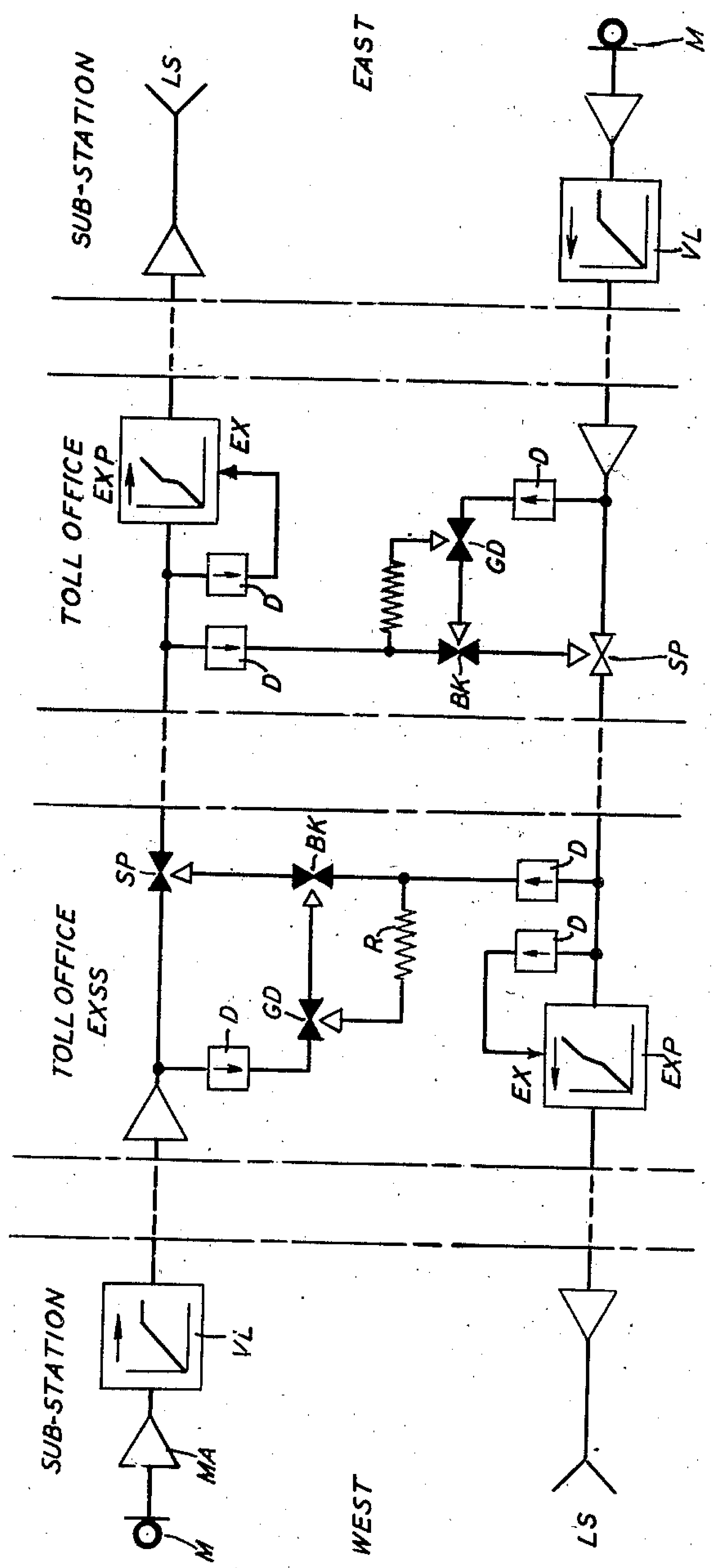
Dec. 23, 1941. D. MITCHELL 2,267,622

VOICE-OPERATED SWITCHING CIRCUIT FOR TWO-WAY TELEPHONY

Filed May 7, 1940 2 Sheets-Sheet 1

FIG. 1



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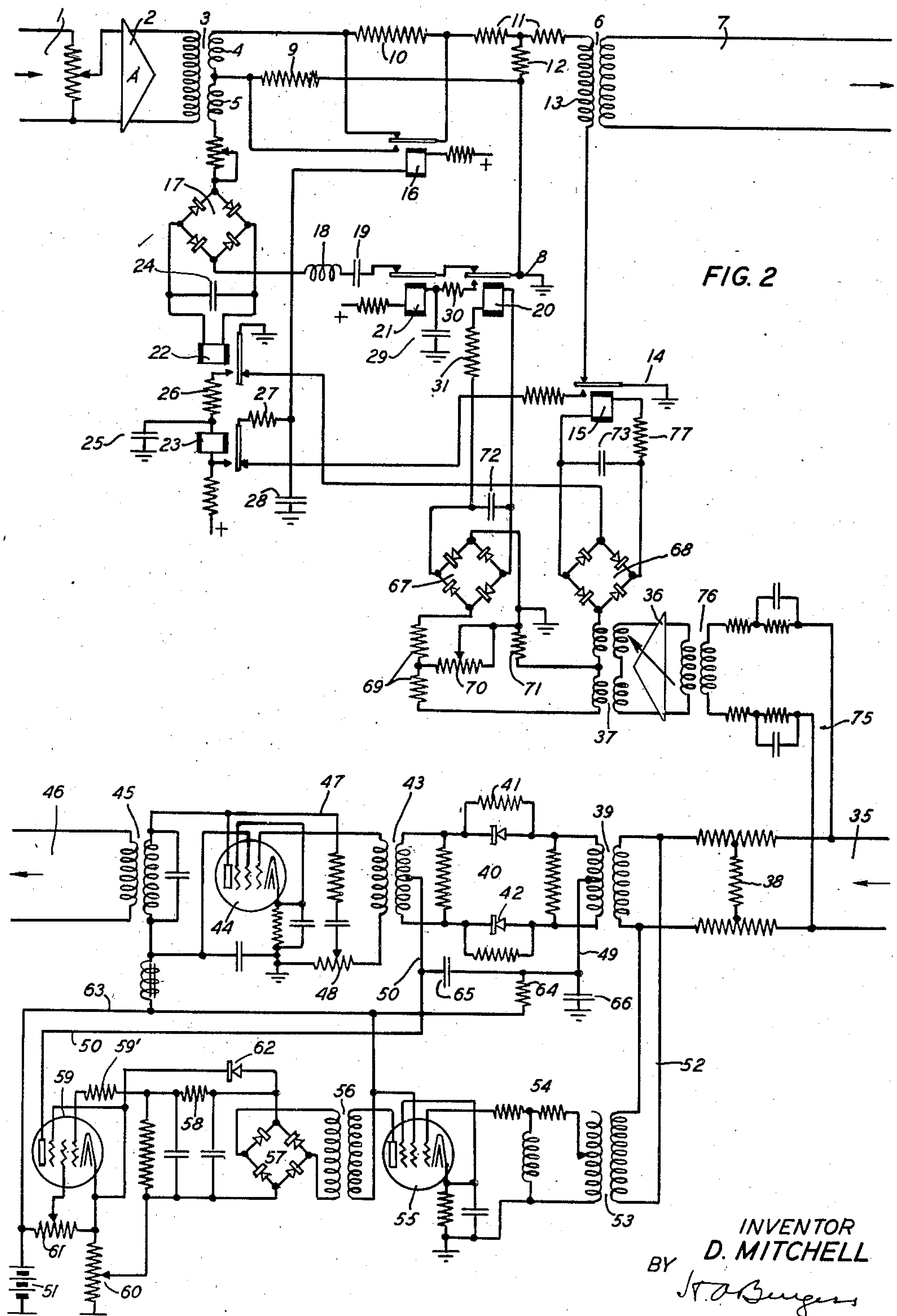

FIG. 2

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VOICE-OPERATED SWITCHING CIRCUIT FOR TWO-WAY TELEPHONY

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Application May 7, 1940, Serial No. 333,735

15 Claims. (Cl. 179—1)

The present invention relates to the two-way transmission of speech or similar waves over a system which has, at least at its terminals, separate transmit and receive circuits with transmission control devices operated under control of the waves traversing the system.

The invention in certain of its aspects represents an improvement upon the system disclosed and claimed in my prior application Serial No. 255,223, filed February 8, 1939, now Patent No. 2,213,991, Sept. 10, 1940. The system there disclosed comprises a two-way telephone system especially adapted for carrying on two-way communication between distantly separated groups of persons on a conference basis, and it involves certain types of voice control adapted to such a service.

The present invention is also adapted to telephone conference service and provides break-in circuits for enabling a talking party at any station to gain the attention of parties at the other station or stations of the system merely by raising his voice and without the manipulation of push buttons or the like. These provisions are made with the aim of simulating conditions in an actual conference room where a person naturally raises his voice to gain the attention of the other persons in the group.

