

Oct. 7, 1947.

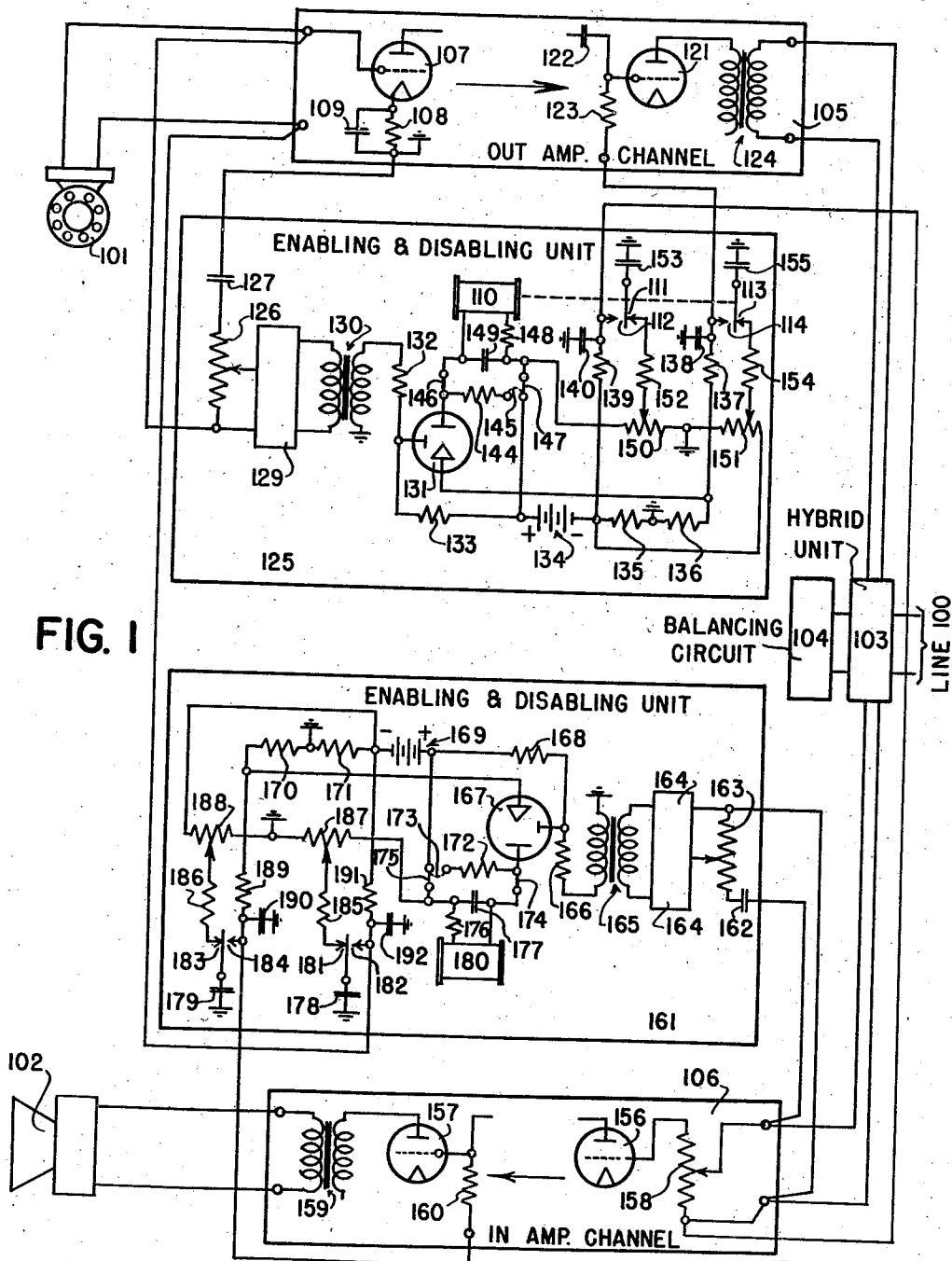
R. H. HERRICK

2,428,520

TRANSMISSION SYSTEM

Filed May 1, 1943

2 Sheets-Sheet 1



INVENTOR.
ROSWELL H. HERRICK

BY

Davis, Lindsey, Smith & Shonts

ATTORNEYS

Oct. 7, 1947.

