

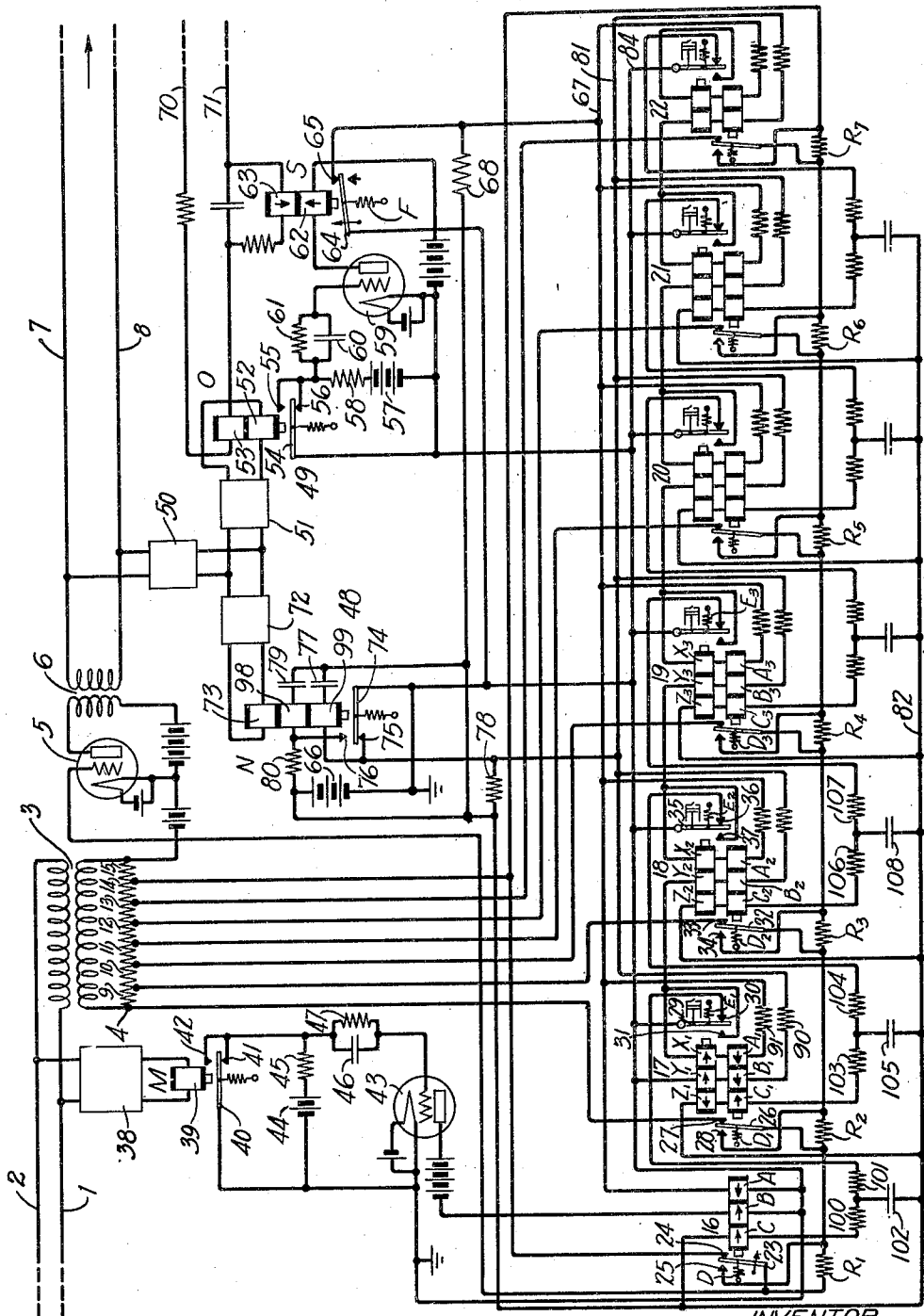
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TRANSMISSION SYSTEM

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TRANSMISSION SYSTEM

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This invention relates to wave transmission systems and particularly to volume control in telephone transmission systems.

One object of the invention is to provide a transmission system with a volume control means that shall maintain the volume substantially constant in an improved manner and that shall operate without hunting action during periods when signal energy is received at a substantially constant level.

Another object of the invention is to provide a volume control system that shall operate on the peaks of the signal energy to effect quick setting of the impedance in a signal channel to hold the energy level substantially constant and that shall hold the impedance constant in the signal channel for a limited period after the setting thereof.

Another object of the invention is to provide a volume control system having a potentiometer in the transmitting channel for controlling the volume of the transmitted signals with improved means controlled in accordance with the energy level in the transmitting channel beyond the potentiometer for governing the potentiometer to maintain the volume of the transmitted signals substantially constant while insuring against hunting action when the energy level of the incoming signals is substantially constant.