The invention also includes features to protect against false operation of the transmission control circuits by noise, and other improvement features that will appear as the description proceeds.

While the invention will be specifically disclosed as embodied in a telephone conference system, it is not limited to such systems but in certain of its aspects it is of general application. The channel interconnecting the various terminal stations, of which there may be two or more than two, may be of any type such as physical lines or radio or other type of channel.

In the drawings,

Fig. 1 is a single line over-all schematic or a functional diagram of a complete two-terminal, two-way talking system in accordance with the invention; and

Fig. 2 is a schematic circuit diagram of the apparatus located at the west toll office shown in Fig. 1.

In Fig. 1 the upper and lower horizontal lines indicate speech transmission paths in opposite directions between the two substations. The lines terminating in arrows indicate controls exercised in the direction of the arrow. Two arrows with their points in contact indicate a normally operative transmission path which is broken under control of the arrow pointing toward the meeting point of the two arrows in contact. With this explanation in mind the general transmission features will now be outlined.

Considering speech transmitted from the west substation originating in the microphone M, this is amplified by the microphone amplifier MA and is passed through a volume control VL which has no effect on speech of normal volume but prevents transmission of high energy peaks of speech. At the west toll office the speech after amplification passes over the line through the normally closed contacts of the suppressor SP to the east toll office. Some of the speech at this point is detected at D and opens the contacts of the suppressor SP of the opposite line. Some of the speech energy also removes loss from the expander EXP over the control EX. The speech passes through the expander and on to the east substation where it is heard from the output of the loud-speaker LS. The equipment at the two toll offices is the same so that the description of the action which takes place at either office will suffice for both.

Returning to the west toll office, the controls are such that the outgoing speech path which was just traced through the normally closed contacts of the suppressor SP is normally under control of the receiving side, so that if speech is incoming in the receiving side provision is made for opening the suppressor SP in the transmitting side, thus preventing transmission in the outgoing path. The west talker can, however, break in by operating the break contacts BK in the suppressor control, as a result of some of the outgoing speech being detected and operating through the normally closed guard contacts GD. The arrangements are such, however, that received speech of greater than a predetermined value can disable this break control by breaking the guard contacts GD, the resistance R indicating that relatively large volume is required to accomplish this. Summarizing the above functions, it is seen that the outgoing path is normally under the control of the received speech; that the talker's outgoing speech can make this normal control ineffective in order to enable him to break in; but that the received speech can regain control by operating the guard control.

In addition to the foregoing controls the incoming speech as already noted removes loss from the expander EXP. The use of an expander to switch the loss under control of incoming speech is preferably to use of a relay or the equivalent which would produce sudden and very large changes in the loss. The operation of such a relay is found in practice to be annoying and disturbing because its contacts would be operating frequently to open and close the transmission path. The expander on the other hand is so controlled that its loss is not changed instantaneously but rather at approximately syllabic rate. For example, in a typical case it requires 10 to 30 milliseconds to remove the loss and from 70 to 90 seconds to restore the loss in the expander. The characteristic of the expander is of the general type indicated by the curve included in the rectangle which represents the expander. From this curve it is seen that the ratio of output to input is much steeper over an intermediate range of volume than it is for very weak volume or very strong volume. The settings of the circuit are such that on normal received volume from the distant terminal practically all of the loss is out of the expander all of the time that the speech is incoming. In the absence of received speech, however, a sufficiently high loss is introduced into the expander to prevent a singing condition in the system. It is found that the use of an expander in this manner for voice operated switching gives a much more pleasant effect than the use of a relay. This feature is disclosed and claimed in my prior application referred to above.

The suppressor control is set to be quite sensitive and is also given a considerable hang-over period in order to guard against the effect of echoes from reverberations of the conference room, which may persist for a considerable time, for example, of the order of 200 milliseconds. This means that the suppressor control is operated a large percentage of the time when there is incoming speech in the receiving side. This is especially true if there is more than one talker at the distant terminal. This fact makes it very desirable to provide the break control BK to facilitate breaking in by a talker at the local terminal. The break control is made considerably less sensitive than the suppressor control relative to normal speech volume. This is satisfactory in practice since a speaker in trying to interrupt or break in naturally raises his voice.

