

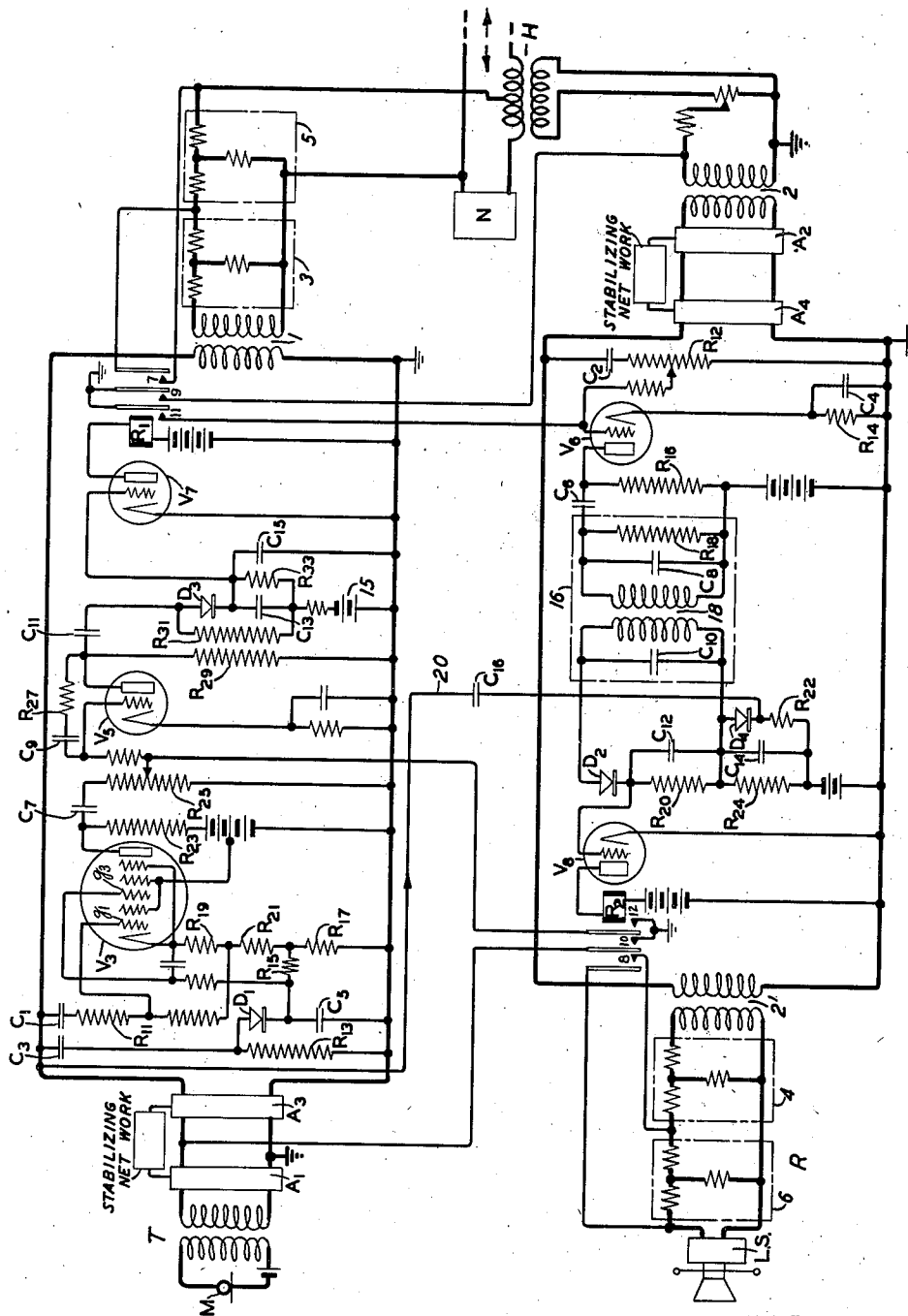
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TELEPHONE CONTROL CIRCUITS

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TELEPHONE CONTROL CIRCUITS

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This invention relates to control circuits which find application in various places but are here shown for illustrative purposes as applied to a two-way communication system with particular reference to communication terminal circuits. Specifically, the invention relates to improvements in voice operated control circuits of the type disclosed in my copending application, Serial No. 285,042, filed July 18, 1939, now Patent No. 2,214,804, issued Sept. 17, 1940, which control circuits are there described in connection with a telephone conference circuit.