A further object of the invention is to provide a volume control system of the above indicated character that shall vary the number of sections of a potentiometer included in a signal channel by relays in a manner to insure against sudden impedance changes, that shall maintain the potentiometer setting during a receiving period, and that shall not interfere with the transmission of signals during the changing of the potentiometer setting.

In signal systems and particularly in telephone communication systems it is desirable to limit the energy level by reason of the load carrying capacity of the transmitter or some relay device in the system. It is often desirable to maintain a constant maximum peak level of power at a particular point regardless of the level at which the speech has been transmitted to such point. In the

transatlantic radio telephone and the transatlantic cable systems it is important to keep the final transmitting amplifier loaded to its full capacity. Moreover, in radio broadcasting and public address systems, where music and speech are transmitted to a distant point over telephone or other transmission circuits, it is desirable to maintain the transmitted waves at a constant energy level.

The disclosed volume control system comprises a potentiometer divided into sections included in the transmission channel of a communication system. Relays are provided for varying the number of potentiometer sections included in the channel to maintain the volume substantially constant. Normally, when no signals are being transmitted or received, the potentiometer is held in its lowest operating position to prevent any voice operated control circuits that may be included in the system from being operated by any so called noise which may be received. Upon receipt of any signals for transmission at a constant volume, the first relay for controlling the potentiometer is operated by a starting control circuit to change the potentiometer from its lowest to its highest or most efficient position. The starting control circuit is connected to the transmission line ahead of the potentiometer and is provided with means for holding the first operated relay in set position a limited period after operation thereof.

A secondary control circuit is operated from the transmission channel at a point beyond the potentiometer at an energy level corresponding to the level required to operate the starting control circuit. A main control circuit is operated from the same point on the transmission channel as the secondary control circuit at an energy level one unit above the level required to operate the first relay by the starting control circuit. The unit referred to is considered to be the change effected in the volume level in the channel by one potentiometer section. The main control circuits operate the remaining potentiometer relays according to the energy level obtaining in the transmission channel to maintain the volume substantially constant. The sec-

ondary control circuit establishes locking circuits and holds the relays operated by the main control circuit in set position a predetermined time after operation thereof. The secondary control circuit provides against the constant hunting for a proper setting by the potentiometer relays when the incoming energy level is substantially constant.

The secondary control circuit is not only governed by the energy level in the transmission channel but is governed from the receiving channel when the apparatus is used for two-way service as in the transatlantic radio terminal circuits. Circuits of this type are shown in the application of R. C. Mathes, Serial No. 747,164, filed November 1, 1924. The secondary control circuit is governed by the receiving channel to hold the potentiometer in the transmitting channel in any set position during a receiving period so that resetting of the potentiometer is not necessary at the start of the following transmitting period.

The sections of the potentiometer in the transmission channel are connected to the input circuit of a thermionic amplifier in the transmission channel and are each shunted by auxiliary resistance elements. The auxiliary resistance elements have a relatively high resistance value when compared with the potentiometer sections so that the removal of the resistance elements from shunt connection with respect to the potentiometer section will not cause an undesirable disturbance in the impedance of the potentiometer when viewed from the line. The resistance elements have a low impedance value in comparison with the input impedance of the amplifier so as to produce no sensible change in the efficiency of transmission when the resistance elements are shunted out of the circuit by the relays. A similar arrangement of resistance elements with respect to sections of a potentiometer in a volume control system is disclosed in the application of J. L. Hogg, Serial No. 375,629, filed July 3, 1929.

The single figure in the accompanying drawing is a diagrammatic view of a volume control system constructed in accordance with the invention.

Referring to the drawing, an incoming line comprising conductors 1 and 2 is connected by a transformer 3, a potentiometer 4, a thermionic amplifier 5 and a transformer 6 to the outgoing line comprising conductors 7 and 8. This circuit comprises the transmitting channel of a four-wire system. The potentiometer 4 is divided into sections 9 to 15, inclusive, under the control of relays 17 to 22, inclusive. A slow-acting and quick-releasing relay 16 is provided for changing the potentiometer from its least efficient position to its most efficient position.

The relay 16 comprises an operating coil B and two locking coils A and C for control-

ling an armature 23. The armature 23, which is biased by a suitable spring member D, is adapted to engage contact members 24 and 25. The relay 16 is polarized and the windings B and C oppose the spring bias D. The winding A exerts a force tending to assist the spring bias. It is assumed the winding B plus the winding C when energized exert a greater force on the armature 23 than the bias D and will hold the armature 23 in engagement with the contact member 24. The mechanical bias D is assumed to have a greater strength than either the winding B or the winding C alone. Furthermore, the winding A plus the bias D are assumed to exert a stronger force than the winding B plus the winding C when energized. A more complete description of the operation of this relay will be given when the general operation of the system is described.

