

March 5, 1946.

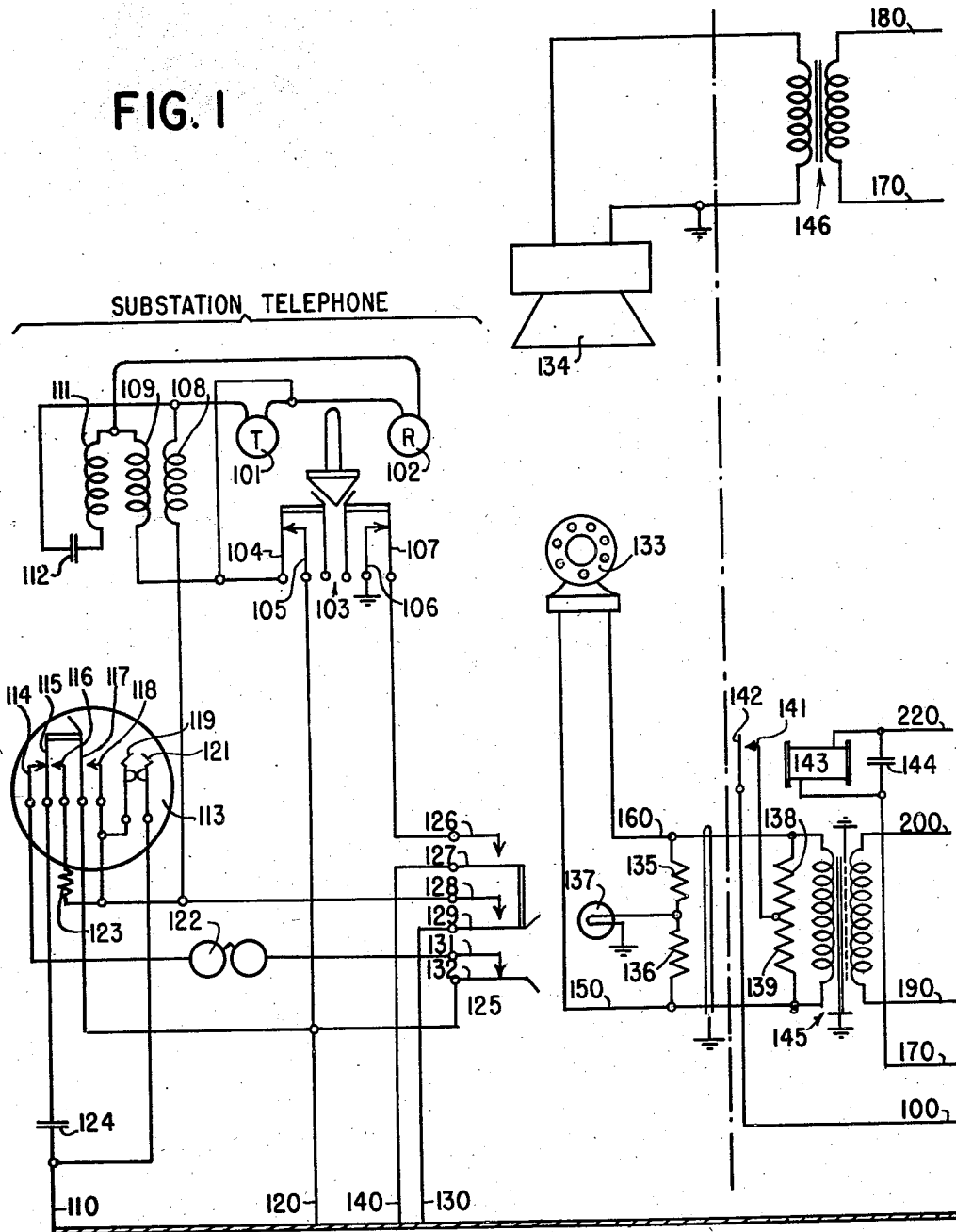
R. H. HERRICK
TRANSMISSION SYSTEM

2,396,175

Filed May 1, 1943

4 Sheets-Sheet 1

FIG. 1



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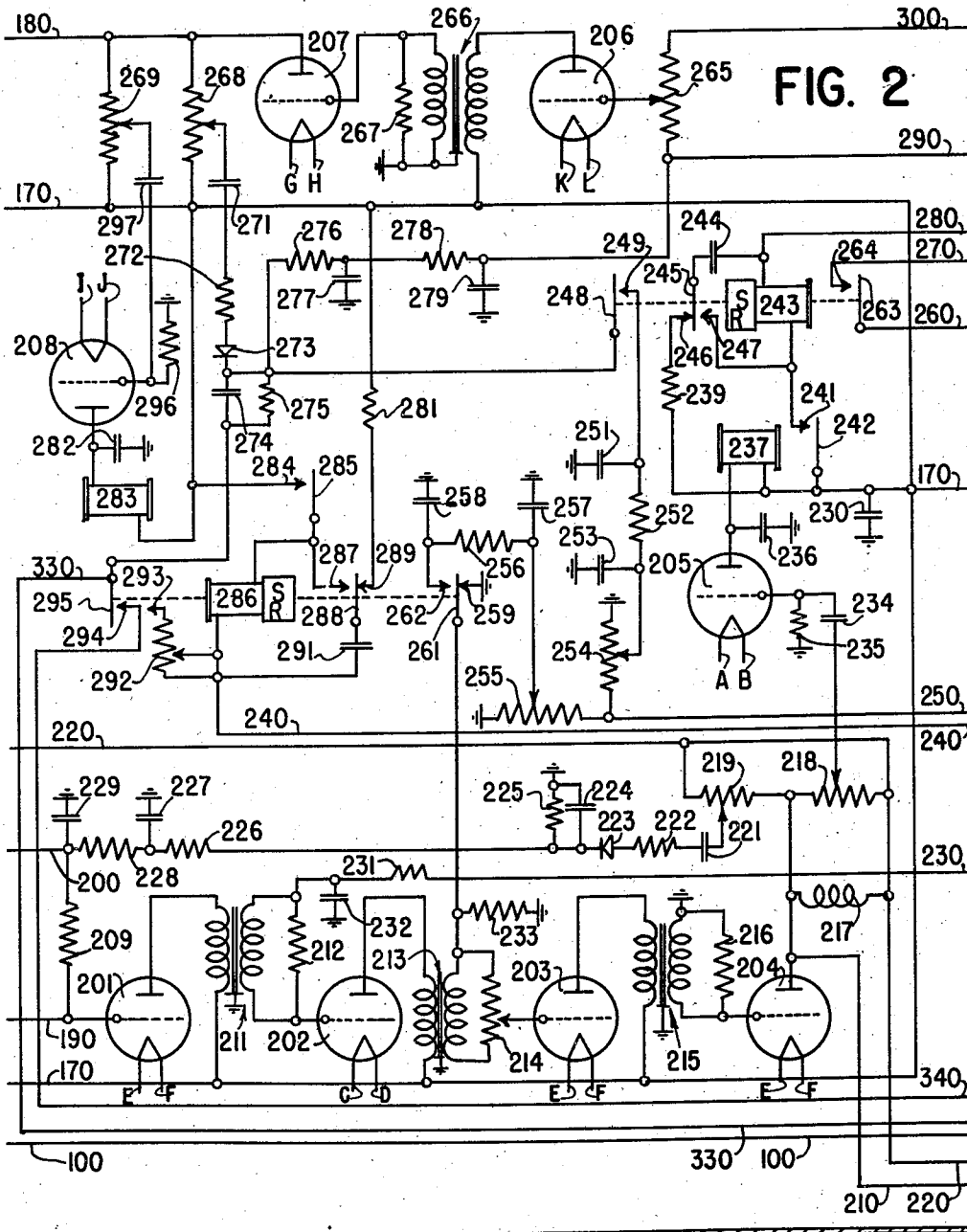
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TRANSMISSION SYSTEM