In two-way communication terminals, especially if used in conference circuits where the connection between a plurality of terminals is more or less permanent, it is desirable that when no normal signal is taking place the system shall be as quiet as possible, being substantially immune from room noise and other background disturbances. Even during periods of signaling, such as speech signaling, it is desirable that in the pauses of the usual speech the circuits shall be brought to a highly quiescent condition. Furthermore, it is necessary, if the terminal is a two-way circuit, that the high gain which is characteristic of amplifiers in such circuits shall not lead to singing.

In my copending application as well as in the present disclosure the output of a microphone amplifier is connected through a hybrid coil to the input of a loud-speaker amplifier at the same terminal. The output load of the amplifier on the transmit side comprises the communication line or some signal responsive device. In order to maintain the system in a quiet condition during intervals of no signal, there is inserted in the signal path a loss device or attenuator which may be a series resistance or a shunt resistance, or a combination of the two. When signal is initiated in this path the loss is removed, this being accomplished by a control circuit, the input of which is itself connected in parallel to the main load. A similar arrangement of loss device with control circuit is associated with the receive side of the terminal.

However, the cutting out of a large loss substantially alters the impedance into which the amplifier works, causing a drop in output voltage which may be of sufficient magnitude to seriously affect the operation of the control circuits. Accordingly, there is introduced a stabilizing means in the amplifier circuits in such manner that the output voltage is nearly independent of the variations in load impedance. In addition, for a two-way terminal having a transmit and a

receive side, the control circuits on the one side, when subjected to signal, operate to disable the circuits on the other side.

These general statements apply both to the circuit of my copending application and to the circuit of this application. One of the specific objects of this invention is to improve on the control circuits of my copending application by (a) providing a better signal-to-noise ratio and hence on a given signal-to-noise ratio to improve the operation, (b) decreasing the attack time, that is the time required for a circuit to perform its operation after the signal is applied, and (c) providing a more nearly constant hold-over time of control relays for varying level input signals. These objects are attained in part by the insertion of an expander circuit in front of the previously disclosed voice operated switching circuits and in part by the use of negative feedback on the control amplifier in one or both switching circuits.

The invention will be better understood by reference to the following specification and the accompanying drawing in which the figure is a schematic circuit diagram of one terminal of a two-way telephone conference circuit.

Referring more specifically to the drawing, there is shown a transmit side T of the terminal and a receive side R, the two being associated with each other by means of a hybrid coil H. Ideally, the hybrid coil would make the two circuits conjugate, but in practice the transmission loss introduced between the two circuits depends on line characteristics, line length, etc., so that perfect balance is not ordinarily obtained. Accordingly, signal originating at the microphone M will pass through the hybrid coil and appear on the loud-speaker amplifier input terminals. Frequently, for the average balance obtained in the hybrid coil, the signal level at the loud-speaker amplifier input terminals of signals which come from the microphone amplifier is higher than the lowest signal received from the line. Hence if the sensitivity of the loud-speaker control amplifier is set to operate on the lowest line levels it will be operated by signal incoming through the hybrid coil from the microphone. This will cause the loud-speaker amplifier circuit to disable the microphone amplifier, thus removing the signal incoming from this side of the circuit. The loud-speaker amplifier control circuit thereupon falls back to normal, only to be operated by the restored signal, and hence a type of singing known as "motorboating" is set up. One remedy for this, as disclosed in my co-

pending application, is to place a large loss in the transmit side in front of the hybrid coil.

In the circuit of the figure here shown, the output of the microphone M is impressed on an amplifier, indicated as the two amplifiers A₁ and A₃ in tandem. The output of the amplifier then goes directly to a transformer 1 and from there to the hybrid coil H. An impedance correcting network or pad 3 is inserted in the line in a manner now customary in the art. In addition, a loss or attenuating device 5 is introduced in the line, this loss being of such characteristics as to reduce any signals coming from the microphone to a negligibly small value. If, however, signal above a certain level originates at the microphone M then, through the operation of the control circuits to be described hereinafter, this loss is removed. Prior to removal, however, the same control circuit disables the receiving side of the terminal in a manner to be described hereinafter.

In accordance with the invention as described in my copending application and for the purposes referred to, a stabilizing network is associated with the amplifiers A₁ and A₃, which stabilizing network may take on a wide variety of forms. In my copending application it is shown as a negative feedback circuit from the output of the second amplifier to the input of the first amplifier and comprises, in its simple form, a series condenser and resistance.