The relay 17 is divided into two parts. One part comprises windings A_1 , B_1 and C_1 which operate an armature 26 between contact members 27 and 28. The armature 26 controls the operation of the potentiometer section 9. The second part of the relay 17 comprises windings X_1 , Y_1 and Z_1 which operate an armature 29 between contact members 30 and 31. The armature 29, under the control of the windings X_1 , Y_1 , Z_1 , is slow in operation when compared with the operation of the armature 26 by means of the windings A_1 , B_1 and C_1 . The windings Y_1 and B_1 are operating windings, whereas the windings X_1 , A_1 , Z_1 and C_1 are locking windings.

The relay 18 is divided into two parts the same as the relay 17. The first or quick-acting part comprises windings A_2 , B_2 and C_2 which operate an armature 32 between contact members 33 and 34. The armature 32 controls the potentiometer section 10. The second portion of the relay comprises windings X_2 , Y_2 and Z_2 which operate an armature 35 between contact members 36 and 37. The windings Y_2 and B_2 are operating windings, whereas windings X_2 , Z_2 , A_2 and C_2 are locking windings. The relay 17 is provided with a mechanical bias D_1 for the armature 26 and the relay 18 is provided with a mechanical bias D_2 for the armature 32. The mechanical biasing means D_1 and D_2 for the relays 17 and 18 each exert a force tending to assist the operating windings. The armature 29 of relay 17 and the armature 35 of the relay 18 are made slow acting by suitable dash pots.

The relays 19, 20, 21 and 22 which control the potentiometer sections 11, 12, 13 and 14 are similar in construction and operation to the relays 17 and 18 and a detailed description thereof is deemed unnecessary. Resistance elements R_2 , R_3 , R_4 , R_5 , R_6 and R_7 are so connected to the quick-operating armatures of the relays 17 to 22, inclusive, as to

insure against opening or breaking the line upon operation of any of the relays.

Referring to relay 17, the armature 28 is normally in engagement with the contact member 27. Upon operation of the armature 28 to break engagement with contact member 27 and engage the contact member 28, it will be noted the resistance element R_2 completes the line circuit during transit of the armature. The resistance member R_2 has a relatively high resistance value when compared with the associated potentiometer section 9, so that removal of the resistance element from shunt connection with respect to the potentiometer section will not cause an undesirable disturbance in the impedance of the potentiometer as viewed from the incoming line. The resistance elements R_3 to R_7 , inclusive, bear like relation to the potentiometer sections 10 to 15, inclusive. The resistance elements R_2 to R_7 , inclusive, have a low impedance value in comparison with the input impedance of the line amplifier 5.

A resistance element R_1 is connected to the armature 23 of the relay 16 in the same manner as the resistance elements R_2 to R_7 , inclusive, are connected to the fast-operating armatures of the relays 17 to 22, inclusive. The resistance element R_1 prevents opening of the line circuit upon transit of the armature 23 from engagement with the contact member 24 to engage the contact member 25 when the potentiometer 4 is being changed from its least efficient position to its most efficient position.

The incoming line designated by reference characters 1 and 2 and the outgoing line designated by reference characters 7 and 8 are part of a transmitting channel. The receiving channel is not shown in detail on the drawing. One connection which will be described hereinafter is provided from the receiving channel to hold the potentiometer 4 in any set position during a receiving period.

A starting circuit is connected to the incoming conductors 1 and 2 for controlling the slow-acting and quick-releasing relay 16 as soon as the peaks of speech reach a level above the weakest speech which the system is designed to handle. This level for the purposes of describing the invention will be designated as the zero level. The starting circuit comprises a thermionic amplifier-rectifier 38 which directly connects a relay M to the line conductors 1 and 2. The relay M comprises an operating winding 39 and an armature 40 which is adapted to engage contact members 41 and 42. The relay M controls a thermionic tube 43 for governing the excitation of the winding B of the relay 16. In the released position of the relay M with the armature 40 thereof in engagement with the contact member 41, a shunt circuit for a battery 44 is completed through a re-

sistance element 45. The negative pole of the battery 44 which is grounded is connected to the filament of the thermionic tube 43. The positive pole of the battery 44 is connected through the resistance element 45, and a condenser 46 and a resistance element 47 in parallel to the grid of the tube 43.

When the armature 40 of the relay M is in engagement with the contact member 41 to establish the shunt circuit around the battery 44 through the resistance element 45, little or no potential will be impressed on the grid of the thermionic grid 43. Consequently space current will flow through the tube and the winding B of the relay 16 will be energized. If the relay M is operated to move the armature 40 from engagement with the contact member 41 into engagement with the contact member 42, the shunt circuit around the battery 44 through the resistance element 45 is opened. Thereupon a positive potential is impressed on the grid of the thermionic tube 43 and the condenser 46 gets a negative charge from the filament to grid current of the tube 43. At this time, therefore, during the transit of the armature 40 between the contact members 41 and 42, the condenser 46 is being charged and an extra energizing current flows through the winding B of the relay 16. Upon engagement of the armature 40 with the contact member 42, the shunt circuit around the battery 44, through the resistance element 45 is again completed, thereupon the condenser 46 discharges and impresses a negative potential on a grid of the thermionic tube 43. The negative potential impressed on the grid of the tube stops the space current flow to deenergize the winding B of the relay 16. The rate of discharge of the condenser 46 is controlled by the resistance element 47. The function performed by the starting circuit will be fully set forth hereinafter.