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FIG. 2



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TRANSMISSION SYSTEM

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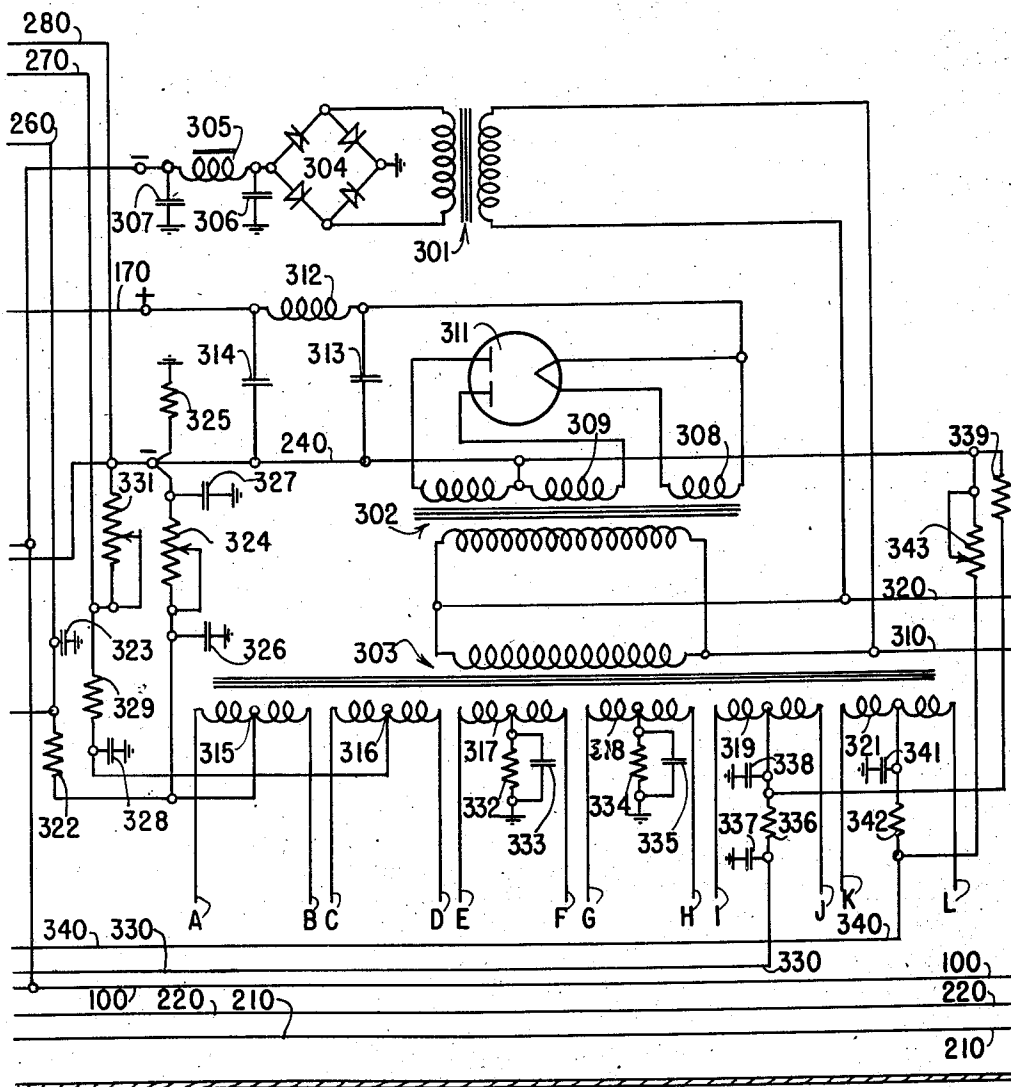
300

300

FIG. 3

290

290



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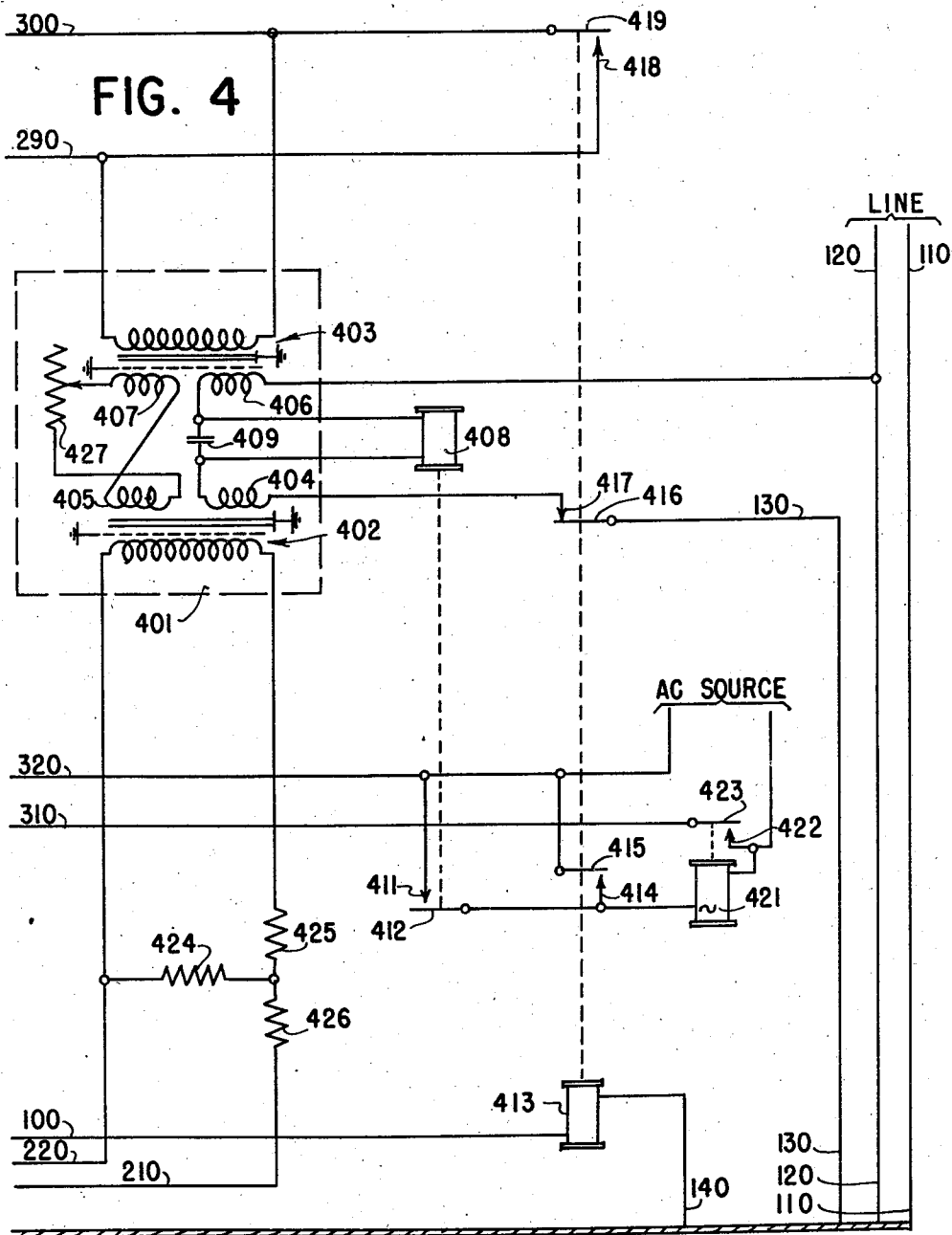
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4 Sheets-Sheet 4



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2,396,175

TRANSMISSION SYSTEM

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Application May 1, 1943, Serial No. 485,268

17 Claims. (Cl. 178-44)

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 fully blocking, under certain conditions, certain of the signal channels included therein and to increase the gain of certain of the other signal current channels, and, more particularly, to improvements in telephone substation circuits having coupled signal current channels for the transmission of incoming and outgoing signal currents.

Heretofore, telephone substation circuits have been provided with a hybrid system or anti-sidetone impedance networks for preventing signal currents developed during operation of the transmitter from being transmitted to the receiver and for similarly preventing signal currents incoming over the line extending to the substation from being transmitted to the transmitter for reproduction. In such arrangement one of the factors which determines the efficiency of the sidetone suppression is the impedance of the talking circuit established by way of two connected subscriber lines. Since the impedance is not the same for any two different established connections, the hybrid system of each substation is usually balanced to provide maximum sidetone suppression efficiency for average line conditions. In installations wherein amplification of incoming and outgoing signal currents is required, as, for example, in executive loudspeaking sets, the conditions of unbalance introduced in the substation circuit by the impedances of the lines over which an established connection extends may become intolerable. This is particularly true in substation installations provided in an exchange area where the subscriber lines are of widely different lengths. In order to obviate or to minimize the singing resulting from unbalance of the substation circuit, signal control switching means may be provided in the substation circuit for selectively blocking the channels when not in use. While in some arrangements the signal channels are completely blocked when not in use, in other arrangements the signal channel not being used is rendered comparatively inactive. Apparatus of the type in which the channels are only partially blocked when not in use have the advantage of permitting conversation break-ins.