The guard control is provided to prevent the operation of the break control BK on echoes of loud speech. For example, when speech is incoming all of the loss is switched out of the expander so that if the break control were operated by an echo of the received speech to remove the loss at the suppressor point the system would be in a singing condition. Received speech of sufficient volume to produce such echoes, however, is strong enough to operate the guard control. This guard circuit can be set considerably less sensitive than the suppressor, for example 10 decibles less sensitive, and also will operate satisfactorily with a shorter hang-over time.

Referring to the circuits shown in Fig. 2, the west to east transmission path at the west toll office has its input at 1 and its output at 7, while the east to west transmission path at this toll office has its input at 35 and its output at 46.

The speech incoming in circuit 1 is amplified at 2 and is transmitted to the outgoing circuit 7 through transformers 3 and 6. The transformer 3 has its secondary divided into two parts 4 and 5. The upper portion 4 is included in a circuit which may be traced from ground at 8 through resistance 9, winding 4, resistance 10 and 11 and primary winding 13 of transformer 6 to ground at 14 when the suppressor relay 15 is deenergized, as normally. Resistances 11, together with shunt resistance 12, form a T-network. The winding 5 is in a circuit which may be traced from ground at 8 through the normal rest contacts of guard relays 20 and 21, tuned circuit comprising inductance 18 and capacity 19, rectifier bridge 17, winding 5 and resistance 9 to ground 8. The resistance 9 is of such value with respect to the resistance looking into the output of amplifier 2 as to make the transformer 3 operate like a hybrid coil and to effectively isolate the separate circuit branches traced above for the respective windings 4 and 5.

Suppressor relays 15 and 16 are operated under control of the receiving side of the circuit and in the absence of received speech they are in a deenergized condition. In this condition they establish a talking path of low impedance from transformer 3 through transformer 6 to the outgoing line 7. When relay 15 is energized in the manner to be described, it opens the speeech transmission circuit previously traced through winding 13, thus interrupting the outgoing talking path. This action occurs as soon as the armature leaves its back contact. When the armature of relay 15 closes its front contact suppressor relay 16 becomes energized by current from positive battery through the winding of relay 16, resistance 27, back contact of relay 23 (assuming this relay to be deenergized), front contact of relay 15 and ground. Relay 16 in operating first removes the short circuit around resistor 10, thus increasing the loss in the outgoing speech path and then upon closure of its front contact provides a short circuit across winding 4 and resistor 10 so as effectively to suppress outgoing speech. The effect of these two relays operating under control of received speech is, therefore, to disable the outing speech path, corresponding to opening the contacts of the suppressor SP in Fig. 1.

A part of the speech impressed on incoming circuit 1 is transmitted through the circuit traced above including winding 5. The speech waves in this branch are rectified at 17, the rectified current is smoothed by the shunt condenser 24 and operates break control relay 22. The tuning of the circuit branch 18, 19 is chosen to make this circuit especially responsive to the high energy portion of the speech band in the neighborhood of 1,000 cycles. This has the effect of discriminating against certain types of noise. Relay 22 in operating closes an energizing circuit for break relay 23 extending from positive pole of grounded battery through the winding of relay 23, resistor 26, front contact of relay 22 and ground. Relay 23 in operating breaks the previously traced energizing circuit for suppressor relay 16, which releases and replaces the short circuit around resistance 10. Relay 22, upon having energized as above described, interrupted, at its back contact in a manner to be described hereinafter, the energizing circuit for suppressor relay 15, which deenergizes and reestablishes the speech transmitting path through transformer 6. The effect of the operation of break relays 22 and 23 as described is to prevent received speech in the receiving side of the circuit from disabling the outgoing path, or in case the received speech has already disabled the outgoing path, to restore the continuity of the outgoing path under control of the outgoing speech. This corresponds in the functional diagram of Fig. 1 to operating the BK control and removing the SP control from the receiving side.