A main control circuit 48 and a secondary control circuit 49 are connected by a thermionic amplifier 50 to the transmitting channel beyond the potentiometer 4. The secondary control circuit is operated at a lower level than the main control circuit and is assumed to operate at five transmission units lower than the main control circuit. Furthermore, the secondary control circuit is assumed to operate at the corresponding level which effects operation of the starting circuit. Although the operating points of the starting circuit and the main control circuit are assumed to be separated by five transmission units, it is to be understood that any desired separation of the operating points for the two circuits may be effected.

The secondary control circuit 49 comprises a thermionic rectifier-amplifier 51 which is connected to a relay O. The relay O comprises two windings 52 and 53 which operate an armature 54 between contact members 55

and 56. The armature 54, when in engagement with the contact member 56, closes a shunt circuit around a battery 57 through a resistance element 58 in the same manner as the armature 40 of the relay M in the starting circuit completes a shunt circuit around the battery 44. The relay O controls a thermionic tube 59 which, in turn, controls a locking relay S. A condenser 60 shunted by a resistance element 61 is inserted in the grid circuit of the tube 59 for establishing a hang-over circuit in the same manner as the condenser 46 and the resistance element 47 in the grid circuit of the tube 43 in the starting circuit.

The relay S is slow acting and quick releasing and comprises two windings 62 and 63 which operate an armature 64. Normally the armature 64 is in engagement with a contact member 65 and upon energization of the winding 63 or deenergization of the winding 62 is moved away from the contact member 65 for opening a shunt circuit around a battery 66 to impress potential on a locking bus conductor 67. When the armature 64 is in engagement with the contact member 65 a shunt circuit is connected around the battery 66 through a resistance element 68. When the armature 64 disengages the contact member 65 positive potential from the battery 66 is impressed on the locking bus conductor 67. The locking bus serves to supply potential for windings of the relay 16 to 22, inclusive, for holding or locking purposes.

Upon release of the relay S, the winding A of the relay 16 is energized from the locking bus 67. Upon operation of the armature 29 of the relay 17, windings X_1 and A_1 of such relay are energized from the locking bus. The windings X_2 and A_2 upon operation of the armature 35 of relay 18 are energized from the locking bus 67. In like manner the windings of the relays 19, 20, 21 and 22 are energized from the locking bus.

The winding 53 of relay O and the winding 63 of the relay S are connected to conductors 70 and 71 which are joined to the receiving channel (not shown). Thus, during the receiving period the coils 53 and 63 are energized to insure release of the locking relay S. The function of this connection to the receiving channel will be described more fully when the general operation of the system is considered.

The main control circuit 48 comprises a main control rectifier 72, which is preferably a thermionic rectifier, in circuit with a winding 73 of a main control relay N. The relay N is provided with two supplemental windings 98 and 99 and an armature 74 which is adapted to engage contact members 75 and 76. In the released position of the relay N when the armature 74 is in engagement with the contact member 75, a shunt circuit is connected around the battery 66 through the

supplementary winding 99 and the condenser 77. Upon operation of the armature 74 by the winding 73, the charge on the condenser 77 discharging through the winding 99 and a resistance element 78 assists the operation of the relay. The charging of the condenser 79 in series with the winding 98 will hold the relay armature 74 temporarily in engagement with the contact member 76. As soon as the armature 74 is released from engagement with the contact member 76, the above cycle of operations are repeated by the windings 99 and 98 and the condensers 77 and 79. A resistance element 80 is connected around the winding 98 and the condenser 79.

The operation of the relay N impresses potential from the battery 66 on the operating bus conductor 81. The operating bus supplies the potential for controlling relays 17 to 22, inclusive. A battery wire 82, which is connected to the battery 66, supplies potential for energizing the windings Z_1 and C_1 of the relay 17, the windings Z_2 and C_2 of the relay 18 and windings on each of the relays 19 to 22, inclusive. Relays similar in type to the relay N are disclosed and claimed in the application of R. C. Mathes, Serial No. 368,895, filed June 6, 1929.