Usually telephone substation circuits having channel amplifiers have been arranged so that the operation always included the use of such amplifiers. Since this did not always provide the de-

sired degree of privacy for telephone conversation, there was provided an arrangement whereby either a loudspeaking type of communication or the usual telephone type of communication could be obtained selectively. Such an arrangement included means whereby rapid change-over could be made between the two types of conversation without appreciable interruption. In order that speech clipping might be minimized the amplifying channels were provided with control circuits arranged to be exceedingly fast in operation. In order to provide such fast operation it was found necessary to reduce the time delay factor encountered by the enabling circuit equipment which, however, made the equipment more susceptible to feedback between the control circuits and between the channel amplifiers. The advantage of a relatively rapid acting control circuit which would minimize speech clipping and which also would retain the advantages of preventing feedback between the different components of the apparatus has been made possible by certain circuit arrangements and by the use of various types of tubes.

The present invention is directed to channel amplifiers and control circuits for telephone substation apparatus which provides selective communication by the usual subset or by an executive loudspeaking telephone apparatus. In providing such arrangements, it furthermore would be desirable to minimize the number of types of tubes used in such equipment, thereby to simplify servicing and replacement of tubes.

It is an object of the present invention to provide an improved telephone substation apparatus which is adapted to be operated either as a conventional telephone circuit or as an executive loudspeaking telephone circuit.

It is another object of this invention to provide an improved telephone substation circuit transmission system having a plurality of channel amplifiers provided with control circuits sufficiently fast in operation to minimize speech clipping, and yet adequate provisions for the prevention of feedback are provided.

Still another object of this invention is to provide a pair of channel amplifiers and associated control circuits which utilize a minimum number of different types of tubes.

A still further object of this invention is to provide a channel amplifier having a plurality of stages of amplification and a control tube therefor, whereby the operation of the channel amplifier is controlled by a combination of con-

trol voltages acting in opposition to each other or acting to produce accumulative effects.

In the illustrated embodiment of the invention there is provided a telephone substation apparatus of the type adapted to be connected to an associated telephone line. This apparatus includes the usual transmitting and receiving telephone subset, a transmission system comprising a hybrid system or network, a microphone, a loudspeaker, and a pair of channel amplifiers together with control tubes therefor. A switch is provided for conditioning the channel amplifiers for operation to render effective the loudspeaking equipment. Means are also provided for subsequently rendering ineffective the loudspeaking communication channels when it is desired to communicate by the conventional telephone subset.

Each of the channel amplifiers is provided with a control circuit responsive to signal currents passing through the channel amplifier for increasing the gain of that channel and for decreasing the gain of the other channel. Automatic volume or gain control means are provided which have a time constant sufficient to maintain the gain of the amplifier so as to hold over word and syllable pauses. To provide an exceedingly rapid enabling action by the control circuits, an initial control voltage is applied to the associated amplifier which is obtained from means having a minimum filter action, and subsequently adequately filtered voltage is supplied to the amplifier to prevent feedback between the amplifier channels. In order that a minimum of time be required to condition the amplifiers for use, the amplifiers and control tubes are equipped with tubes requiring low thermal filament energy, and each control tube and each group of amplifier tubes are supplied from individual sources of direct current to prevent feedback between the various circuits through the filament sources.

In accordance with the present invention each of the control circuits, in response to signal currents passing through the associated amplifier, generates a control voltage by means having a relatively short time constant, thereby to rapidly increase the gain of the associated channel amplifier. Subsequently a relay operates to render ineffective this initial control voltage and to apply a smaller negative bias to the channel amplifier.

Other and further features of this invention will subsequently become apparent in the following description.

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 Figs. 1 to 4, inclusive, illustrate the substation circuit having incorporated therein certain of the features of the invention as briefly outlined above. More specifically, Fig. 1 illustrates the apparatus provided at a telephone subscriber substation and includes loudspeaking apparatus and switching equipment for selective operation of the substation as a regular telephone subscriber substation or as a loudspeaking type substation; Fig. 2 illustrates the outgoing amplifier, the incoming amplifier and the control apparatus at the substation; Fig. 3 illus-

trates the power equipment for supplying the necessary operating and controlling potentials for the amplifier apparatus; and Fig. 4 illustrates the hybrid system and control relays for selectively controlling the interconnection of the substation amplifier apparatus and the substation telephone line.

Referring more particularly to Fig. 1 of the drawings, there is shown a telephone subset comprising a transmitter 101, a receiver 102, a receiver switch 103, induction coils 108, 109 and 111, and an isolating or coupling capacitor 112. The subset may be provided with a dial switch 113 and also with a ringer 122 and a ringing capacitor 124. These parts constitute the conventional elements commonly found in a subscriber telephone subset. The standard subset is arranged for selective use with an executive type loudspeaking set. The selective operation of either type of communication, which will subsequently become apparent, is brought about in part by a switch 125 which operates to condition for operation the loudspeaking equipment. The loudspeaking equipment includes a microphone 133 and a loudspeaking telephone 134.

The telephone transmitter 101, the receiver 102, the induction coils 108, 109 and 111, the calling device 113, and the receiver switch 103 are interconnected to form a substation circuit of the well known anti-sidetone type. This circuit includes the line conductors 110 and 120 between which the three inductively coupled windings 108, 109 and 111 are serially included in a branch circuit. This branch circuit also includes an isolating capacitor 112 connected between the two windings 108 and 111, the capacitor being effective to prevent the receiver from being energized by the direct current flowing over the conductors 110 and 120 when the subset is connected for use. The portion of the branch circuit including the two windings 109 and 111 and the capacitor 112 is shunted by the transmitter 101, and the receiver 102 is connected between the juncture point of the two windings 109 and 111 and the line 120 through the contacts 104 and 105 of the receiver switch 103. Since the capacitor 112 is connected between the two windings 109 and 111, it is protected against high voltages appearing upon the line comprising the conductors 110 and 120, which voltage surges might result in puncturing the insulation of the capacitor.

For the purpose of giving an audible indication of calls incoming to the substation, there is provided a signal device in the form of a ringer 122 which is normally connected to be energized over an operating circuit including the line conductor 110, the capacitor 124, the contacts 114 and 115 of the calling device 113, and the contacts 131 and 132 of the switch 125 which are connected to the other line conductor 120. The induction coil 108 which has one terminal connected to the juncture between the transmitter 101 and the capacitor 112, has its other terminal connected to the make contact 128 of the switch 125 and also to a resistor 123 which is connected to the contact 116 of the calling device 113. The purposes of the contact 128 on the switch 125 and the resistor 123 will subsequently become apparent.

The calling device 113 is provided with a make contact 116 which cooperates with the contact 115 which, it will be remembered, was connected to the capacitor 124. The calling device, furthermore, has a pair of make contacts 117 and 118

which are connected between the line conductor 120 and the common juncture between the resistor 123, the inductance coil 108 and the switch contact 128 of the switch 125. Upon actuation of the calling device 113 a pair of interrupter contacts 119 and 121 are arranged to be broken to provide the calling impulses. These contacts are connected between the switch contact 118, which is connected to the common juncture of the resistor 123, the inductance coil 108, the switch contact 128, and the other line conductor 110. When the dial or calling device 113 is actuated the ringer 122 is disconnected from the conductors 110 and 120 which comprise the telephone line, and the capacitor 126 is connected through the resistor 123 so as to be in parallel to the interrupter contacts 119 and 121, thereby to prevent or minimize transient effects occurring as a result of the making and breaking of the contacts 119 and 121. The calling device 113 is arranged to be effective whenever the hook or receiver switch 103 has been operated to the position shown, whereby the contacts 104 and 105 thereof are closed so as to complete the circuit from the contacts 119, 121 of the calling device through the inductance coil 108 and the transmitter 101 to the contact 104. At the same time that the contacts 104 and 105 are closed, contacts 106 and 107 have also been closed so as to prepare a circuit which is arranged to operate to render ineffective the hybrid system connected to the telephone line 110 and 120 if the loudspeaker set is in operation. This circuit operation also will subsequently become apparent in the following description. The contacts 106 and 107 of the hook switch 103 are connected to the make contacts 126 and 127 of the switch 125, the latter contact being connected to the conductor 140 which, in turn, is connected to control a relay to perform the operation mentioned.

The calling device or dial mechanism 113 is also arranged to become effective upon actuation of the switch 125 which will close the make contacts 128 and 129, the latter contact being connected to the conductor 130 which is connected to a hybrid system interposed between the line conductors 110 and 120, and the two channels connected to the microphone 133 and the loudspeaker 134. Upon actuation of the switch 125 the break contacts 131 and 132 are opened so as to disconnect the ringer 122 from across the line conductors 110 and 120.