The control circuit on the transmit side is in part substantially the same as that in my copending application. Therein it is shown as including a condenser and a potentiometer, corresponding to C₇ and R₂₅, bridged directly across the line. The connection here is altered somewhat as will be described below. Across the potentiometer there is connected the grid circuit of the amplifier V₅. In the output of V₅ is included a detector D₃ in series with condenser C₁₃. These latter are shunted by the resistance R₃₁ and around C₁₃ is shunted the resistance R₃₃. In the detector circuit is also included a biasing battery 15, and finally a condenser C₁₅ is connected across the resistance R₃₃ and battery 15. Associated with this detector circuit is the input of amplifier tube V₇, the grid of this tube being normally biased by the battery 15 to such an extent that the current flowing through relay R₁ connected in the output circuit of tube V₇ is not sufficient to operate the relay. When signal of sufficient amplitude is present, rectified current through R₃₃ raises the potential of the grid of V₇ sufficiently to operate the relay R₁. The hang-over characteristics of R₁ and its circuits is determined by the relative capacities of C₁₃ and C₁₅ and the associated resistances.

On the receive side of the terminal the transformer 2 is connected to the hybrid coil and feeds into an amplifier, here shown as two amplifiers, A₂ and A₄, connected in tandem and having associated a stabilizing network to perform a function similar to that of the stabilizing network on the transmit side. The output of the amplifier proceeds to the loud-speaker through transformer 2', a pad 4 and a loss device 6, similar to the corresponding elements described for the transmit side. The attenuation introduced by the loss device 6 is sufficient so that when in the line, signal reaching the loud-speaker is negligible. However, by means of the control circuit in the receive side, this loss is removed when signal of sufficient intensity arrives.

The control circuit for the receive side is con-

nected to the line by the bridging circuit C₂, R₁₂. Associated with this bridge is the amplifier V₆, with the output of which there is associated a wave-shaping circuit 16. This wave-shaping circuit comprises a transformer 18, which transformer is tuned by the condensers C₈ and C₁₀ to a frequency approximately in that portion of the speech range of highest power, that is from 200 to 1000 cycles. The tuning is rendered rather flat by the resistance elements in the circuit, such as R₁₈. The circuit thus discriminates against the low frequencies characteristic of room noises and produces favorable signal-to-noise ratio for voice operated devices working from a telephone line. Additional low frequency attenuation is obtained by condenser C₆. The output of transformer 18 is impressed on a rectifier circuit comprising detector D₂, resistance R₂₀ and condenser C₁₂. The direct current voltage developed across the resistance R₂₀ serves to raise the potential of the grid of tube V₈ whereupon the relay R₂ in the output of that tube is operated.

On the initiation of speech signal of sufficient power level at the microphone end the relay R₁ is operated to close its contacts 7, 9 and 11. The closing of the contacts at 7 effectively removes the loss 5 from the transmitting circuit and the closing of the contacts at 9 disables the receiving amplifiers A₂, A₄ by connecting one side of the input line to ground. The closing of the contacts at 11 brings the potential of the grid of V₆ to ground, thus disabling the receiver control circuit. The time constants of the circuits are such that the latter two functions are performed before the removal of the loss 5 and the hang-over characteristics of the relay R₁ are such that the loss 5 is again introduced before the receiving side is enabled.

On the receipt of signal from a remote station and if the receive circuit is not disabled, the receiver control circuit operates the relay R₂ to close its contacts 8, 10 and 12; closing of the contacts at 8 effectively removes the loss 6 in front of the loud-speaker; closing of the contacts at 10 disables the transmit side of the terminal; closing of the contacts at 12 grounds the grid of V₅, thus disabling the transmitter control circuit.

In addition to the circuit as thus far described certain other features are incorporated of which the following three are of particular importance: (a) The introduction of an expander tube V₃ and circuit in front of the linear amplifiers of the transmitter control circuit; (b) the insertion of a shunt negative feedback in the circuit of amplifier V₅; (c) the introduction of a desensitizing means for the circuit of V₈ in the receiver control circuit. These will now be described in further detail.