Assume the system to be in the position shown on the drawing and the armature 23 of relay 16 to be in engagement with the contact member 24 so as to position the potentiometer 4 in its least efficient position. If the weakest speech that the system is designed to handle is received in the transmitting channel, relay M is operated to deenergize the winding B of the relay 16. The winding B is deenergized by reason of the discharge from the condenser 46 operating on the grid of the thermionic tube 43. As before set forth, the discharge of the condenser 46 is controlled by the resistance element 47. Upon deenergization of the winding B the spring bias D overcomes the action of the winding C and quickly moves the relay armature 23 from engagement with the contact member 24 into engagement with the contact member 25. Such movement of the relay armature 23 connects the potentiometer 4 from its least efficient position to its most efficient position. The relay M, being operated by the peaks of speech current on the conductors 1 and 2, will constantly operate its armature 40 between the contact members 42 and 41. A negative potential is impressed on the grid of the tube 43 when the armature 40 is moved from engagement with the contact member 41 and into engagement with the contact member 42 or when the armature disengages the contact member 42 and engages the contact member 41. At this time the winding B is deenergized and relay 16 is released. When the armature 40 is in transit between the contact members 41 and 42 the grid of the tube 43 will have positive

potential impressed on it and the winding B of the relay 16 will be momentarily energized. However, the relay 16 is slow in acting and quick in releasing. The armature 23 of the relay 16 is quickly moved into engagement with the contact member 25 upon deenergization of the winding B and is slowly moved out of engagement with the contact member 25 upon energization of the winding B. Accordingly, the armature 23 of the relay 16 is not moved out of engagement with the contact member 25 when the armature 40 of the relay M is in transit between the contact members 41 and 42 and the winding B of relay 16 is momentarily energized. Normally, the input circuit of the line amplifier 5 is only connected across the potentiometer section 15. However, upon movement of the armature 23 into engagement with contact member 25 the input circuit of the line amplifier is connected across all sections of the potentiometer 4.

Upon release of the armature 23 of the relay 16, the relay O in the secondary control circuit is operated. Relay O operating through the hang-over circuit comprising condenser 60, resistance element 61 and the thermionic tube 59 effects release of the locking relay S. The condenser 60 and the resistance element 61 operate with respect to the thermionic tube 59 in the same manner as the condenser 46 and the resistance element 47 operate with respect to the thermionic tube 43. Normally, the winding 62 is energized by the space current flow through thermionic tube 59. The discharge of the condenser 60, upon movement of the armature 54 into engagement with the contact member 55, impresses a negative potential on the grid of the tube 59. The slow acting and quick releasing feature of the relay S insures the holding of the armature 64 in released position when armature 54 of relay O is in transit in the same manner as the relay 16 is controlled. The circuit for energizing the winding 62 of the relay S is similar in construction and operation to the circuit which energizes the winding B of the relay 16. The armature 64 of the relay S is moved away from the contact member 65 by a suitable mechanical bias F.

Upon movement of the armature 64 away from the contact member 65, the shunt circuit through the resistance element 68 across the battery 66 is opened and potential is impressed on the locking bus conductor 67. A locking circuit is completed from the positive terminal of the battery 66 through the resistance member 68, the locking bus 67, and winding A of the relay 16 to the ground bus conductor 84 which is connected to the negative terminal of the battery 66. The winding A of the relay 16 assists the mechanical bias D in opposing the operation of the relay by the winding C. If the level of the energy

in the outgoing line 78 does not rise five transmission units above the zero level required to operate the starting circuit and the secondary control circuit, no operation of the main control circuit will take place. However, if the level in the outgoing circuit comprising conductors 7 and 8 is raised five transmission units above the level required to operate the starting circuit, the relay N will be operated to control the relay 17.

When the relay N is operated and the armature 74 disengages contact member 75, the shunt circuit through the resistance element 78 around the battery 66 is opened and positive potential from such battery is impressed on the operating bus conductor 81. A circuit is then completed from the positive pole of the battery 66 through the resistance element 78, operating bus 81, resistance element 90, and windings B₁ and Y₁ to the negative pole of the battery 66.

The windings C₁ and Z₁ of the relay 17 are normally energized from battery conductor 82 through contacts of the relay 18. The relay 17 is a polarized relay and the windings C₁ and Z₁ operate to hold the armature 29 in engagement with the contact member 30 and the armature 26 in engagement with contact member 27. The windings B₁ and Y₁ exert a force tending to move the armature 29 into engagement with contact member 31 and the armature 26 into engagement with contact member 28. The windings A₁ and X₁ exert a force to assist the windings B₁ and Y₁. A mechanical bias D₁ is provided to exert a force in opposition to the winding C₁. The windings are so adjusted that the force exerted by the winding C₁ is greater than the force exerted by the mechanical bias D₁. The force exerted by the winding B₁ is greater than the force exerted by the winding C₁ and furthermore the force exerted by the winding A₁ plus the force exerted by the mechanical bias D₁ is greater than the force exerted by the winding C₁.