R. H. HERRICK
TRANSMISSION SYSTEM

2,428,520

Filed May 1, 1943

2 Sheets-Sheet 2

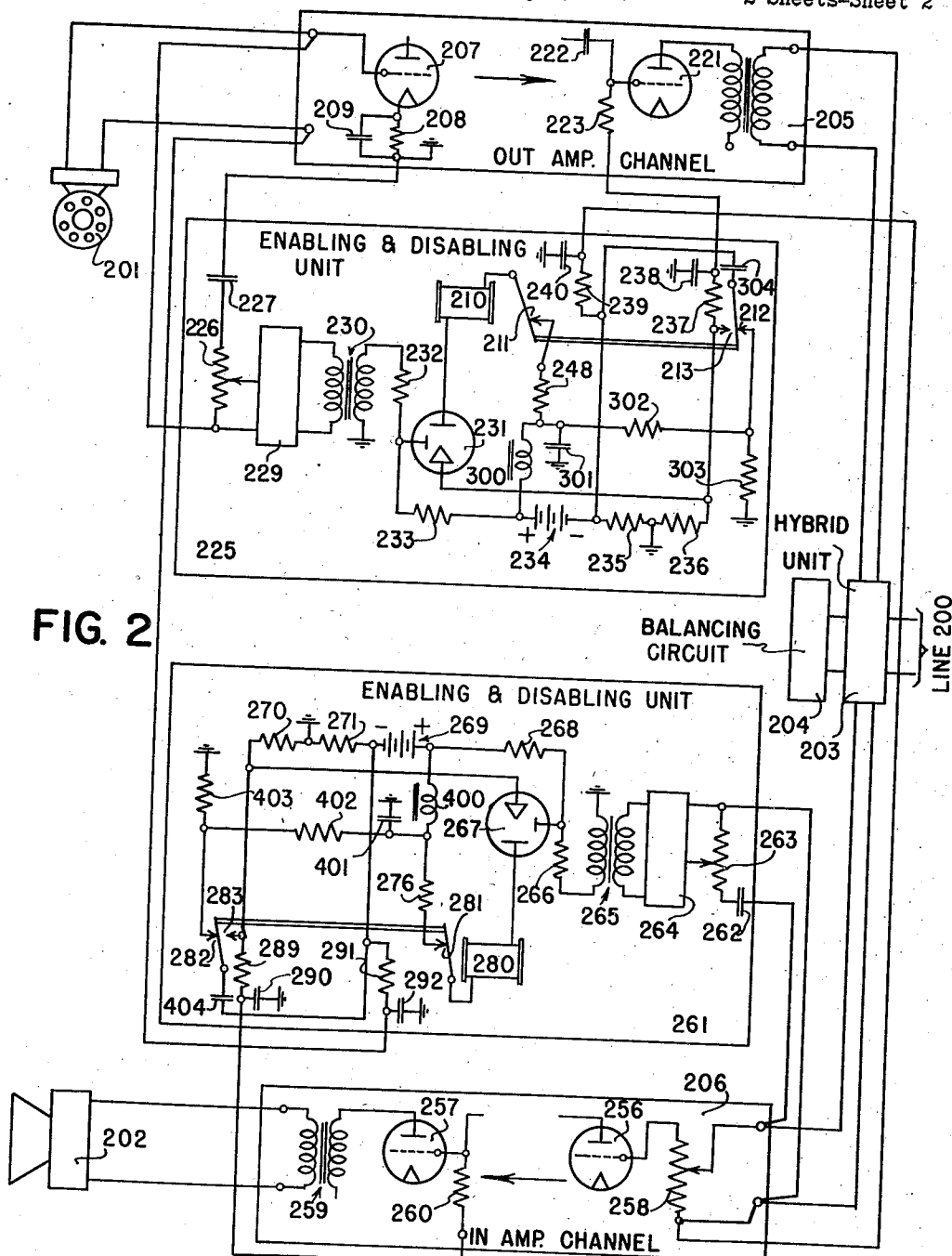


FIG. 2

INVENTOR.
ROSWELL H. HERRICK

BY
Davis, Lindsey, Smith & Shonts

ATTORNEYS

UNITED STATES PATENT OFFICE

2,428,520

TRANSMISSION SYSTEM

Roswell H. Herrick, Oak Park, Ill., assignor to
Automatic Electric Laboratories, Inc., a corpo-
ration of Delaware

Application May 1, 1943, Serial No. 485,269

12 Claims. (Cl. 178-44)

1

The present invention relates generally to improvements in signal current transmission systems of the type in which signal controlled switching circuits are provided for partially or completely blocking, under certain conditions, certain of the signal channels included therein and, more particularly, to improvements in telephone substation circuits of the type disclosed in United States Letters Patent No. 2,282,405, granted May 12, 1942, upon the application of Roswell H. Herrick, for Transmission systems.

In the patent referred to there is disclosed an improved telephone substation apparatus of the character wherein the channels are preferably only partially blocked when not in use, and wherein the control of the channel blocking circuit is arranged to utilize a hot cathode controlled gas tube, whereby effective channel blocking and unblocking operations are obtained without any substantial speech clipping.

In such an arrangement there is provided a telephone substation connected to an associated line by a hybrid or anti-sidetone impedance network and a first channel is provided for transmitting signal currents from the transmitting means through the hybrid system to the associated line, and a second channel is provided for transmitting incoming signal currents from the hybrid system to the receiving means. Associated with each channel is a control circuit including a controlled gas tube together with means controlled by the flow of current therethrough for changing the transmission efficiency of at least one of the channels. Apparatus comprising rectifying means is provided for coupling the control electrode of each of the gas tubes to the associated channel so that a predetermined potential is impressed on the control electrode of the tube to render it conductive when signal current traverses its associated channel.

Each of the control circuits is provided with circuit means operative to lower the potential difference between the anode and cathode of the associated control tube when the flow of signal currents through the associated channel is arrested, thereby to arrest the flow of current through the tube and to restore the control to the control electrode. Two different embodiments of the current arresting means are disclosed. In one of these embodiments a slow-to-release relay is provided in the load or output circuit of the rectifying means, which relay functions momentarily to interrupt the anode circuit of the associated gas control tube when the input signal voltage derived from the associated channel, and impressed

2

upon the input circuit of the rectifying means, is removed. In the other embodiment there is locally provided a source of alternating current which is utilized as the anode current source for each of two control tubes. With the latter arrangement, when the control electrode of one of the tubes is biased to a starting potential, the tube functions as a half-wave rectifier so that direct voltages are developed in the output circuit thereof, which are utilized to perform the desired channel control functions.