Considering now the receiving side of the circuit, speech waves entering the circuit 35 pass in part through the pad 38 and through the loss circuit 40 and amplifier 44 into the outgoing side 46. In order to remove loss normally present in the circuit 40 a portion of the incoming speech waves is diverted into circuit 52 and is impressed through input transformer 53 upon the input terminals of amplifier tube 55. The network 54 comprising series resistance and shunt inductance is designed to make this circuit sensitive to the high energy portion of the speech band in the neighborhood of 1,000 cycles to discriminate against noise. The amplified speech waves in the output of tube 55 pass through transformer 56 to the rectifier 57 where they are rectified into pulsating direct current. The filter 58 suppresses the pulsations and the resulting direct current is impressed on tube 59. The direction of the current is such as to increase the space current through the tube 59 in proportion to the amount of the rectified input. The space current of tube 59 flows in series from the plate over conductor 50 to the mid-point of the primary winding of transformer 43 where it divides and flows through the varistors 41 and 42 in parallel to the mid-point of the secondary winding of transformer 39 and returns through conductor 49, resistance 64 and conductor 63 to the positive pole of plate battery 51 and thence through ground 60 to the cathode of tube 59. Increase of current flow through this circuit decreases the loss in the circuit 40 by lowering the impedance of the varistors 41 and 42. The effect of the incoming speech in branch 52 is, therefore, to operate the control corresponding to EX of Fig. 1 and remove loss from the expander circuit, thereby giving increased volume to the speech in circuit 46.

The pad 38 is introduced to enable a relatively high signal level to be impressed on circuit branch 75 to operate the suppressor relays in a manner to be described and to permit a lower level to be used for operating the expander circuit as described.

The loss circuit 40 is constructed to be accurately balanced throughout in order to prevent alternating components of the control waves and harmonics thereof from entering the through speech path. Resistance 64 and condensers 65 and 66 act to filter out and by-pass any remaining alternating current in the plate circuit of tube 59 which might produce noise in the through transmission circuit.

Rectifier 62 affords a by-pass around the filter 58 to limit the speed of the expander action for very high input levels. Excessive voltages due to such signals are not able to be applied to the condensers of filter 58 due to the shunt action of rectifier 62 where such voltages exceed the normal range. The series resistance 59' in the grid circuit limits the amount of expansion by insuring that the control grid can never go positive by more than a very small fraction of a volt regardless of the magnitude of the applied signal voltage.

A negative feedback connection is provided for amplifier 44 by way of connection 47 to an adjustable point on grid resistor 48. Adjustment of this movable contact varies the magnitude of feedback for gain control purposes. The plate circuit is provided with a condenser around the output coil in order to attenuate frequencies above 10,000 cycles.

Receiving branch circuit 75 across incoming circuit 35 leads to the control circuits for the suppressor relay 15 and guard relay 20. Circuit 75 is shown as comprising series resistances shunted by condensers which act with the mutual inductance of the input transformer 76 to tune this circuit broadly at 1,000 cycles to discriminate against noise. After amplification in 36, the speech waves in this branch are applied to the coil 37 which acts similarly to the coil 3 in the transmitting side to divide the currents into two circuits which are mutually independent of each other to a high degree from an impedance standpoint. This is achieved by providing a mid-tap on the secondary of coil 37 and including resistance 71 to balance the output impedance of amplifier 36. The upper winding leads to rectifier circuit 68 which rectifies the speech waves supplied to it and renders them suitable for operating suppressor relay 15. Series resistance 77 and shunt capacity 73 act as a filter to suppress the alternating current components. The voltage across the lower half of the secondary winding of coil 37 is applied to rectifier 67 through the intermediary of attenuating resistances 69 and 70, the latter of which is shown as adjustable. These resistances control the relative sensitivity of the energizing circuit for the guard relay 20 to which the rectified output of rectifier 67 is applied. Series resistance 31 and shunt capacity 72 act as a filter to suppress the alternating components. The loss pads 69 and 70 correspond to the resistance R in the simplified diagram of Fig. 1 to insure that the guard relay 20 is operated only by received speech above a predetermined magnitude.

The various switching devices are adjusted to operate in particular timed relationship and certain of them are provided with means for giving a certain amount of hang-over time as will now be described. The suppressor relay 15 operates and releases quickly, this relay being provided with no hang-over. As its armature 14 leaves its back contact (as already described) the transmitting path is immediately interrupted between winding 13 of output transformer 16 and ground. As soon as the armature of relay 15 reaches its front contact ground is supplied over back contact and armature of relay 23 and resistance 27 to the upper plate of condenser 28 and to a terminal of the winding of relay 16. Condenser 28 is normally charged to the full voltage of the relay operating battery from the positive terminal adjacent relay 16. The application of ground from the armature of relay 15 as described first discharges this condenser and then effects energization of relay 16 over the path just traced. Although the armature of relay 15 may be vibrated frequently during received speech, the relay 16 is held energized for a greater portion of the time due to the delay release characteristic provided by condenser 28. For example, when the armature of relay 15 leaves its front contact momentarily current continues to flow through the winding of relay 16 and into condenser 18 providing hang-over. If relay 15 reenergizes during the hang-over period, condenser 28 is quickly discharged and the full hang-over time is again restored to relay 16. Relay 16 is released only provided relay 15 releases its armature for more than a given time interval.