Before operation of the relay N the windings C₁ and Z₁, opposing the mechanical bias D₁, hold the armature 29 in engagement with contact member 30 and the armature 26 in engagement with contact member 27. The energization of the winding B₁ by means of the circuit traced above moves the quick-acting armature 26 into engagement with the contact member 28. Such movement of the armature 26 reduces the effectiveness of the potentiometer 4 by excluding section 9 thereof from the input circuit of the line amplifier 5. After a predetermined delay the winding Y₁ operates the armature 29 to disengage the contact member 30 and engage the contact member 31. A spring bias E, exerts a force on the armature 29 corresponding to the force exert-

ed on the armature 26 by the bias D_1 . Upon movement of the armature 29 away from the contact 30, the energizing circuit for the winding C of the relay 16 is opened and upon engagement of the armature with contact member 31 a circuit is completed for energizing the locking windings A_1 and X_1 . The circuit through the locking windings A_1 and X_1 extends from the locking bus 67 through a resistance element 91, the windings A_1 and X_1 , contact member 31, and the armature 29 to the ground bus 84. The relay 17 is now held in position by the windings A_1 , X_1 , B_1 , and Y_1 and the mechanical bias members D_1 and E_1 . The engagement of the armature 29 with contact member 31 not only completes a circuit for energizing the windings A_1 and X_1 but also connects the windings B_2 and Y_2 of the relay 18 to the ground bus 84 so that, upon the next operation of the relay N, relay 18 will be controlled.

In order to insure proper operation of the system it is necessary to have the length of times for operating the relays N and 17 bear a definite relation one to the other. Assuming that it takes a time T_1 for the armature 74 to disengage contact 75, and a time T_2 for the fast armature 26 to disengage the contact member 27, the relay N should be prevented from returning its armature 74 to normal position in engagement with the contact member 75 before an additional time interval T_3 long enough to insure the safe operation of the slow operating armature 29 of the relay 17. A time T_4 for operating the slow armature 29 of the relay 17 should be less than the time intervals T_2 plus T_3 . However, the time interval T_5 for the completion of contact between the armature 29 and the contact member 30 must be greater than the sum of the intervals T_2 and T_3 within which the armature 74 of the relay N must return to its normal position. If the relays are not operated in accordance with the above conditions, the windings B_2 and Y_2 of the relay 18 will be connected to the operating bus 81 while potential is still on it from the first operation of the relay N to effect operation of the relay 17. In such case, not only the potentiometer section 9 but also the potentiometer section 10 would be excluded from the input circuit of the line amplifier 5.

In case the volume on the conductors 7 and 8 of the transmitting channel is still above the value required at this point, the relay N is again operated. The second operation of the relay N impresses potential from the battery 66 on the operating bus 81 for energizing the windings B_2 and Y_2 of the relay 18. The windings and the mechanical bias members of the relay 18 are similar to the same parts in the relay 17 and operate in exactly the same manner.

Upon energization of the winding B_2 and Y_2 , the fast operating armature 32 of the re-

lay 18 disengages the contact member 33 and engages the contact member 34. The engagement of the armature 32 with the contact member 34 excludes the potentiometer section 10 from the input circuit of the line amplifier 5. The force exerted by the windings B_2 and Y_2 is opposed by the force exerted by the windings C_2 and Z_2 and is assisted by the force exerted by the mechanical bias members D_2 and E_2 .

After a time interval the slow operating armature 35 disengages the contact member 36 and engages the contact member 37. The disengagement of the armature 35 with the contact member 36 opens the energizing circuit for the windings C_1 and Z_1 of the relay 17. The engagement of the armature 35 with the contact member 37 completes a circuit from the locking bus 67 to the ground bus 84 for energizing the locking windings A_2 and X_2 . The engagement of the armature 35 with the contact member 37 also completes a connection from the ground bus to the windings B_3 and Y_3 of the relay 19. The relay 19 is similar in construction and operation to relays 17 and 18 and is provided with windings A_3 and X_3 corresponding to the windings A_2 and X_2 and windings C_3 and Z_3 corresponding to windings C_2 and Z_2 and mechanical bias members D_3 and E_3 corresponding to mechanical bias members D_2 and E_2 . The relays 20, 21 and 22 are similar to the relays 17, 18 and 19 with one exception, that the relay 22 is not provided with windings corresponding to the windings C_1 and Z_1 of the relay 17.

If the volume on the conductors 7 and 8 of the transmitting channel is still above normal, the relay N will again be operated to control the operation of the relay 19 and if necessary to control the operation of the relays 20, 21 and 22. If the armatures of the relays 16, 17 and 18 have been moved from normal position and the volume on the conductors 7 and 8 of the transmitting channel falls below normal value, the successive impulses will cease operating the relay O. Thereupon the locking relay S will be operated by the winding 62.

Upon operation of the locking relay S potential is removed from the locking bus 67. Thereupon the windings A_2 and X_2 of the relay 18 are deenergized. At this time it may be noted the windings B_2 and Y_2 are deenergized as the relay N is in the release position and no potential is on the operating bus conductor 81. Upon the deenergization of the windings A_2 and X_2 , the windings C_2 and Z_2 , which are energized, effect movement of the armature 32 into engagement with contact member 33 and the armature 34 into engagement with the contact member 36. The armature 32, upon movement into engagement with contact member 33, reinserts the potentiometer section 10 in the input circuit of the line amplifier 5. The slow operating

armature 35 breaks the connection of ground bus 84 to the operating windings B_2 and Y_2 of the relay 19 and the windings A_2 and X_2 of the relay 18. Moreover, the armature 35 upon engagement with contact member 33 completes a circuit from the battery conductor 82 to the ground bus 84 for energizing the windings C_1 and Z_1 of the relay 17. Resistance elements 103 and 104 and a condenser 105 are connected to the circuit completed by the armature 35 through the windings C_1 and Z_1 of the relay 17 for delaying the energization of the windings C_1 and Z_1 .