While such arrangements have proven to be entirely satisfactory it may be desirable to provide certain other characteristics and advantages not contained therein. For example, it may be desirable to utilize in place of a hot cathode controlled gas tube, a cold cathode controlled gas tube. The particular advantage to be gained is that the need for filament power for the control tube is eliminated, and furthermore, since many hot cathode controlled gas tubes have cathodes which require a longer heating time than the cathodes of the tubes used in the associated channel amplifiers, there of course is some delay between the times when the two types of tubes are conditioned for use after the heating circuit for the cathodes has been closed. Since controlled gas tubes must have the anode potential interrupted or reduced in order to restore the control of the control electrode, various methods and devices must be provided. In certain instances it is possible to provide improved arrangements which, for certain situations, may have distinct advantages over arrangements such as those already known in the art. For example, where an alternating current supply is used to bring about the periodic interruption of the conductivity of the control tube, there is a possibility of some delay occurring in accordance with the probabilities relative to the positive half-cycles of alternating current. In other words, in certain instances the initiation of speech might fall within the negative loop of alternating current which would provide a maximum delay not less than 8.35 milliseconds or $\frac{1}{120}$ of a second, which, together with the two or three milliseconds required for a positive half-cycle of anode potential to reach a value at which the tube will become conductive, might produce at certain times some speech clipping. In order to reduce such possibilities of speech clipping or delay which might be undesirable for certain purposes, it is proposed to provide a direct current potential for the control tube which, together with some means responsive to the conductivity of the tube will periodically

3
render the tube non-conductive. Such periodic rendition of the tube to non-conductive state is preferably produced at a frequency which is low compared to production voice frequencies, but which, however, is sufficiently high so that it will not be difficult to provide a filter arrangement adequate to remove the noise which is brought about as a form of an alternating current component due to interruptions of the conductivity of the tube. If such an arrangement has provided periodically interrupted conductivity of the tube by a variation of the anode voltage, the conductivity is re-established at the next half-wave of proper polarity from the controlling voice or signal wave. It therefore becomes apparent that it is desirable to avoid a relatively high frequency of interruption because this would result in a smaller proportion of time of conductivity of the control tube which, in turn, would produce a smaller average anode current flow and a resultant smaller control voltage for application to the associated channel amplifier.

In accordance with the present invention several embodiments are disclosed for periodically rendering the control tube non-conductive. In one of these embodiments circuit means are included in the anode circuit of the control tube which, due to the flow of anode current built up an IR drop which, in turn, sufficiently reduces the anode potential so as to bring about the interruption of the conductivity of the tube. In the other embodiment other means are provided responsive to the conductivity of the tube for periodically rendering the tube non-conductive, and in this arrangement a predetermined control voltage is constantly applied to increase the gain of the associated channel amplifier and yet the anode supply to the controlled gas tube is periodically interrupted so as to periodically give the control electrode a renewed opportunity to control the conductivity of the tube. Upon cessation of voice or signal current flowing through the associated channel amplifier the failure of the control electrode to supply a potential sufficient to renew the conductivity of the control tube brings about operation of a slow-to-release relay which thereby removes from the control electrodes of the tubes of the channel amplifier the fixed bias which was applied to increase the gain thereof.

It is an object of the present invention to provide improved telephone substation apparatus of the character described wherein the channels are preferably only partially blocked when not in use, the blocking of the signal current transmitting and receiving channels is accomplished in a simple and reliable manner, and wherein the control circuits are arranged to effect channel blocking and unblocking operations without any substantial speech clipping.

It is another object of the invention to provide an improved transmission system particularly suited for use in telephone substation circuits of the character described, wherein the control or channel blocking circuit is arranged in an improved manner to utilize a cold cathode controlled gas tube.

It is still another object of the invention to provide an improved transmission system utilizing channel amplifiers wherein the control circuit employs a controlled cold cathode gas tube and wherein means are provided responsive to the conductivity of the tube for periodically rendering the tube non-conductive.

Further features of the invention pertain to the particular arrangement of the circuit ele-

ments, whereby the above and additional operating features are obtained.

The novel features believed to be characteristic of the invention are set forth with particularity in the appended claims. The invention, both as to its organization and method of operation, together with further objects and advantages thereof will best be understood by reference to the following description taken in connection with the accompanying drawings, in which Figure 1 illustrates a substation circuit having incorporated therein one embodiment providing certain features of the invention as briefly outlined above; and Fig. 2 illustrates a different embodiment of the improved transmission system as incorporated in the substation circuit.

Referring now more particularly to Fig. 1 of the drawings, the substation circuit therein illustrated is adapted to be connected to a telephone line 100 which may, for example, form a part of a conventional automatic or manual telephone system, in which case the distant end thereof will terminate in a line circuit, the character of which is determined by the character of the exchange. Briefly described, the substation circuit comprises a transmitter or microphone 101, receiving means in the form of a loudspeaker 102, an anti-sidetone impedance network or hybrid system 103, a balancing circuit therefor 104, and outgoing and incoming amplifier channels 105 and 106. The outgoing amplifier channel may comprise a plurality of stages of amplification of any suitable type, such as resistive, capacitive or inductive coupled amplifiers. Since the particular type used is of no special significance to the present invention, only the input and output tubes thereof have been disclosed to show how the control circuit associated therewith is to be connected to the amplifier channel. The outgoing amplifier channel is shown having an input vacuum tube 107 which has a grid energized from voice currents produced by the microphone 101. The grid to cathode circuit includes a self-biasing resistor 108 suitably by-passed by a capacitor 109, both of which are connected to ground. A portion of the output stage of the amplifier is shown comprising the output tube 121 having a grid connected to a coupling capacitor 122 and a coupling resistor 123. The anode of the vacuum tube 121 is connected to a transformer 124, the output of which is connected to the hybrid unit 103. The outgoing amplifier channel is provided with an enabling and disabling unit 125 which is connected to be responsive to signal currents passing through the outgoing amplifier channel by a circuit including a voltage divider 126 and a coupling capacitor 127 effectively arranged to be bridged across the input or grid circuit of the outgoing amplifier channel tube 107. A portion of the voltage appearing across the adjustable resistor or voltage divider 126 may be amplified by a suitable amplifier 129 which is provided with an output transformer 130. The control circuit 125 includes a cold cathode gas tube 131 having a cathode, an anode, and a control or starting electrode. The control or starting electrode of the gas tube 131 is connected to a predetermined point on a bleeder circuit comprising the grounded output winding of the transformer 130 and the resistors 132 and 133 which are connected to the positive terminal of a source of voltage 134. The control electrode is connected to the common juncture of the resistors 132 and 133. The source of potential 134 has its negative terminal connected through a

