connected between the cathode and anode, and a parallel combination of resistance and capacity connected in series with said relay, said capacity enabling a rapid building up of the space current upon initiation of discharge to cause rapid operation of said relay, and said resistance reducing the steady space current to facilitate restoration of the device to its un-ionized condition.

9. A voice-operated circuit comprising a current-controlled device and a hot-cathode gas-filled discharge tube for supplying control current to said device, a source of space current for said tube, said tube having a discharge control member or grid, means normally biasing said grid so far negative that no discharge current passes in said tube, and a circuit for applying speech waves to said grid, said tube passing substantially constant maximum discharge current for all values of grid voltage in excess of that required to initiate the discharge.

10. A circuit according to claim 9 in which said tube has means in its anode circuit reducing the discharge current to a value such that the grid is able to restore the tube to its non-transmitting condition when the applied speech waves cease.

11. A voice-operated circuit comprising a current-operated device, a hot-cathode gas-filled electric discharge tube for supplying operating current to said device, a control element in said tube negatively biased toward the cathode, and a circuit for applying speech waves between the cathode and control element to initiate space current discharge between cathode and anode for operating said device, said tube after its initial discharge supplying substantially constant peak amplitude current to said device so long as said speech waves continue to be applied.

12. A voice-operated circuit comprising a current-operated device, a hot-cathode gas-filled electric discharge tube for supplying operating current to said device, a grid or control element in said tube negatively biased toward said cathode, and a circuit for applying speech waves between said cathode and control element to

initiate space current discharge between said cathode and anode for operating said device, said tube initiating its discharge at a certain critical value of applied grid voltage and said discharge current ceasing, under grid control, at a smaller critical value of applied grid voltage.

13. In a voice-operated circuit, a hot-cathode gas-filled space discharge device, an anode and a grid or control element therefor, a circuit for applying speech waves to the grid to cause the discharge device to break down, said device when broken down operating by gas ionization to develop extremely low internal impedance between its cathode and anode whereby the discharge current under given grid circuit conditions is limited principally by the external anode-cathode impedance, a current-operated member to be controlled connected in the anode-cathode circuit, and a large capacity condenser connected in series with said member to enable substantially maximum discharge current to flow to said member upon breakdown of said device.

14. In a telephone system utilizing a voice-current repeater element, voice-controlled means for alternately rendering said element effective and ineffective to repeat speech waves comprising a gas-filled space discharge tube having an input circuit and an output circuit, polarizing means normally maintaining the input voltage on said gas-filled tube below the discharge point, an amplifier for impressing amplified voice waves on the gas-filled tube to cause its breakdown, and a circuit operated by the discharge current of said gas-filled tube for blocking the action of said repeater element.

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