The microphone 133 is connected to a pair of conductors 150 and 160 which, in turn, are connected to the primary winding of a transformer 145. Across the conductors 150 and 160 there are connected resistors 135 and 136, the midpoint of which is connected through a signal device or lamp 137 to ground. At the other end of the conductors 150 and 160 a pair of resistors 139 and 139 are connected, the midpoint thereof being connected to the make contacts 141 and 142 of a relay 143. The contact 142 is connected to a conductor 170 which, in turn, is connected to a suitable source of voltage. The relay 143, which is shunted by a capacitor 144, is connected between the conductors 220 and 170. The conductor 220 is connected to the output circuit of the outgoing channel amplifier and the hybrid system, the purpose of which subsequently will become apparent. The conductor 170 is connected to a suitable source of voltage.

Reference may now be made to Figs. 1 and 2, wherefrom it will be seen that the secondary winding of the microphone transformer 145 is

connected to the conductors 190 and 200 which are connected across the input coupling resistor 209 connected to the grid of a vacuum tube 201. The microphone 133 is therefore coupled to an outgoing channel amplifier which is provided with a control tube, and which includes triode vacuum tubes 201, 202, 203, 204 and 205. The anode of the triode 201 is connected to the primary winding of a transformer 211. The secondary winding of the transformer 211 is shunted by a coupling resistor 212 and one terminal thereof is connected to the grid of the vacuum tube 202. Similarly, vacuum tube 202 is coupled to vacuum tube 203 by means of a transformer 213 and coupling resistor 214; and, likewise, tube 203 is coupled through the transformer 215 and coupling resistor 216 to the output vacuum tube 204. One terminal of the primary winding of each of the transformers 211, 213 and 215 is connected to the conductor 170 which supplies a suitable anode potential. The anode of the vacuum tube 204 is connected to the conductor 210 which, in turn, is connected to a hybrid system 401 shown in Fig. 4, which is also connected to the conductor 220. The conductor 220 is also connected to the relay 143, and hence between the conductors 210 and 220 there appears a choke coil 217, a voltage divider resistor 218, and a second voltage divider resistor 219. An adjustable contact of the voltage divider resistor 219 is connected through a capacitor 221, a current limiting resistor 222, and a dry disk or contact rectifier 223, to a resistor 225 which is connected to ground and which is by-passed by a capacitor 224. The juncture of the dry disk rectifier 223 with the capacitor 224 and the resistor 225 is connected to resistors 226 and 228, which together with capacitors 227 and 229 constitute a time delay circuit connected to the grid circuit of the input vacuum tube 201. The capacitors 227 and 229 are connected between ground and opposite terminals of the resistor 228. The movable contact on the resistor 219 takes a certain amount of the output voltage of the vacuum tube 204, which is passed through the dry disk rectifier 223, thereby to develop across the resistor 225 and the capacitor 224 a certain amount of direct current voltage, which is a function of the signal current being transmitted and which is used to supply an automatic gain control voltage to the input tube 201. The manner in which this arrangement functions will more readily be understood after the remaining circuit elements have been described and a fuller explanation will be given in connection with a description of the operation of the system. The grid return of the vacuum tube 202 includes a resistor 231, by-passed to ground by a capacitor 232, and a conductor 230 which is connected to a circuit subsequently described. The grid return circuit of the vacuum tube 203 includes a resistor 233 connected to ground, and a connection to contact 231 of a relay 236. The secondary winding of the transformer 215 and the coupling resistor 216 of the vacuum tube 204 are connected directly to ground.

A portion of the voltage appearing across the resistor 218 is coupled through the capacitor 234 to the grid of a vacuum tube 235 which is provided with a grid coupling resistor 235 having one end thereof connected to ground. The anode of the vacuum tube 235 is connected to a capacitor 236 which is grounded and to a relay 237 which is connected to the conductor 170 which supplies anode voltage. The relay 237 is provided with make contacts 241 and 242 connected

between the conductor 170 and a slow release relay 243 which, in turn, is connected to a conductor 280 which is connected to the low potential side of a source of voltage. The relay 243 is provided with make contacts 263 and 264 connected to conductors 280 and 270 which are connected to a circuit subsequently to be described. The relay 243 is provided with a capacitor 244 connected between the conductor 280 and through the break contacts 245 and 246 and a current limiting resistor 239 to the conductor 170 which is connected to the positive side of the high voltage source. The contact 246 is arranged to make with contact 247 so as to connect the capacitor 244 across the relay 243, thereby to provide and enhance a slow release characteristic. The slow release relay 243 is also provided with make contacts 248 and 249 which are arranged to disable the incoming channel amplifier.

The incoming channel amplifier is energized from a voltage divider 265 connected across the incoming leads 290 and 300 which are connected to the hybrid system 401 of Fig. 4. The input of the vacuum tube 206 is connected to the voltage divider 265, and the anode of the vacuum tube 206 is connected to the primary winding of a transformer 286, the secondary winding of which is shunted by a resistor 267 and it is connected between ground and the grid of an output vacuum tube 207. The anode of the vacuum tube 207 is connected by the conductor 180 to a loudspeaker transformer 146 which has a secondary winding which energizes the loudspeaker 134. Between the anode conductor 180 of the vacuum tube 207 and the anode potential conductor 170 there are connected voltage dividers 268 and 269. The adjustable contact on the voltage divider 268 is connected through a coupling capacitor 271, a current limiting resistor 272, and a dry disk rectifier 273 to a resistance capacitance circuit comprising a capacitor 274 connected across a resistor 275. A portion of the signal voltage appearing across the voltage divider 268, therefore, is rectified by the dry disk rectifier 273 to produce across the resistance capacitance circuit 274, 275 a direct current voltage proportional to the signal current passing through the amplifier. This voltage is applied to one terminal of the grid coupling voltage divider 265 of the vacuum tube 206 through a resistance capacitance filter circuit comprising the resistors 276 and 278 and the capacitors 277 and 279. The capacitors 277 and 279 are connected between ground and opposite terminals of the resistor 278. The junction of the dry disk rectifier 273, the resistor 275 and the capacitor 274 is connected to the contact 248 of the slow release relay 243, for a purpose which will subsequently become apparent. The other terminal of the resistor 275 is connected to a contact 285 of a slow release relay 286 and also to a conductor 330 which extends to the source of voltage shown in Fig. 3.

A portion of the output voltage appearing across the voltage divider 269 is connected through a coupling capacitor 297 to the grid of the control tube 208 which is provided with a grid coupling resistor 296 connected between the grid and ground. The anode of the control tube 208 is connected to a grounded capacitor 282 and to a relay 283 which is energized from the high potential conductor 170. This conductor is also connected to the contact 284, of the relay 283, which is arranged to make contact with contact 285. Contact 285 is connected to relay 286 which, in turn, is connected to the conductor

240 which is connected to the negative side of a high voltage source of power. A capacitor 291, connected through the break contacts 288 and 289 of the relay 286 in series with a current limiting resistor 281, is connected between conductors 170 and 240. The contact 288 is arranged to make with the contact 287 to connect the capacitor 291 across the relay 286, thereby to provide and enhance the slow release characteristics of this relay. The slow release relay 286 is also provided with make contacts 295, 294 and 293, the latter contact being connected to an adjustable resistor 292 which, in turn, is connected to the conductor 240. The contact 294 is connected to a conductor 340 which extends to the power supply circuit shown in Fig. 3. The slow release relay 286 has a contact 281 connected to the input circuit of vacuum tube 203 which is arranged to break with the contact 259 connected to ground, and to make with contact 262 which is connected to the grounded capacitor 258, and a resistor 256 which, in turn, is connected to an adjustable contact on the voltage divider 255 and to grounded capacitor 257. A voltage divider 254 has an adjustable contact connected through a resistor 252 to the make contact 249 of slow release relay 243. Suitable filter capacitors 251 and 253 are connected between ground and opposite terminals of the resistor 252. The voltage dividers 254 and 255 are each connected between ground and a conductor 250 which is connected to the negative side of a low voltage source of direct current.