5

resistor 135 to ground. The cathode of the control tube 131 is connected through a resistor 136 to ground. The anode of the control tube 131 is arranged to be connected through a suitable circuit to the positive terminal of the source of voltage 134. As has been stated, the control electrode of the tube 131 is connected to a bleeder circuit which is arranged so that the voltage drop appearing across the resistor 132 supplies the greater portion of the voltage required by the control electrode to render the control tube conductive. The remainder of the necessary required voltage is obtained from the voice components appearing across the output winding of the transformer 130. While the control electrode of the vacuum tube 131 might be energized solely from voice components appearing across the transformer 130 by supplying sufficient stages of amplification in the amplifier 129, it is believed to be an uneconomical arrangement. When anode current flows it will be noted that the anode to cathode circuit includes both the resistors 135 and 136, the common juncture of which is connected to ground. The opposite terminals of the resistors 135 and 136 are arranged to supply suitable potentials to the incoming channel amplifier thereby to disable that channel amplifier, and to the outgoing channel amplifier thereby to enable that amplifier. Accordingly, the remaining terminal of the resistor 136 is connected to a suitable circuit including a resistor 137 and a grounded capacitor 138 and the grid coupling resistor 123 of the outgoing channel amplifier output tube 121. The other terminal of the resistor 135 is connected to a circuit including a series resistor 139 and a grounded capacitor 140 and the grid circuit of the input tube of the incoming amplifier channel 106.

As has previously been stated, it is desired to provide a control circuit wherein, in response to the conductivity of the tube, means are operative for periodically rendering the tube non-conductive. One of the simplest circuit arrangements which would thus provide such operation would be to provide a resistor 144 connected in series between the anode of the control tube 131 and the positive potential of the anode supply 134 by connecting the strap 145 and disconnecting the straps 146 and 147. By proper selection of the value of the resistor 144 in series with the anode to cathode circuit, the resulting IR drop produced in response to the conductivity of the tube 131 will be such as to reduce sufficiently the effective anode voltage that the tube will no longer remain conductive. Thereupon the voltage appearing across the series resistor 144 also disappears and again the full anode potential is applied to the control tube 131. If it is assumed that signal currents are still being transmitted through the outgoing channel amplifier the next succeeding positive half-wave of voice voltage appearing at the control electrode of the control tube 131 will again render the control tube conductive. This cycle of operation therefore will continue to recur as long as voice currents are being transmitted through the outgoing amplifier channel. Such an arrangement, however, would require that considerable filtering action be provided for the resistors 135 and 136 in order to suppress the rather low interruption frequency resulting from such operation, which of course would reduce seriously the rapidity with which the enabling and disabling unit 125 could enable and disable the outgoing and incoming channel amplifiers 105 and 106. In order to obviate this disadvantage an-

6

other arrangement has been provided, whereby the initial enabling and disabling potentials supplied to the channel amplifiers have a relatively small amount of filtering action provided and subsequently additional filter circuit elements are introduced in order to filter out the effects of starting and stopping the control tube 131.

This improvement which provides for more rapid enabling and disabling action is accomplished by disconnecting the strap 145 and connecting the straps 146 and 147 of a circuit which may be traced from the anode of the control tube 131, strap 146, a relay 110 connected in series with a resistor 148 which, together with the relay 110, is by-passed by a capacitor 149 through the strap 147 to the positive side of the anode potential 134. A voltage divider circuit comprising the resistors 150 and 151 is connected across the source of potential 134. The common juncture between the resistors 150 and 151 is connected to ground. The relay 110 is provided with break contacts 111 connected between a resistor 152 which is connected to an adjustable contact on the resistor 150, and a filter capacitor 153 which is connected to ground. Make contacts 112 are provided for connecting the capacitor 153 in parallel with a small filter capacitor 140 which is connected to one terminal of a resistor 139. Another pair of contacts are also provided for the relay 110 which include the break contacts 113 connected between a resistor 154 which is connected to the adjustable contact of resistor 151, and a filter capacitor 155. By means of make contacts 114 the filter capacitor 155 is arranged to be connected in parallel to the smaller capacitor 138 which is connected to one terminal of resistor 137.

In the circuit just described, initial energization of the control tube 131 produces a flow of anode current which rapidly produces potentials across the resistors 135 and 136 so that these potentials are impressed through the resistors 139 and 137 respectively upon the incoming and outgoing channel amplifiers. Thereupon the relay 110 attracts its armature thereby to break contacts 111 and 113 and to make contacts 112 and 114. Thus shortly after the initial enabling and disabling voltages are supplied to the channel amplifiers, additional filtering action is supplied by connecting in circuit the capacitors 153 and 155. The relay 110 is provided with the capacitor 149 so as to provide a holdover action, so that the relay does not respond to the periodic and momentary interruptions of the control tube 131. The anode circuit of the control tube 131 is therefore provided with a relay 110 and with a bridging capacitor 149 which offers the required impedance, together with the resistor 148 which is sufficient to periodically render non-conductive the control tube 131 due to the IR drop. In this new arrangement therefore the interruption frequency is dependent upon the supply voltage 134 and the total effect of resistors 135, 136 and 148. In order that the connection of the capacitors 153 and 155 should not disturb the value of the enabling and disabling voltage already applied to the channel amplifiers, the capacitors 153 and 155 are initially charged through the break contacts 111 and 113 of the relay 110 and the current limiting resistors 152 and 154 from the voltage divider resistors 150 and 151 which are connected across the source of potential 134.