The resistance 10 controlled by the back contact of relay 16 is desirable in order to provide for disabling the transmitting path into two steps. When relay 15 releases its armature the transmitting path is partially restored but is not fully restored until relay 16 releases. This prevents a too sudden application of high energy waves when the local party breaks in with loud speech the effect of which might be in some cases to cause false operation of the local receiving controls by a short impulse of high magnitude getting around the distant end of the circuit before the suppressor at that end has time to operate.

The energizing path for the relay 15 from the output coil 37 of amplifier 36 is by way of the ground at one terminal of resistance 71 through the upper winding of the secondary of transformer 37, rectifier 68, and back contact of relay 22 to ground. When there is sufficient energy in the transmitting talking circuit to operate the break relay 22 the suppressor relay 15 is immediately deenergized by the opening of the circuit just traced, as soon as the armature of relay 22 leaves its back contact. When the armature of relay 22 reaches its front contact it almost immediately discharges condenser 25 which has previously been charged to approximately full battery voltage over the circuit including the winding of relay 23 and associated resistance to the plus terminal. Relay 23 is then energized by current flow from the plus terminal through the relay winding and resistance 26 to ground over the front contact of relay 22. When the armature of relay 23 reaches its front contact condenser 28 is quickly charged to full battery potential through resistance 27, thus wiping out any remaining hang-over time for relay 16. Relay 16, therefore, releases very quickly and allows the speech of the breaking party to get through to the outgoing circuit 7. When the local speech ceases relay 22 quickly releases and relay 23 releases after a hang-over time provided by condenser 25 in the same manner as described for relay 16 and condenser 28. If relay 22 is not reoperated within the hang-over time of relay 23, relay 23 releases and restores the normal control circuit between relays 15 and 16.

When a sufficiently high level of received speech is present in the branch 75 the guard relay 20 is operated as previously described. As soon as the armature of relay 20 leaves its back contact it disables the breaking circuit by opening the energizing circuit for the break relay 22 at a point between the rectifier 17 and ground. When the armature of relay 20 reaches its front contact it discharges condenser 29 and causes operation of relay 21. Condenser 29 operates to give a delay release action to relay 21 in the manner previously described for relays 16 and 23. Thus, if relay 20 releases and is reenergized within the hang-over time of relay 21, relay 21 remains energized and its hang-over interval is restored.

The connection of the transformer 37 to the energizing circuits for the relays 15 and 20 to function after the manner of a hybrid coil as above described, permits sensitivity adjustments to be made for the relay 20 without affecting the sensitivity of the relay 15.

What is claimed is:

1. In a two-way speech transmission system, an outgoing speech path and an incoming speech path at the same station, means operated by speech energy in the incoming speech path for introducing loss into the outgoing speech path, means operated by speech energy in the outgoing speech path to disable the operation of said first means, and means operated by speech energy only in excess of a predetermined volume in said incoming path for preventing the disabling of the operation of said first means by said second means.

2. In a telephone system, a speech transmitting circuit at a terminal station, a speech receiving circuit at said station, said transmitting and receiving circuits serving as the opposite sides of a four-wire two-way conversational path, voice-operated means operating in response to received speech in the receiving circuit for inserting loss in the transmitting circuit, voice-operated means operating in response to speech in said transmitting circuit for disabling the first voice-operated means, and marginally operating means operated only by speech energy above a predetermined level in the receiving circuit for disabling said second-mentioned voice-operated means.

3. In a speech transmission system, an outgoing speech path and an incoming speech path at the same station, means for disabling the outgoing path under control of received speech in the incoming circuit, break means operated by speech energy on the input side of said outgoing path for making the first-mentioned means inoperative to disable said outgoing path, and guard means operated only by received speech energy in excess of a predetermined magnitude in said incoming circuit for rendering said break means ineffective.

4. In combination, a speech sending circuit and a speech receiving circuit at the same station, means controlled by speech in the receiving circuit for increasing the gain in the receiving circuit and increasing the loss in the sending circuit, means controlled by speech energy in the sending circuit for breaking the loss-increaser control to enable a talker at such station to transmit from the station, and marginally operating means controlled by speech only in excess of a predetermined level in the receiving circuit for disabling the breaking means.