Referring more particularly to the expander, the control circuit on the transmit side includes a bridge across the line comprising a blocking condenser C₁ and a potentiometer R₁₁ to which the grid g₁ of the vacuum tube V₃ is connected. This tube serves as an expander amplifier, the output of which is supplied to the tubes V₅ and V₇ in tandem to operate the relay R₁, which relay performs functions described heretofore. The expander characteristics of V₃ are brought out in the following manner. Bridged across the line is a circuit including the blocking condenser C₃, detector D₁ and condenser C₅. The detector may be of any suitable form, such as a crystal detector or a vacuum tube diode. Shunted around the detector D₁ and the condenser C₅ is a resist-

ance R_{13} and shunted around the condenser C_5 are the resistances R_{15} and R_{17} , the latter being in the cathode circuit of V_3 . Included in the cathode circuit are also resistances R_{19} and R_{21} serving to provide one self-bias for grid g_1 and a different one for grid g_3 in the tube V_3 . The grid g_3 is so associated with the detector circuit that as the value of the signal from A_3 increases, the potential drop across R_{15} and R_{17} renders g_3 more positive, thus increasing the gain of the tube V_3 . The blocking condenser C_7 and resistance R_{25} are included in the load circuit of V_3 instead of being bridged directly across the line as in my aforementioned copending application.

The purpose of the expander circuit is to permit operation in locations where the signal-to-noise ratio is unfavorable. In particular, the use of the expander causes a greater variation in the current through the relay R_1 for variations in signal level than is obtained from a linear amplifier. Two arrangements of the expander are permissible, one in which the expander is arranged with a threshold value and the other without a threshold value. In my invention I prefer to use the expander with the threshold value in order to obtain a control circuit with about the same sensitivity and attack time characteristics at the operating point of the control circuit as the control amplifier possesses when no expander is used. This threshold is obtained from the voltage drop over R_{17} due to currents through V_3 . With the expander circuit I find that the current in the relay winding above the operating point is practically independent of the input level. This arises from the fact that the voltage built up across condenser C_{13} above the operating point is correspondingly independent of the input level.

The negative feedback referred to is shown as comprising a resistance R_{27} and condenser C_9 bridged from the plate to the grid of V_5 . This connection is that commonly known as the shunt negative feedback and such a feedback has the property of decreasing the effective resistance of this tube as a source as it feeds the detector D_3 . This makes it possible to charge the associated condenser C_{13} at a faster rate and this in turn causes the plate current of the relay control tube V_7 to rise more rapidly and hence decreases the attack time of relay R_1 . This improvement of attack time on low input levels is especially desirable because speech sounds in most cases build up from a low level. With a lower attack time the control circuits are actuated sooner by the speech wave and less of the speech build-up wave is lost. I find in practice that the combination of having both the feedback and the expander provides a nearly constant hold-over time for all signals about 5 decibels above the operating point. This means that signals of different

levels will experience the same hang-over time and this is a desirable feature since the hang-over time of the circuit should not be dependent upon input level but rather should be only that required to hold the circuit up during the intervals between syllables of speech. The time constant of the expander circuit should be made small in order not to adversely affect the attack time of the microphone amplifier control circuit.

The desensitizing circuit referred to, which is the invention of another party, consists of means actuated by signal on the transmit side to decrease the sensitivity of the receiver tube V_8 for signals which might come in on the receive side because of unbalance at the hybrid coil. The means consists essentially of an additional detector D_4 associated with resistances R_{22} , R_{24} and condenser C_{14} . This detector circuit is actuated by the signal from the microphone amplifier over circuit 20 which gives rise to a rectified voltage over R_{24} . The polarity of this is such as to oppose the potential on the grid of V_8 arising from the detector D_3 and the magnitude is adjusted so that when voice signal originates at the microphone M and finds its amplifier enabled the nullifying effect of the voltage drop over R_{24} is sufficient to prevent operation of relay R_2 . The desensitizing circuit makes it possible to maintain suitable operation of the terminal as a whole with a smaller switching loss at 5 than is otherwise necessary. This reduction in the switching loss at 5 is an important asset for when such loss is excessive its switching in and out gives rise to undesirable popping noises in the circuit and a reduction in the magnitude of the switched loss reduces such undesirable effects.

What is claimed is:

1. In combination, a two-way telephone system including oppositely directed one-way transmission paths for repeating the telephone signals in opposite directions, a voice operated switching system comprising amplifier-rectifier switching circuits controlled from the respective one-way paths for switching losses between the paths in such manner as to suppress echoes and prevent singing, and means to improve the operation of said switching system including a voice-operated volume range expander connected in front of the rectifier in at least one of said switching circuits, the expander operating to provide a better signal-to-noise ratio, to increase the speed of operation of the circuit and to provide a more nearly constant hold-over time for varying level input signals.

2. The combination of claim 1 in which the said means includes a negative feedback circuit associated with the amplifier-rectifier in the switching circuit operating to further increase the speed of operation of the circuit.

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