The incoming channel amplifier 106 may comprise any desired number of stages of amplification dependent upon the requirements to be met, and for purposes of simplicity only two amplifier

tubes, an input tube 156 and an output tube 157, have been shown. The control grid electrode of the input vacuum tube 156 is energized from a resistor or voltage divider 158 which, in turn, is connected to the hybrid unit 103. The grid of the vacuum tube 156 may be biased negatively so as to disable the incoming channel amplifier whenever the outgoing channel amplifier is used, and this is accomplished by connecting one terminal of the resistor 158 to one terminal of a resistor 139 of the enabling and disabling unit 125 associated with the outgoing amplifier. The output tube 157 is connected to an output transformer 159 which, in turn, is connected to the loudspeaker 162. The grid circuit of the output tube 157 may include a resistor 160, one terminal of which is connected to an enabling and disabling unit 161 associated with the incoming channel amplifier.

A portion of the incoming energy supplied across the input resistor 158 of the incoming channel amplifier is coupled through a capacitor 162 and a voltage divider resistor 163 to a suitable amplifier 164 which is connected to a coupling transformer 165. The secondary winding of the transformer 165, which has one terminal grounded, is connected through a resistor 166 to the control electrode of a controlled gas tube 167. This gas tube 167 is of the same type as the gas tube 131 of the other enabling and disabling unit 125. While in each of these cases the gas tubes represented have been shown as comprising an envelope containing a gas or other suitable ionizable medium with an anode, a cold cathode, and a control electrode shown in the form of a starting electrode, it of course is understood that the control electrode may comprise any one of the other forms of control electrodes commonly used with this type of cold cathode gas tube including a control grid. The control electrode of the gas tube 167 is connected to the common juncture of the resistor 166 and a resistor 168 which, in turn, is connected to the positive terminal of a suitable source of potential 169 so that the circuit comprising the secondary winding of the transformer 165 and the series resistors 166 and 168 constitute a bleeder circuit similar to the bleeder circuit provided for the enabling and disabling unit 125. The cathode of the gas tube 167 is connected to the negative side of the source of voltage 169 through a pair of resistors 170 and 171, the common juncture of which is connected to ground.

If it is desired to provide a simplified form of circuit wherein the IR drop in the anode circuit will be sufficient to cause the voltage appearing between the anode and cathode of the gas tube 167 to drop in response to the conductivity of the tube, a series resistor 172 may be connected by completing the anode circuit through the strap 173 and disconnecting the straps 174 and 175. The operation of this circuit would be similar, therefore, to the circuit described for the outgoing amplifier enabling and disabling unit 125 when the resistor 144 was connected in the anode circuit of the gas tube 131.

It is preferable, however, to use a circuit which has certain advantages over this simple circuit and, hence, the strap 173 is disconnected and the straps 174 and 175 are connected in order to disconnect the resistor 172 and to connect in the anode circuit of the gas tube 167 a relay 180 and a resistor 176 connected in series with each other and in parallel to a capacitor 177. The relay 180 is provided with two pairs of break contacts 181

and 183 which are connected to grounded capacitors 178 and 179 and to current limiting resistors 185 and 186. The resistors 185 and 186, in turn, are connected to movable contacts on a voltage divider comprising a pair of resistors 187 and 188 connected across a source of voltage 169. The common juncture of the resistors 187 and 188 is connected to ground. The cathode of the gas tube 167 is connected through a circuit including a resistor 189 to one terminal of the grid coupling resistor 160 of the output vacuum tube 157. The juncture between the resistors 189 and 160 is provided with a capacitor 190 which is connected to ground to provide a small amount of filter action. The negative terminal of the battery 169 and one terminal of the resistor 171 are connected by a circuit having a series resistor 191 which is provided with a grounded filter capacitor 192, to the grid circuit of the input tube 107 of the outgoing channel amplifier.

In response to signal energy appearing across the input of the incoming channel amplifier the control electrode of the gas tube 167 has its potential increased sufficiently so as to ionize the tube, thereby to render it conductive. Thus anode current will flow through the relay 180 and the resistor 176 so that shortly thereafter the IR drop of these two elements will be sufficient to reduce the anode voltage below that required to maintain conductivity of the gas tube 167. When this occurs control is again restored to the control electrode of the gas tube. If signal energy is still being impressed on the incoming amplifier the gas tube 167 will again be rendered conductive upon the next positive half-cycle of voice or signal energy. The relay 180, when energized, will disconnect the capacitors 178 and 179 from the resistors 185, 187, 186 and 188 whereby they were being charged to a predetermined potential, and these capacitors will then be connected by the make contacts 182 and 184 thereby to filter adequately the disabling voltage supplied to the outgoing channel amplifier and the enabling voltage supplied to the output tube of the incoming channel amplifier. The capacitor 177 connected in parallel to the resistor 176 and the relay 180 provides sufficient holdover or slow release characteristics so that the additional filter capacitors 178 and 179 are not disconnected at the time that the anode voltage of the gas tube 167 is reduced sufficiently to restore control to the control electrode of the tube. If, however, no further incoming signal energy is present the gas tube 167 will not be rendered conductive upon the next positive half-cycle of signal voltage which of course is no longer there, and hence the relay 180 will release. It is believed that no further explanation of the operation of this enabling and disabling unit 161 is necessary in view of the similarity of circuit elements and operation to the circuit elements and operation of the enabling and disabling unit 125 associated with the outgoing channel amplifier which previously was described in considerable detail.

From the above description it therefore becomes apparent that each channel amplifier has associated therewith an enabling and disabling unit which includes a cold cathode controlled gas tube which, in response to signal currents traversing its associated channel amplifier, supplies control potentials, one of which enables its channel amplifier and the other of which disables the other channel amplifier. Each of the control tubes is connected in a circuit which

is responsive to the conductivity of the tube to periodically interrupt the conductivity thereof so as to restore the control of the tube to the control electrode. In the preferred circuit arrangement the initial enabling and disabling voltages are provided with a relatively small amount of filter action which has a relatively short time constant so that rapid enabling and disabling may be accomplished, thereby to minimize or prevent speech clipping. Subsequent to the initial application of the rapid enabling and disabling control voltages additional filter means are connected so as to provide control voltages which have no appreciable alternating current components, and the additional filter means also serve to prevent feedback between the two channel amplifiers through the control circuits.