If the volume on the conductors 7 and 8 of the transmitting channel is still below normal value, the relays O and N will be held in released position and relay S will be held in operated position. The windings C_1 and Z_1 of the relay 17, which were energized when the relay 18 was returned to normal position, will move the armature 26 out of engagement with the contact member 28 and into engagement with contact member 27 for reinserting the potentiometer section 9 in the input circuit of the line amplifier 5. The armature 29 of the relay 17 disengages the contact member 31 for disconnecting the windings A_1 and X_1 of the relay 17 and the windings B_2 and Y_2 of the relay 18 from the ground bus 84.

The engagement of the armature 29 with the contact member 30 completes a circuit from the battery conductor 82 to the ground bus 84 for energizing the winding C of the relay 16. Resistance elements 100 and 101 and a condenser 102 are connected to the circuit completed by the armature 29 through the winding C of the relay 16 for delaying the energization of the winding C. The windings C_1 , Z_1 , C_2 , Z_2 , C_3 , Z_3 , etc. serve to return the relays to normal position. It will be noted that the windings last mentioned for these relays cannot be energized for returning the associated relay to normal position until the preceding relay has been returned to normal position. This insures the release of the relays 16 to 22, inclusive, in a predetermined order. The windings C_2 and Z_2 of the relay 18 are associated with resistance elements 106 and 107 and a condenser 108 which operate similarly to the resistance elements 103 and 104 and the condenser 105. Like resistance elements and condensers are associated with the relays 19, 20 and 21.

Assuming that the speech which has been transmitted through the transmitting channel is stopped, the locking relay S will be held in a released position for a suitable number of seconds by the hangover circuit between such relay and the relay O. During the time the relay S is held in released position by the hangover circuit, the talker at the other end of the line will energize the receiving channel and the potential received by the conductors 70 and 71 will effect en-

ergization of the winding 53 of the relay O and the winding 63 of the relay S. The winding 63 of the relay S, which is polarized, opposed the force of the winding 62 on the armature 64. When the speaker at the opposite end of the line stops talking, the receiving channel releases control of the relays O and S and the hangover circuit will again hold the locking relay S in released position for a limited period until the first speaker has again taken control of the volume control apparatus by energizing the transmitting channel.

In the system above described, the secondary control circuit 49 is operated by a lower volume level than the main control circuit 48. If the volume control apparatus is in any set position, no change in the setting will be effected until the volume level goes below a predetermined point for effecting operation of the relay O in the secondary control circuit or rises above a predetermined point for effecting operation of the relay N in the main control circuit. If the level of the speech current received in the transmitting channel is substantially constant, the level in the channel beyond the potentiometer 4 will be between the levels required to operate the relays O and N in the two control circuits and no hunting on the part of the volume control apparatus will be effected. In volume control apparatus where the control is taken from the transmitting channel beyond the impedance control means, special means such as hereinbefore disclosed must be provided if hunting action is to be prevented.

Modifications in the system and in the arrangement and location of parts may be made within the spirit and scope of the invention and such modifications are intended to be covered by the appended claims.

What is claimed is:

1. In a signal transmission system, a transmitting channel, a potentiometer in the transmitting channel for controlling the volume of the transmitted signals, control means automatically governed according to the volume on said channel for selectively operating said potentiometer to maintain the level of the transmitted signals constant, and means acting on said control means for insuring the holding of said control means in a fixed position for a fixed period variable at will after each setting thereof.

2. In a signal transmission system, a transmitting channel, a potentiometer in the transmitting channel for controlling the volume of the transmitted signals, means comprising relays for controlling said potentiometer, means automatically controlled by changes in level of received signals for selectively operating said relays rapidly to vary the operative position of the potentiometer and maintain the level of transmitted signals constant and

means for insuring the holding said relays in a set position for a limited period after each setting thereof.

3. In a signal transmission system, a signal channel, a potentiometer in said channel, relays for controlling said potentiometer to govern the volume of the signals in said channel, control means automatically governed according to the volume of the signals on said channel for controlling said relays to maintain the volume of the signals substantially constant, and means comprising a condenser shunted by a resistance element for governing said control means to insure the holding of the potentiometer in any set position for a limited period.

4. In a signal transmission system, a transmission channel, a potentiometer divided into sections and included in said channel, relays for controlling said potentiometer sections, resistance elements connected in shunt circuit relation to said potentiometer sections by said relays to prevent opening of the transmission circuit upon operation of said relays, said resistance elements having relatively large impedance as compared to the impedance of the potentiometer sections, and means automatically governed according to the volume on said channel for selectively operating said relays to hold the volume of the transmitted signals substantially constant.