5. In combination, an outgoing speech path, an incoming speech path, a singing suppressor including a quick-release relay operated from the incoming circuit and a second relay operated from the first relay and provided with a normal hang-over interval, said second relay holding the singing suppressor operated during vibrations of the first relay, a breaking circuit under control of the outgoing circuit, and means operated by said breaking circuit for disabling said first relay and for restoring the second relay in less time than its normal hang-over interval.

6. In combination, a speech transmitting circuit, a singing suppressor including a relay for introducing loss in said circuit, a condenser connected to the energizing winding of said relay to provide a hold-over interval therefor by flow of its charging current through the energizing winding of the relay, a breaking circuit controlled by speech energy in the outgoing circuit for disabling said singing suppressor, and means controlled by said breaking circuit for charging said condenser over a path separate from the energizing winding of said relay to reduce said hold-over interval.

7. In combination in a two-way speech transmission system a speech sending circuit includ-

ing a singing suppressor comprising a quick-release suppressor control relay, a slow-release relay controlled thereby, a contact in series in said sending circuit controlled by said quick-release relay, a series resistance in said sending circuit normally shunted by said slow-release relay when unenergized, and a shunt circuit across said sending circuit closed by said slow-release relay when energized.

8. In a speech transmission circuit, an input circuit therefor having two branches mutually conjugate with respect to each other, one of said branches forming a part of the through transmission circuit for speech, loss elements in said one branch, and means for switching said loss elements to disable said one branch, the second of said branches including switching control means for determining the operation of said switching means.

9. In a speech transmission system, a transmitting circuit and a receiving circuit at the same station, a singing suppressor including a suppressor relay for disabling the transmitting circuit, a breaking circuit for restoring said relay, a guard relay for disabling said breaking circuit, a switching control circuit controlled by speech energy in said receiving circuit and comprising two branches mutually conjugate with respect to each other, said suppressor relay being connected to one of said branches and said guard relay being connected to said other branch, and means in said other branch for controlling the sensitivity of said guard relay.

10. In a two-way telephone system, stations including terminal stations, oppositely-directed one-way transmission paths at said stations for transmitting telephone signals in opposite directions, a transmitter and a loud-speaking receiver connected respectively to the outgoing and incoming one-way paths at said terminal stations, a transmission device in one one-way path at one or more of said stations, normally providing a singing suppression loss therein and operating in response to applied telephone signals to effectively increase the gain of said one one-way path, voice-operated means responsive to the signals in the input of said device to insert loss in the other one-way path at said one station, break means responsive to telephone signals in said other one-way path to disable said voice-operated means, and marginal means operating in responsive to telephone signals in the input of said transmission device at said one station, of a level a given amount greater than normal level to disable said break means.

11. The system of claim 10, in which said transmission device is an expander type singing suppressor, one such transmission device being used at two different stations and being connected in oppositely-directed one-way paths at the two stations.

12. In combination in a two-way telephone system including oppositely-directed one-way transmission paths for respectively transmitting over the system the voice signals of the subscribers at opposite terminals thereof, one control device connected to each path, responsive to voice signal transmission therein, in the absence of prior voice signal transmission in the other path, to disable said other path, a second control device connected to each path, responsive to voice signal transmission therein to disable said one control device connected to said other path, and means to allow one subscriber to gain control of the system while another subscriber is talking and has operated said one control device connected to the path carrying his signals, to obtain directional control of the system, comprising a third relatively insensitive control device connected to each path responsive to voice signal transmission therein only of a level a predetermined amount greater than average level to disable said second control device connected to the other path so as to enable immediate operation of said one control device connected to the first path to disable said other path.

13. The combination of claim 12, in which said second control device is connected to each path in front of the disabling point therein.

14. The combination of claim 12, in which said one control device and said third control device are connected to each path beyond the disabling point therein and said second control device is connected to each path in front of the disabling point therein.

15. In a two-way speech transmission system, an outgoing speech path and an incoming speech path at the same station, means operated by speech energy in the incoming speed path for introducing loss into the outgoing speech path, means operated by speech energy in the outgoing speech path of a volume appreciably greater than normal speech volume to disable the operation of said first means, and means operated by speech energy only in excess of a predetermined volume in said incoming path for preventing the disabling of the operation of said first means by said second means.

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