Referring to Fig. 2, another embodiment is shown wherein means are provided for disabling and enabling incoming and outgoing channel amplifiers. In order to simplify the disclosure and the description, those elements which are similar to the elements previously shown in Fig. 1 have been given reference numerals one hundred greater than the numerals in Fig. 1. The substation circuit there illustrated is connected to a telephone line 200 which, in turn, is connected to a hybrid unit 203 which interconnects a balancing circuit 204, an outgoing channel amplifier 205 and an incoming channel amplifier 206. The microphone 201 is connected to the outgoing channel amplifier and a loudspeaker 202 is connected to the incoming channel amplifier. The outgoing channel amplifier is provided with a control circuit comprising an enabling and disabling unit 225, and similarly the incoming channel amplifier is provided with an enabling and disabling unit 261.

In order that the enabling and disabling unit 225 may be responsive to signal currents passing through the outgoing channel amplifier 205, a portion of the signal energy is obtained by a voltage divider 226 and a coupling capacitor 227 from the input circuit of the vacuum tube 207. This energy may be amplified by a suitable amplifier 229 which is connected to a transformer 230. A cold cathode controlled gas tube 231 has a control electrode connected to a bleeder circuit comprising the grounded secondary winding of the transformer 230 and resistors 232 and 233 which are connected to the positive side of a source of voltage 234. The cathode of the gas tube 231 is connected to the negative side of the source of voltage 234 through a pair of resistors 235 and 236, the common juncture of which is connected to ground. Before the gas tube 231 is rendered conductive there is normally provided an anode circuit which includes a relay 210, break contacts 211, a current limiting resistor 248, and a choke coil 300 which is connected to the positive side of a source of voltage 234. The juncture between the choke coil 300 and the current limiting resistor 248 is connected to a grounded filter capacitor 301. The choke coil 300 and the capacitor 301 are provided to filter out the transient impulses occurring from repeated opening and closing of the contacts 211. The value of the resistance and impedance of the choke coil 300, the relay 210 and the resistor 248 is such that the anode current is limited to a predetermined maximum amount. The juncture of the resistor 248 and the choke 300 is connected to a resistor 302 which, in turn, is connected to a resistor 303, one terminal of which is grounded. The juncture of the resistors 302 and 303 is con-

nected to the break contact 212 of the relay 210. The break contact 212 is connected to a capacitor 304 which, in turn, is connected to the negative terminal of the voltage source 234. The capacitor 304 is of such size as to provide sufficient holdover characteristics to the voltages developed across the circuit comprising the resistors 235 and 236 in parallel with the capacitor 304, so that the control voltages supplied to the incoming and outgoing channel amplifiers hold over word and syllable pauses. The capacitor 304, by virtue of its connection to the juncture between the resistors 372 and 303, is initially connected to a bleeder circuit which charges the capacitor so that when it is connected by the make contacts 213 to one terminal of the resistor 236 there will not be any appreciable change in the voltages appearing across the resistors 235 and 236 which are applied to the channel amplifiers. One terminal of the resistor 236 is connected through a resistor 237 to the grid coupling resistor 223 of the output vacuum tube 221 of the outgoing channel amplifier. One terminal of the resistor 237 is provided with a capacitor 238 connected to ground. One terminal of the resistor 235 is connected through a resistor 239 which is provided with a grounded capacitor 240 and this circuit is connected to the input resistor 258 of the input tube 256 of the incoming channel amplifier 206.

The relay 210 is so arranged that upon the conductivity of the gas tube 231 the first operations that will occur will be the interruption of the break contacts 212 and the closing of the make contacts 213. During the initial flow of current from the anode to the cathode the voltage developed across the resistors 235 and 236 is supplied to the control circuits of the vacuum tubes 255 and 221 of the incoming and outgoing channel amplifiers, respectively, thereby to disable rapidly the incoming channel amplifier and to enable rapidly the outgoing channel amplifier. Subsequent to the initial application of the rapid enabling and disabling voltages the capacitor 304 is connected across the resistors 235 and 236 to provide a certain amount of smoothing and filtering action, which also serves to stabilize the control voltages so that they will be effective to hold over word and syllable pauses. As the relay 210 continues to attract its armature, eventually the contacts 211 will be interrupted. The relay 210, having interrupted the anode voltage, restores control of the tube 231 to the control electrode. If signal currents are still passing through the outgoing channel amplifier the tube 231 will again become conductive, thereby again attracting the armature of the relay 210. The contacts 211 are so arranged that making and breaking of these contacts may occur as long as the speech continues to be transmitted by the outgoing channel amplifier, without actuating the break or make contacts 212 and 213. Therefore, while signal currents are being transmitted through the outgoing channel amplifier, the relay 210 is intermittently energized and deenergized so as to make and break the contacts 211 at a relatively rapid rate, thereby periodically restoring the control of the tube 231 to the control electrode. This operation continues until there is a cessation of the voice or signal currents through the outgoing channel amplifier, whereupon the relay 210 is released so that the contacts 211 are made and the contacts 212 and 213 are restored to the positions shown in the figure. Therefore, in the arrangement above described means are provided

responsive to the conductivity of the cold cathode controlled gas tube to periodically restore control of the tube to the control electrode without removing the control voltages being supplied to the outgoing and incoming channel amplifiers. While a single relay 210 has been shown to perform the operations of periodically interrupting the anode voltage and to switch the capacitor 304 across the resistors 235 and 236, it of course will become apparent that these operations could be performed by several relays, or a relay and a vibrator.