Reference may now be had to Figs. 3 and 4, which show the incoming line circuit and the source of power which supplies anode, grid and filament voltages for the various tubes. The telephone line 120 is connected to the hybrid system 401 which preferably is composed of a pair of transformers 402 and 403, each having a pair of secondary windings 404, 405 and 406, 407, respectively. The conductor 120 is therefore connected through the secondary winding 406, a relay 408 shunted by a capacitor 409, and secondary winding 404 to the make contacts 416 and 417 of a relay 413, the contact 416 being connected to a conductor 130. It will be remembered that the conductor 130 extends to Fig. 1 where the conductor is connected to the make contact 129 of the switch 125. The remaining secondary windings 405 and 407 of the transformers 402 and 403 are reversely connected through a balancing impedance or resistor 427. The primary winding of the transformer 403 is connected across the conductors 290 and 300, so as to energize the voltage divider 265 which is connected to the grid of the input tube 206 of the incoming channel amplifier. The conductors 290 and 300 are also connected to the make contacts 418 and 419 of the relay 413. The primary winding of the transformer 402 is connected to the conductors 210 and 220 through a T-pad comprising the resistors 424, 425 and 426.

It will be remembered that the conductors 210 and 220 are connected in the output circuit of the output tube 204 of the outgoing channel amplifier. If it is assumed that the switch 125 of Fig. 1 is actuated to close the contacts 128 and 129, the conductor 130 is connected to the line conductor 110 through the contacts 119 and 121 of the dial device 113. When this circuit is completed the relay 408 and the transformer windings 404 and 406 are connected across the line conductors 110 and 120, whereby current flows to energize the relay 408. The operation of

the relay 408 closes the contacts 411 and 412, thereby to energize the relay 421 from a suitable alternating current source, whereupon contacts 422 and 423 of this relay are closed, thereby to supply alternating current energy across the conductors 310 and 320 which, in turn, are connected to the primary windings of three power transformers 301, 302 and 303. The secondary winding of the transformer 301 is connected to a bridge rectifier 304, the output of which is connected between ground and a conductor 250. Interposed between the low potential side of the rectifier network 304 and the conductor 250 is a filter choke 305, the opposite terminals of which are connected through capacitors 306 and 307 to ground. The rectifier and filter arrangement therefore supply a relatively low voltage direct current to the voltage dividers 254 and 255 of Fig. 2, whereby a certain amount of negative bias is provided for application to certain circuits of the channel amplifiers.

The transformer 302 is provided with a pair of secondary windings 308 and 309 which energize the filament and anodes of a full wave rectifier tube 311. The cathode or high potential side of this circuit is connected through a filter reactor 312 to the high potential conductor 170 which supplies anode voltage to all of the amplifier and control tubes. The midpoint of the secondary winding 309 which constitutes the low voltage side of the rectifier circuit is connected to conductors 240 and 280, the conductor 240 being connected to the slow release relay 286 and the conductor 280 being connected to the slow release relay 243. A pair of filter capacitors 313 and 314 are connected at opposite ends of the filter reactor 312 and to the negative conductor 240.

The filament power transformer 303 is provided with a plurality of mid-tap secondary windings 315, 316, 317, 318, 319 and 321. The secondary winding 315 has output terminals A and B which supply only the filament of control tube 205. The midpoint of the secondary winding 315 is connected through a resistor 322 to the junction of the conductors 230 and 260 which, in turn, is connected through a capacitor 323 to ground. The midpoint of the secondary winding 315 is also connected to a filter bleeder circuit comprising the adjustable resistor 324 and the fixed resistor 325. One terminal of the fixed resistor 325 is connected to ground and the other terminal is connected to the negative side of the source of power provided by the rectifier 311. At opposite terminals of the resistor 324 there are provided grounded capacitors 326 and 327.

The output terminals of the secondary winding 316, which have been indicated as C and D, supply power only to the second stage vacuum tube 202 of the outgoing channel amplifier. The midpoint of this secondary winding 316 is connected through a resistor 328 to the conductor 270 and to an adjustable resistor 331 which, in turn, is connected to the conductors 240 and 280 and the negative side of the anode voltage. A capacitor 329 is connected between the midpoint of the transformer 316 and ground to provide a certain amount of filter action.

The midpoint of the secondary winding 317 is connected to the resistor 332 which is grounded and which is by-passed by the capacitor 333. The output terminals E and F of this transformer supply filament energy to the vacuum tubes 201, 203 and 204 of the outgoing channel amplifier.

The secondary winding 318 having output terminals G and H supplies power only to the output tube 207 of the incoming channel amplifier and the midpoint of the transformer is connected through the resistor 234 to ground which, in turn, is by-passed by a capacitor 335.

The secondary winding 319 has output terminals I and J which energize the filament of the control vacuum tube 208. The midpoint of the transformer 319 is connected through the resistor 336 to the conductor 330 which, it will be remembered, is connected to the make contact 295 of the slow release relay 286, and to the other terminal of the automatic gain control resistor 275. On either side of the resistor 336 there are provided grounded capacitors 337 and 338. The midpoint of the secondary winding 319 is also connected through a resistor 339 to the midpoint of the secondary transformer winding 309 which constitutes the negative potential lead of the anode voltage supply.

The secondary winding 321 which has output terminals K and L supplies filament current to the input vacuum tube 206 of the incoming channel amplifier. The midpoint of the secondary winding 321 is connected through a resistor 342 to the conductor 340 which is connected to the make contact 294 of the slow release relay 286. A by-pass capacitor 341 is connected between ground and the midpoint of the secondary winding 321. The terminal of the resistor 342 which is connected to the conductor 340, is also connected through an adjustable resistor 343 to the negative side of the plate voltage source.

The purpose and function of certain circuit elements and arrangements will now become apparent in the following explanation of the operation of the system. If it is assumed that the handset comprising the transmitter 101 and the receiver 102 is resting on its cradle, so that the receiver switch 103 is actuated to open circuit position, and it is further assumed that it is desired to communicate by means of the executive loudspeaking telephone system, the switch 125 will be actuated. Actuation of the switch 125 breaks the contacts 131 and 132, thereby removing the ringer 122 from across the telephone line 110 and 120. At the same time contacts 128 and 129 are closed, thereby connecting the conductor 130 through contacts 119 and 121 of the calling device 113 to the line conductor 110 so that current flows through the transformer coils 404 and 406 of the hybrid system 401 of Fig. 4, thereby to energize the relay 408. The relay 408, having been energized, closes its contacts 411 and 412, thus causing the relay 421 to close its contacts 423 and 422. The alternating current source therefore is connected to the conductors 310 and 320, whereby the power transformers 301, 302 and 303 are energized. The various filament transformer windings of the transformer 303 thereby heat the various vacuum tubes 201 to 208, inclusive, to condition the executive loudspeaking apparatus for use. The anode of the output vacuum tube 204 of the outgoing channel is connected through the conductor 210, the hybrid transformer 402, the conductor 220, the relay 143, and the conductor 170 to the high potential side of the plate supply which is furnished by the rectifier tube 311 of Fig. 3. As soon as the tubes have reached operating temperature, anode current will flow thereby to energize the relay 143 which closes its contacts 141 and 142. The closing of the contacts 141 and 142 completes a circuit through conductor 160 which is connected to the negative terminal of the low voltage direct

current source supplied by the transformer 301 and the bridge rectifier 304, so that current flows over a simplex circuit superimposed on the microphone conductors 150 and 160. Current therefore enters at the common juncture of resistors 132 and 139 flowing over the microphone conductors 150 and 160 and leaving at the common juncture of the resistor 135 and 136 to energize the signal lamp or device 137. When the signal lamp 137 is lighted, this indicates that the channel amplifiers and control tubes are now in condition for use.

The actuation of the switch 125 by the closing of the contacts 128 and 129 has placed the calling device 113 in circuit so that a subscriber may be called by actuation of this device. At the same time the actuation of switch 125 has closed contacts 126 and 127 to prepare a circuit which includes conductor 140 and contact 107 of the receiver switch 103. The conductor 140 is connected in Fig. 4 to relay 413 which, in turn, is connected to conductor 100 which is supplied by power from the bridge rectifier direct current source 304. If after communication has been started by the executive loudspeaking system it is desired for purposes of privacy to utilize the handset, the receiver switch 103 becomes actuated thus closing the contacts 106 and 107, whereby the relay 413 is energized to make contacts 414 and 415 to lock in circuit the relay 421, to break contacts 416 and 417 to disconnect the hybrid system 401 from the telephone line, and also to short-circuit the input to the incoming signal channel by closing the contacts 418 and 419.