The incoming channel amplifier 206 is provided with an enabling and disabling unit 261 which is similar in circuit arrangement and operation to the control unit 225 associated with the outgoing channel amplifier. A certain amount of the signal energy appearing across the input resistor 258 of the incoming channel amplifier is obtained by a circuit comprising a coupling capacitor 262 and a resistor 263 which is provided with an adjustable contact connected to a suitable amplifier 264. The amplifier 264 is connected to a transformer 265, the secondary winding of which is grounded and connected in a bleeder circuit including a pair of resistors 266 and 268 connected to the positive terminal of the source of voltage 269. The control electrode of a controlled cold cathode gas tube 267 is connected to the juncture between resistors 266 and 268. The anode circuit of the gas tube 267 includes a relay 280, break contacts 281 of the relay 280, a current limiting resistor 276, and a choke coil 400 which is connected to the positive terminal of the source of voltage 269. A suitable grounded filter capacitor 401 is connected to the juncture of the resistor 276 and the choke coil 400. A bleeder circuit comprising resistors 402 and 403 connected between ground and one terminal of the choke coil 400 is arranged for charging a capacitor 404 through the break contacts 282 of the relay 280 to a potential which approximates the average potential appearing across the resistors 270 and 271. One terminal of the resistor 270 is connected through a resistor 289 to the grid coupling resistor 260 of the output tube 257 of the incoming channel amplifier 206. The terminal of the resistor 289 which is connected to the resistor 260 is also connected to a capacitor 290 which is grounded so as to provide a small amount of filter action. When the charged capacitor 404 is connected by the make contacts of relay 280 to the juncture of the resistor 289, the resistor 270 and the cathode of the gas tube 267, additional filtering action is obtained. One terminal of the resistor 271 is connected through a resistor 291 to the grid circuit input tube 207 of the outgoing channel amplifier. A suitable capacitor 292 is connected between ground and one terminal of resistor 291 to provide a certain amount of filter action.

The control circuit or enabling and disabling unit 261 operates in response to signal currents appearing across the input of the incoming channel amplifier in a manner identical to the response of the other control unit 225 so as to enable its channel amplifier and to disable the other channel amplifier.

While two different arrangements have been shown for controlling the gain of a pair of channel amplifiers operating in different directions, it will be appreciated that in each instance the control circuit utilizes a cold cathode controlled gas tube and that means are provided in the anode circuit thereof which are responsive to the

conductivity of the control tube to periodically render the tube non-conductive so as to periodically return the control of the tube to the control electrode. As long as signal currents continue to traverse the channel amplifier associated with a particular control tube, the control tube will again be rendered conductive. The anode current which flows produces control potentials across a pair of resistors, and the potential thus obtained is maintained by suitable capacitors at a value sufficient to hold over the enabling and disabling action through the intervals during which the control tube is periodically rendered non-conductive.

While two embodiments of the invention have been disclosed, it will be understood that various modifications may be made therein which are within the true spirit and scope of the invention.

What is claimed is:

1. The combination of a channel amplifier and a control circuit therefor, said control circuit including a controlled gas tube having a control electrode, a source of anode potential connected to said tube, means responsive to signal currents passing through said amplifier for impressing a control potential on the control electrode thereby to render said tube conductive, means connected in the anode-cathode circuit of said tube and having a relatively short time constant for generating a voltage to be applied to said amplifier to control the gain thereof, delay means, means operated by said tube for connecting to said anode-cathode circuit said delay means to delay the time constant of said voltage generating means, and means connected in said anode-cathode circuit so as to be responsive to the conductivity of said tube for periodically rendering said tube non-conductive.
2. The combination of a channel amplifier and a control circuit therefor, said control circuit including a controlled gas tube having a control electrode, a source of anode potential connected to said tube, means responsive to signal currents passing through said amplifier for impressing a control potential on said control electrode thereby to initiate conductivity of said tube, means connected in the anode to cathode circuit of said tube for deriving control voltages to be applied to said amplifier to control the gain thereof, said means having a relatively short time constant, means for supplying filter action, means operated by said tube for connecting said filter means to increase the time constant of said voltage deriving means sufficiently to hold over the derived voltages for periodic interruptions of the conductivity of said tube, and means connected in the anode circuit of said tube and responsive to the conductivity thereof for periodically rendering the said tube non-conductive.
3. The combination of a channel amplifier and a control circuit therefor, said control circuit including a controlled gas tube having a control electrode, a source of anode potential connected to said tube, means responsive to signal currents passing through said amplifier for causing said control electrode to initiate conductivity of said tube, means connected in the anode circuit of said tube including an interrupter responsive to the conductivity of said tube for periodically disconnecting said source of anode potential during the period of time the signal currents pass through said amplifier, and means responsive to the average anode current flow for applying a bias to said amplifier to control the gain thereof.
4. The combination of a channel amplifier and

a control circuit therefor, said control circuit including a controlled gas tube, a source of potential for said tube, means responsive to signal currents passing through said amplifier for causing said tube to become conductive, means having a relatively short time constant associated with said tube for deriving control voltages therefrom to control the gain of said amplifier, means including a circuit interrupter connected in series with said tube and said source of potential, said interrupter being arranged in response to the conductivity of said tube to disconnect said source of potential from said tube, and means to be connected subsequently by said circuit interrupter in circuit with said means for deriving control voltages therefrom to increase the time constant thereof sufficiently to supply to said amplifier a relatively stable potential to hold over word and syllable pauses in the signal currents passing through said amplifier.

5. The combination of a channel amplifier and a control circuit therefor, said control circuit including a controlled gas tube, a source of potential for said tube, means responsive to signal currents passing through said amplifier for causing said tube to become conductive, means including an interrupter connected between said source of potential and said tube for periodically disconnecting said source of potential from said tube in response to the conductivity of said tube, means associated with said tube for deriving control voltages therefrom for controlling the gain of said amplifier, switching means controlled by said tube, and means arranged to be connected by said switching means in circuit with said means for deriving control voltages from said tube to increase the time constant thereof sufficiently to supply a control potential proportional to the average current transmitted by said gas tube.