Each of the channel amplifiers is so arranged by supplying to certain of the tubes thereof a relatively high negative voltage, that the amplification thereof is at a predetermined low level which would be insufficient to supply signal currents to the telephone line of the desired magnitude. Each of the signal channels, therefore, is provided with a control tube responsive to signal currents passing therethrough, whereby the gain of one channel is rapidly increased thereby enabling that channel, and the gain of the other channel is decreased thereby disabling the other channel. A portion of the initial voice currents fed to the outgoing channel amplifier appears in the output circuit of the output tube 204 across the voltage divider 218. A certain amount of this signal voltage is impressed across coupling capacitor 234 on the grid of the control tube 205, thereby to cause an increase in the anode to cathode current of this tube. The cathode circuit of the control tube 205 may be traced from the midpoint of the filament transformer winding 315 through the adjustable resistor 324 to the negative side of the plate potential supplied by the rectifier tube 311. A change in anode current of the control tube 205 therefore rapidly changes the voltage drop appearing across the resistor 324. The resistor 324 is effectively connected in circuit with the grid to cathode circuit of the vacuum tube 202. A circuit from the grid of the vacuum tube 202 may be traced through the secondary winding of the transformer 211 which is shunted by the resistor 212, through the resistor 231, the resistor 322, the resistor 324, resistor 331 and resistor 329 back to the mid-tap of filament transformer winding 316 which energizes the filament of the vacuum tube 202. The effective negative bias applied to the vacuum tube 202 therefore is the drop appearing across resistors 329 and 331 when no current is flowing in the vacuum tube 205. With the increase in anode to cathode cur-

rent of the vacuum tube 205, however, the negative bias supplied by the resistors 329 and 331 is opposed by the bias appearing across the resistor 324. The potential supplied by the resistor 324 is obtained from a resistance capacitance arrangement which has a relatively short time constant so that a rapid enabling action of the vacuum tube 202 is obtained. The bias obtained across the resistors 329 and 331 does not vary greatly with a change in the plate current of the vacuum tube 202, but the voltage appearing across the resistor 324 varies widely from the standby condition of the channel amplifier to the enabled condition. Therefore, the bias effective on the vacuum tube 202 becomes less negative as the plate current of the vacuum tube 205 increases, thereby bringing up the gain of the outgoing channel amplifier to enabled condition.

The bias of the control vacuum tube 205 is equal to the voltage drop across the resistors 324 and 325, the latter resistor carrying plate currents of the vacuum tubes 201, 203 and 204. Therefore, the net bias applied to the vacuum tube 205 does not change greatly with a change in the anode current of the vacuum tube 205, even though the voltage appearing across the resistor 324 is directly proportional to the increased plate current of the control tube. Therefore, the stabilizing action of the voltage drop appearing across the resistor 325 tends to compensate for the application of voice voltage to the vacuum tube 205 and thus to reduce the rate of increase in plate current in this vacuum tube. If such an arrangement were not provided there would be a much greater rate of increase in the plate current for the vacuum tube 205 which would be highly undesirable from the standpoint of control tube sensitivity.

Since the potential appearing across the resistor 324 varies in proportion to the signal currents passing through the amplifier, and this bias circuit has a relatively short time constant, it is desirable to eliminate this variable effect by connecting the juncture between the resistors 329 and 331 to the juncture between the resistors 231 and 322, which is accomplished by the make contacts 263 and 264 of the slow release relay 243. The anode current of the control tube 205 having been increased in response to signal currents passing through the outgoing channel amplifier, brings about energization of the relay 237 which, in turn, energizes, by the closing of its contacts 241 and 242, the slow release relay 243. Operation of the slow release relay 243 brings about the closing of the contacts 263 and 264, thereby to apply a smaller negative bias to the control of the amplifier tube 202.

At the same time the capacitor 244 is connected in shunt to the slow release relay 243 by the closing of the contacts 245 and 247. This increases the slow release characteristics of the relay. The capacitor 244 is relatively large and therefore would tend to lower the voltage across the relay coil momentarily, were it applied directly without previously charging the capacitor. The capacitor 244, therefore, is initially connected by the break contacts 245 and 246 through the current limiting resistor 239, so that the capacitor may be connected in shunt to the relay without lowering the voltage thereacross. The current limiting resistor 239 prevents the flow of heavy charging currents whenever contacts 245 and 246 are made, which otherwise might disturb the amplifier sufficiently so as to cause a noise or decided change in the level of operation. The slow release relay

243 also closes contacts 248 and 249 thereby connecting the grid of the vacuum tube 206 through the resistors 276, 278 and 252 to the adjustable contact on the voltage divider 254. The voltage divider 254 is connected between ground and the conductor 250 so as to be connected between the negative side and ground of the low voltage direct current biasing source of potential provided by the transformer 301, the bridge rectifier 304, and the choke coil 305. Therefore sufficient negative bias is supplied to the input tube 206 for the incoming channel amplifier to effectively disable the amplifier.

The outgoing channel amplifier in addition to being controlled by the self-biasing arrangements, the control voltage applied by the control tube 205 and the change in negative bias brought about by operation of relay 243, is also controlled by the automatic gain control arrangement. This includes the resistor 219 which is connected across the output circuit of the vacuum tube 204. A portion of the potential appearing thereacross is coupled by the capacitor 221 through the current limiting resistor 222 to the dry disk rectifier 223 which builds up a potential across the capacitor 224 which is proportional to the signal current passing through the amplifier. The capacitor 224 is discharged at a relatively constant rate by the resistor 225. This automatic gain control voltage appearing across the capacitor 224 is applied through a time delay circuit comprising the resistors 226 and 228 and the capacitors 227 and 229 to the grid of the vacuum tube 201. The grid to cathode circuit of this vacuum tube 201 also includes the self-biasing resistor 332 which is shunted by the capacitor 333 and which is connected between the mid-point of the transformer winding 317 and ground. Therefore, the automatic gain control voltage applied to the input tube 201 is superimposed on the self-bias appearing across the bias resistor 332. The resistor-capacitor-filter arrangement introduces a sufficient time constant in the automatic gain control voltage so as to maintain the gain of the amplifier over word and syllable pauses. Since the transformer winding 317 also supplies filament current to the vacuum tubes 203 and 204, the bias appearing across the resistor 332 is stabilized to a considerable degree so that in spite of the fact that the plate current of the vacuum tube 201 reduces considerably as the automatic gain control bias is applied, the vacuum tube operates with a proper amount of negative bias potential.

When currents appear across the incoming conductors 296 and 300 thereby to produce a voltage drop across the voltage divider 265, signal currents are amplified by the incoming channel amplifier comprising the vacuum tubes 206 and 207 together with their associated circuit elements. A portion of output voltage of the vacuum tube 207 is obtained from across the voltage divider 269 and by means of a coupling capacitor 297 is applied to the control grid of the control vacuum tube 208, thereby to cause an increase in the anode to cathode current of the vacuum tube 208. The cathode circuit of the control tube 208 may be traced from the midpoint of the filament transformer winding 319 through the resistor 339 to the negative side of the plate potential supplied by the rectifier tube 311. A change in the anode current of the control tube 208 therefore rapidly changes the voltage drop appearing across the resistor 339. The resistor 339 is effectively connected in circuit with the grid to cathode circuit

of the vacuum tube 206. A circuit from the grid of the vacuum tube 206 may be traced through the lower portion of the voltage divider 265, resistors 278 and 276, resistor 275 which is shunted by the condenser 274, resistors 336, 339, 343 and 342, and back to the mid-tap of the filament transformer winding 321 which energizes the filament of the vacuum tube 206. The negative bias applied to the vacuum tube 206 therefore is the drop appearing across resistors 342 and 343 when no current is flowing in the vacuum tube 208. With the increase in the anode to cathode current of the vacuum tube 208, however, the negative bias applied by the resistors 342 and 343 is opposed by the bias appearing across the resistor 339. The potential supplied by the resistor 339 is obtained from a resistance capacitance arrangement which has a relatively short time constant so that a rapid enabling action of the vacuum tube 206 is obtained. The midpoint of the transformer winding 319 is connected through the resistors 339, 343 and 342 to the midpoint of transformer winding 321 which supplies filament current to the input vacuum tube 206. The change in bias brought about by the change in the anode current of vacuum tube 208 therefore is applied to the grid to cathode circuit of the input vacuum tube 206. The voltage appearing across the resistor 339 varies widely from standby condition to enabled condition, although the voltages appearing across the resistors 342 and 343 do not vary greatly. Since the voltage appearing across the resistor 339 varies considerably in accordance with the change in anode current of the control tube 208, the negative bias applied to the input vacuum tube 206 is rapidly reduced, thereby quickly increasing the gain of the incoming channel amplifier thereby to enable the amplifier. It will be readily appreciated that the action of the vacuum tube 208 has an action with respect to the input vacuum tube 206 very similar to the action of the control tube 205 with respect to the vacuum tube 202 of the outgoing channel amplifier. Having the initial increase in gain of the vacuum tube 206, the increased current flowing in the vacuum tube 208 brings about actuation of the relay 283 which closes its contacts 284 and 285, thereby to energize the slow release relay 286. The capacitor 291 which is arranged to be charged through a current limiting resistor 281 is connected across the relay 286, thereby to improve its slow release characteristics. In order to change the bias appearing on the vacuum tube 206 the contacts 294 and 295 are closed, thereby rendering ineffective the variable bias supplied by the action of the vacuum tube 208 and also changing the degree of bias provided by the resistors 342 and 343 so that the gain of the incoming channel amplifier is stabilized at a new gain level. At the same time contacts 293 and 294 are closed, which place the resistor 292 in shunt with the resistor 343. This gives a combination of voltage drops across the two resistors which is somewhat less than the voltage appearing across the resistor 325. Thus these voltage drops are opposite and unequal and are in series with the automatic gain control voltage path to ground so as to produce an automatic gain delay voltage. The automatic gain voltage which is obtained from the voltage divider 268 by the coupling capacitor 271, the current limiting resistor 272 and the dry disk rectifier 273 appears across the capacitor 274. During the initial period of incoming speech and after the closure of the contacts 294 and 295 of the relay 286 the automatic gain