6. A transmission system comprising a pair of channels for transmitting signal currents in different directions, each channel being provided with a vacuum tube amplifier, a control circuit for each amplifier including a controlled gas tube arranged to be rendered conductive in response to signal currents passing through said amplifier, means associated with each gas tube for deriving control voltages therefrom, means for applying said control voltages to increase the gain of the associated amplifier and to decrease the gain of the other amplifier, means actuated by said gas tube for subsequently connecting to said means for deriving said control voltages means to increase the time constant thereof, and means responsive to the conductivity of said tube for periodically rendering said tube non-conductive.

7. A transmission system comprising a pair of channels for transmitting signal currents in different directions, each channel being provided with a vacuum tube amplifier, a control circuit for each amplifier including a controlled gas tube arranged to be rendered conductive in response to signal currents passing through its associated amplifier, relatively lightly filtered means having a relatively short time constant associated with each gas tube for deriving control voltages therefrom, means for applying said control voltages to increase rapidly the gain of the associated amplifier and to decrease rapidly the gain of the other amplifier, means for supplying additional filter action, means actuated by said gas tube for subsequently connecting to said means for deriving control voltages said means for supplying additional filter action, and means responsive to

the conductivity of said tube for periodically rendering said tube non-conductive.

8. A transmission system comprising a pair of channels for transmitting signal currents in different directions, each channel being provided with a vacuum tube amplifier, a control circuit for each amplifier including a controlled gas tube arranged to be rendered conductive in response to signal currents passing through its associated amplifier, a source of potential for said tube, means associated with each gas tube for deriving control voltages therefrom, means for applying said control voltages to increase the gain of the associated amplifier and to decrease the gain of the other amplifier, means connected in circuit with said gas tube for periodically reducing the potential applied thereto sufficiently to interrupt the conductivity of said tube, means for supplying filter action, and means operated by said tube for connecting said filter means in circuit with said means for deriving control voltages to increase the time constant thereof sufficiently to hold over the derived voltages for the time of the periodic interruptions of the conductivity of said tube.

9. A transmission system comprising a pair of channels for transmitting signal currents in different directions, each channel being provided with a vacuum tube amplifier, a control circuit for each amplifier including a controlled cold cathode gas tube, means for rendering said gas tube conductive in response to signal currents passing through its associated amplifier, a source of potential for said gas tube, means having a relatively short time constant associated with each gas tube for deriving control voltages therefrom, means for applying said control voltages to increase rapidly the gain of the associated amplifier and to decrease rapidly the gain of the other amplifier, means for increasing the time constant of said means for deriving control voltages, means for connecting said last-mentioned means to said means for deriving control voltages in response to the conductivity of said tube, and means connected in circuit with said tube for producing in response to the conductivity of said tube a potential drop sufficient to render said tube non-conductive.

10. A transmission system comprising a pair of channels for transmitting signal currents in different directions, each channel being provided with a vacuum tube amplifier, a control circuit for each amplifier including a controlled cold cathode gas tube arranged to be rendered conductive in response to signal currents passing through said amplifier, a source of anode potential for said gas tube, means connected in the anode circuit of said tube and responsive to the conductivity of said tube for producing a potential drop sufficient to interrupt the conductivity of said tube, means having a relatively short time constant associated with each gas tube for deriving control voltages therefrom, means for applying said control voltages to increase rapidly the gain of the associated amplifier and to decrease rapidly the gain of the other amplifier, a relay connected in the anode circuit of said gas tube, and an energy storage device arranged to be connected by said relay in circuit with said means for deriving control voltages from said tube thereby to increase the time constant thereof sufficiently to hold over the average derived voltage for a time interval equal to or greater than the time of interruption of the conductivity of said tube.

15

11. A transmission system comprising a pair of channels for transmitting signal currents in different directions, each channel being provided with a vacuum tube amplifier, a control circuit for each amplifier including a controlled cold cathode gas tube arranged to be rendered conductive in response to signal currents passing through said amplifier, a source of anode potential for said gas tube, means having a relatively short time constant associated with each gas tube for deriving control voltages therefrom, means for applying said control voltages to increase rapidly the gain of the associated amplifier and to decrease rapidly the gain of the other amplifier, a relay connected in the anode circuit of said gas tube and responsive to the conductivity of said tube for interrupting the conductivity thereof each time it is rendered conductive, an energy storage device arranged to be connected by said relay in circuit with said means for deriving control voltages from said tube thereby to increase the time constant thereof sufficiently to hold over the average derived voltage for a time interval equal to or greater than the time of interruption of the conductivity of said tube, and means for initially charging said energy storage device to a potential substantially equal to the average control voltage derived by the means therefor.

12. A transmission system comprising a pair of channels for transmitting signal currents in different directions, each channel being provided with a vacuum tube amplifier, a control circuit

16

for each amplifier including a controlled cold cathode gas tube arranged to be rendered conductive in response to signal currents passing through its associated amplifier, a source of potential for each tube, means having a relatively short time constant associated with each gas tube for deriving control voltages therefrom, means for applying said control voltages to increase rapidly the gain of the associated amplifier and to decrease rapidly the gain of the other amplifier, means including a circuit interrupter connected in the circuit supplying potential to said tube for periodically disconnecting from said tube said source of potential, and means arranged to be connected by said interrupter in circuit with said means for deriving control voltages from said tube to increase the time constant thereof sufficiently to supply an average control voltage to said amplifiers as long as signal currents are passing through the channel associated with said control tube.

ROSWELL H. HERRICK.

REFERENCES CITED

25. The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
30. 2,018,464	Nebel	Oct. 22, 1935
1,881,642	Jones et al.	Oct. 11, 1932
2,264,311	Herrick	Dec. 2, 1941
2,282,405	Herrick	May 12, 1942