control bias from the capacitor 274 is superimposed upon the normal negative bias applied to the vacuum tube 206 by means of the drop appearing across the resistor 342. Operation of the slow release relay 286 also changes the contact 261 from ground to contact 262, thereby connecting the grid of the vacuum tube 203 through the resistor 256 to a bias voltage appearing across the voltage divider 255. This negative bias voltage is sufficient to reduce the gain of the vacuum tube 203 so as to thereby disable the outgoing channel amplifier.

While the outgoing channel amplifier has been shown utilizing four stages of amplification, it is to be understood that either a greater or lesser number of stages may be utilized, and in the present instances four stages of amplification were deemed necessary to supply a slight excess of gain whereas three stages might be insufficient. In order to balance or offset this excess gain, a T-pad comprising the resistors 424 to 426 is inserted between the conductors 210 and 220 and the winding of the transformer 402 of the hybrid system 401.

If it is desired to interrupt the operation of the executive loudspeaking communication system to obtain the privacy of the handset, the closure of the contacts 106 and 107 causes the conductor 140 to be effectively connected to ground, whereby power flowing over the conductors 250 and 100 will energize the relay 413. This disconnects the hybrid system 401 and short-circuits the input to the incoming signal channel. If subsequently communication is to be resumed by the loudspeaking apparatus, the replacement of the receiver to actuate the receiver switch 103 will break the contacts 106 and 107, thereby to deenergize relay 413 and again to place into operation the signal channel amplifiers.

Mention was previously made of the desirability, of providing a system which used a single type of tube and, hence, in the accompanying drawings all the tubes are shown as being triodes. It, of course, will be understood that while triodes have been shown, the principles herein disclosed may be applied to amplifiers having tubes which have a greater number of elements therein.

In order that the present specification be sufficiently complete and understandable without a reference to other applications, certain circuit arrangements and apparatus have been shown and described to facilitate such understanding. Certain broad aspects of the circuit arrangements and apparatus, herein disclosed but not claimed, are shown, described and claimed in my copending application for improvements in Transmission systems, Serial No. 483,596, filed April 19, 1943, now Patent No. 2,369,460, granted February 13, 1945.

While one embodiment of the invention has 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. In a transmission system, a channel amplifier having a plurality of stages of amplification, a control tube arranged to be responsive to signal currents passing through the output stage of said amplifier, means connected to said amplifier for supplying thereto a negative bias sufficient to maintain the gain thereof at a relatively low level, means connected in circuit with said control tube and said first means for deriving a control voltage in opposition to said negative bias thereby to increase the gain of said amplifier, and means

controlled by said control tube for subsequently rendering ineffective said second means and a portion of said first means to maintain the gain of said amplifier above a predetermined level.

2. In a transmission system, a channel amplifier having a plurality of stages of amplification, a control tube arranged to be responsive to signal currents passing through the output stage of said amplifier, self-biasing means connected to at least one stage of said amplifier for supplying thereto a negative bias sufficient to maintain the gain thereof at a relatively low level, biasing means having a relatively short time constant connected in circuit with said control tube and said first means for deriving a control voltage in opposition to a portion of said negative self-bias thereby to increase the gain of said amplifier, and means controlled by said control tube for subsequently rendering ineffective said second means and a portion of said first means to maintain the gain of said amplifier above a predetermined level.

3. In a transmission system, a channel amplifier provided with means for supplying thereto a negative bias sufficient to maintain the gain thereof at a relatively low level, a control tube arranged to be responsive to signal currents passing through said amplifier, means connected in circuit with said control tube and said first means for deriving a control voltage in opposition to said negative bias, said means having a relatively short time constant thereby to rapidly increase the gain of said amplifier, and means controlled by said control tube responsive to an increase in the gain of said amplifier to a certain level for short-circuiting said second means and a portion of said first means to maintain the gain of said amplifier above a predetermined level.

4. In a transmission system, a channel amplifier having a plurality of stages of amplification, a control tube arranged to be responsive to signal currents passing therethrough, means connected to said amplifier for supplying thereto a negative bias sufficient to maintain the gain thereof at a relatively low level, means having a relatively short time constant connected in circuit with said control tube and said first means for deriving a voltage in opposition to a portion of said negative bias thereby to increase the gain of said amplifier, means controlled by said control tube for subsequently rendering ineffective said second means and a portion of said first means, and an automatic gain control circuit energized from the output stage of said amplifier and having a time constant sufficient to hold over word and syllable pauses for supplying an automatic gain control voltage to said amplifier.

5. In a transmission system, a channel amplifier having a plurality of stages of amplification, a control tube arranged to be responsive to signal currents passing therethrough, means connected to said amplifier for supplying thereto a negative bias sufficient to maintain the gain thereof at a relatively low level, means having a relatively short time constant connected in circuit with said control tube and said first means for deriving a control voltage in opposition to a portion of said negative bias thereby to increase the gain of said amplifier, means controlled by said control tube for subsequently rendering ineffective said second means and a portion of said first means, and an automatic gain control energized from the output stage of said amplifier and having a time constant sufficient to hold over word and syllable pauses connected in circuit with said

first means thereby to superpose an automatic gain control bias on said negative bias.

6. In a transmission system, a channel amplifier including at least an input tube and an output tube, means connected to said amplifier for supplying thereto a negative self-bias sufficient to maintain the gain thereof at a relatively low level, a control tube arranged to be responsive to signal currents passing through the output stage of said amplifier, means connected in circuit with said control tube and said first means for deriving a control voltage in opposition to said negative bias thereby to increase the gain of said amplifier, automatic gain control means energized from the output stage of said amplifier and having a time constant sufficient to hold over word and syllable pauses, said automatic gain control means being connected in circuit with said first means thereby to superpose an automatic gain control bias on said negative bias, and means controlled by the said control tube responsive to an increase in the gain of said amplifier to a certain level for rendering ineffective said second means and a portion of said first means to maintain the gain of said amplifier above a predetermined level and for delaying the application of an automatic gain control bias until a predetermined signal level has been reached.

7. In a transmission system, the combination of a multi-stage amplifier with biasing means for maintaining the gain thereof at a relatively low level, automatic gain control means having an appreciable time constant to hold over word and syllable pauses and being associated with the output stage of said amplifier to derive voltages for effectively controlling the gain of the first stage of amplification, a control tube and circuit for said amplifier arranged to derive a control voltage in response to signal currents passing through said amplifier, means for applying said control voltage in opposition to said biasing means to increase the gain of the amplifier, and means controlled by said control tube responsive to an increase in the gain of said amplifier to a certain level for further reducing the bias of said amplifier to maintain the operation thereof at an increased gain level.

8. In a transmission system, the combination of a multi-stage amplifier with biasing means for maintaining the gain thereof at a relatively low level, automatic gain control means having an appreciable time constant to hold over word and syllable pauses for effectively controlling the gain of the first stage of amplification, a control tube and circuit for said amplifier energized from the output stage and arranged to derive a control voltage in response to signal currents passing therethrough, means for applying said control voltage in opposition to said biasing means to increase the gain of the amplifier, and means controlled by said control tube for subsequently rendering ineffective said second control voltage and a portion of the bias of said amplifier to maintain operation thereof at an increased gain level.

9. In a transmission system, the combination of a pair of channel amplifiers for transmitting signal currents in different directions, negative biasing means for each channel amplifier to maintain the gain thereof at a predetermined low level, a control tube and circuit for each channel amplifier arranged to derive control voltages in response to signal currents passing therethrough, means for applying said control voltages in opposition to said negative bias thereby to increase

the gain of said amplifier, means responsive to currents flowing through said control tube for subsequently reducing the amount of negative bias supplied by said first means, and means controlled by said control tube and circuit for increasing the negative bias of the other channel amplifier thereby to reduce the gain thereof.

10. In a transmission system, the combination of a pair of multi-stage channel amplifiers for transmitting signal currents in different directions, negative biasing means for each channel amplifier to maintain the gain thereof at a predetermined low level, an automatic gain control for each amplifier for effectively controlling the gain of the first stage of amplification, a control tube and circuit for each channel amplifier arranged to derive voltages in response to signal currents passing therethrough, means for supplying said control voltages in opposition to said negative bias thereby to reduce the effectiveness thereof, means responsive to current flowing through said control tube for subsequently reducing the amount of negative bias supplied by said first means, and means controlled by said control tube and circuit for increasing the negative bias of the other channel amplifier thereby to reduce the gain thereof.

11. In a transmission system, the combination of a pair of multi-stage amplifiers for transmitting signal currents in different directions, each amplifier being provided with biasing means for maintaining the gain thereof at a relatively low level, automatic gain control means for each amplifier for effectively controlling the gain thereof, said automatic gain control means having an appreciable time constant to hold over word and syllable pauses, a control tube and circuit for each amplifier arranged to derive control voltages in response to signal currents passing therethrough, means for applying said control voltages in opposition to said biasing means to increase the gain of the amplifier, means controlled by said control tube for subsequently removing said control voltage and reducing the bias of said amplifier, a source of bias potential, and means controlled by said control tube for connecting said source of bias potential to the other amplifier to reduce the gain thereof.

12. In a transmission system, the combination of multi-stage channel amplifiers for transmitting signal currents in different directions, each amplifier being provided with self-biasing means for maintaining the gain thereof below a predetermined level, automatic gain control means for each amplifier for effectively controlling the gain of the first stage of amplification, said automatic gain control means having a time constant sufficient to hold over word and syllable pauses, a control tube and circuit for each amplifier arranged to derive control voltages in response to signal currents passing through said amplifier, means for applying said control voltages in opposition to said self-biasing means to increase the gain of the amplifier, means controlled by said control tube for subsequently reducing the self-bias of said amplifier, a source of bias potential, and means controlled by said control tube for connecting said source of bias potential to the other amplifier to reduce the gain thereof.

13. In a transmission system, the combination of incoming and outgoing multi-stage amplifiers for transmitting signal currents, each amplifier being provided with self-biasing means for maintaining the gain thereof at a relatively low level, a control tube and circuit for each amplifier ar-

ranged to derive control voltages in response to signal currents passing therethrough, means for applying said control voltages in opposition to said self-biasing means thereby to increase the gain of the amplifier, each of said amplifiers being provided with automatic gain control means energized from the output stage and acting upon the input stage of the amplifier, means responsive to the operation of said control tube for subsequently removing the effect of the control voltage generated thereby and for reducing the self-bias of said amplifier, said means including a relay arranged to short-circuit a portion of said self-biasing means and said means for deriving control voltages from said control tube, a source of bias potential, and means controlled by said control tube for connecting said source of bias potential to the other amplifier to reduce the gain thereof.

14. In a transmission system, the combination of multi-stage channel amplifiers for transmitting signal currents in different directions, each amplifier being provided with self-biasing means for maintaining the gain thereof at a subnormal level, automatic gain control means for each amplifier associated with the output stage thereof to derive voltages for effectively controlling the gain of the first stage of said amplifier, said gain control means having a time constant sufficient to hold over word and syllable pauses, a control tube and circuit for each amplifier arranged to derive control voltages in response to signal currents passing through said amplifier, and means for applying said derived control voltages to oppose said self-biasing means to increase the gain of the amplifier to a predetermined normal level, means controlled by said control tube for subsequently removing said control voltage and reducing the self-bias of said amplifier, and means controlled by said control tube for reducing the gain of the other channel amplifier.

15. In a transmission system, a combination of incoming and outgoing channel amplifiers, each amplifier being provided with a control tube arranged to be responsive to signal currents passing therethrough thereby to increase the gain of its amplifier and to decrease the gain of the other amplifier, said incoming channel amplifier having an input stage and an output stage, self-biasing means associated with said input stage for normally maintaining the gain of said amplifier at a relatively low level, automatic gain control means energized from said output stage for supplying in series with said self-biasing means an automatic gain control voltage having a time constant sufficient to hold over word and syllable pauses, means associated with said input stage and said control tube for deriving from said control tube a voltage in opposition to said self-biasing means thereby to rapidly increase the gain of said amplifier, said control tube being provided with a relay arranged to short-circuit said control voltage means and a portion of said self-biasing means thereby to maintain the level of said amplifier at a predetermined amount, means associated with said relay for connecting in series with said automatic gain control voltage sufficient negative bias to delay the operation thereof until a predetermined signal level has been exceeded, a source of negative bias, and means controlled by said relay for connecting said source of negative bias to the outgoing channel amplifier thereby to reduce the gain thereof sufficiently to render said amplifier ineffective.

16. In a transmission system, the combination

comprising an incoming channel amplifier and an outgoing channel amplifier, each amplifier being provided with a control tube and circuit arranged to derive control voltages in response to signal currents passing therethrough thereby to increase the gain of the amplifier, a source of negative bias potential, means controlled by each control tube for connecting said source of bias potential to the other amplifier to reduce the gain thereof, said outgoing channel amplifier having a plurality of stages of amplification including a first stage provided with self-biasing means, means energized from the output stage of said amplifier for supplying in series with said self-biasing means of said first stage an automatic gain control voltage having a time constant sufficient to hold over word and syllable pauses, self-biasing means associated with the second stage of said amplifier for applying thereto a bias sufficient to maintain said amplifier at a relatively low signal level, means connected in circuit with said control tube and with said latter self-biasing means for deriving a voltage in opposition to said self-biasing means thereby to rapidly increase the gain of said amplifier, a relay actuated by said control tube, said relay being arranged to subsequently short-circuit a portion of said self-biasing means and said means for generating a control voltage, said relay being arranged to connect said source of negative bias potential to the input stage of said incoming channel amplifier thereby to disable said amplifier, and means associated with the third stage of said outgoing channel amplifier for disabling said amplifier in response to operation of the control tube associated with said incoming channel amplifier.

17. In a transmission system, the combination comprising an outgoing channel amplifier having a plurality of stages of amplification, self-biasing means for said amplifier for deriving a negative bias sufficient to maintain the gain thereof at a relatively low level, means for deriving from the output stage thereof an automatic gain control voltage arranged to be applied in series with the self-biasing voltage of the input stage of said amplifier, said gain control means having a time constant sufficient to hold over word and syllable pauses, a control tube and circuit arranged to be responsive to signal currents passing through said amplifier, said control tube and circuit being arranged to derive a control voltage in opposition to said self-biasing voltage, said control circuit having a relatively short time constant whereby the gain of said amplifier will be increased at a relatively rapid rate, a relay energized by said control tube, said relay being arranged to short-circuit a portion of said self-biasing means and said means for deriving a control voltage in opposition to said self-biasing means thereby to stabilize the gain of said amplifier at a predetermined level, an incoming channel amplifier having an input stage and an output stage, self-biasing means associated with the input stage for deriving a negative bias sufficient to maintain said amplifier at a relatively low gain level, automatic gain control means energized from said output stage for applying to said input stage in series with said negative bias, an automatic gain control potential having a time constant sufficient to hold over word and syllable pauses, a control tube and circuit arranged to be responsive to signal currents passing through said amplifier, said control circuit having means for deriving control voltages in opposition to said self-biasing means and having a relatively short time constant thereby to

rapidly increase the gain of said amplifier, a relay controlled by said control tube, said relay being arranged to short-circuit said means for deriving control voltages and a portion of said self-biasing means, said relay also being arranged to supply in series with the said automatic gain control voltage a new negative bias potential sufficient to delay the action of said automatic gain control circuit until the signal level of the amplifier exceeds a certain predetermined value, 10

a source of negative bias, means associated with the relay of said last-mentioned control tube for applying to the third stage of amplification of said outgoing channel a negative bias sufficient to further reduce the gain thereof, and means associated with the relay of said first-mentioned control tube for applying the negative bias directly to the input stage of said incoming channel amplifier thereby to reduce the gain thereof.

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