5. In a signal transmission system, a transmitting channel, a potentiometer divided into sections included in the transmitting channel for controlling the volume of the transmitted signals, relays for excluding and placing said potentiometer sections in the transmission circuit in fixed steps, resistance elements connected in shunt to said potentiometer sections across the contact elements of said relays for preventing opening of the channel during operation of the relays, and means automatically governed according to the volume on said channel for operating said relays to hold the volume of the transmitted signals substantially constant.

6. In a signal transmission system, a transmission channel, a potentiometer divided into sections included in the transmitting channel for controlling the volume of the transmitted signals, a thermionic amplifier having the input circuit thereof connected to said potentiometer, a plurality of relays for varying the number of potentiometer sections included in the input circuit of said amplifier, an auxiliary resistance element in shunt across the contact elements of each relay, the impedance of each resistance being relatively high as compared with the impedance of the associated potentiometer section and relatively low as compared with the amplifier input impedance, and means automatically governed according to the volume on said channel for operating said relays to vary the potentiometer sections included in the transmission

channel and hold the volume substantially constant.

7. In a four-wire signal transmission system having transmitting and receiving channels, automatically operated means for controlling the volume of the transmitted signals, means for holding said automatic means in set position for a limited period between transmission peaks, and means operated from the receiving channel by the received impulses for holding said automatic means in the last set position during a receiving period.

8. In a four-wire signal transmission system having transmitting and receiving channels, a potentiometer in the transmitting channel for controlling the volume of the transmitted signals, means comprising automatically operated relays for controlling the potentiometer to govern the transmission level, means for holding said relays in set position for a limited period between transmission peaks, and means operated from the receiving channel by the received impulses for holding said relays in set position through a receiving period.

9. In a signal system, a signal channel, a potentiometer in said channel for controlling the volume of the signals, control means automatically governed according to the volume of signals on said channel for controlling said potentiometer to maintain the volume of the transmitted signals substantially constant, and means acting on said control means for effecting a quick setting of the potentiometer and a slow release from any set position.

10. In a signal system, a transmitting channel, impedance means for controlling the volume of the transmitted signals, control means automatically governed according to the volume on said channel for controlling said impedance means to maintain the volume of the transmitted signals substantially constant, means comprising a condenser shunted by a resistance element for acting on said control means to insure a slow release of the impedance means from any set position.

11. In a signal transmission system, a transmitting channel, impedance varying means comprising a potentiometer divided into sections and a separate relay associated with each potentiometer section for controlling the volume of the transmitted signals, a secondary control circuit operated from said channel for holding said relays in a set position a limited period after operation thereof and for controlling the relays to lower the impedance setting, and a main control circuit operated from the channel by a higher energy lever than the secondary control system for controlling said relays to raise the impedance in said channel in predetermined steps.

12. In a signal transmission system, a transmitting channel, a potentiometer divided into sections and included in said channel, a sepa-

rate relay associated with each potentiometer section for controlling the potentiometer sections included in the channel circuit, and main and secondary control means operated at different energy levels obtaining on the channel beyond said potentiometer for governing said relays to maintain the volume of the transmitted impulses constant and for insuring against hunting action when the incoming energy level is substantially constant.

13. In a signal system, a transmitting channel, impedance means included in said channel for controlling the volume of the transmitted impulses, means comprising a starting control circuit operated from the channel ahead of said impedance means for changing said impedance means from its lowest setting point to its highest setting point when transmission of signals is started, and control means operated by said channel beyond said impedance means for governing said impedance means to maintain the volume of the transmitted impulses substantially constant.

14. In a signal system, a transmitting channel, a potentiometer divided into sections included in said channel for controlling the volume of the transmitted signals, relays for controlling said potentiometer sections, a starting control circuit for operating the first relay to change the potentiometer from its lowest setting point to its highest setting point when signals are first transmitted, a secondary control circuit for holding the operated relays in set position for a limited period, and a main control circuit for selectively operating said relays after the operation of the first relay by the starting circuit to maintain the volume of the transmitted signals substantially constant.

15. In a signal system, a transmitting channel, a potentiometer divided into sections included in said channel for controlling the volume of the transmitted signals, relays for controlling said potentiometer sections, a starting control circuit operated from the channel ahead of said potentiometer for operating the first relay to change the potentiometer from its lowest setting point to its highest setting point when transmission of signals is started, a secondary control circuit operated by the channel beyond said potentiometer for holding the operated relays in set position for a limited period after operation thereof, and a main control circuit for operating the remaining relays after the operation of the first relay to maintain the volume of the transmitted signals substantially constant.

16. In a signal system, a transmitting channel, a potentiometer divided into sections included in said channel for controlling the volume of the transmitted signals, relays for controlling said potentiometer sections, a starting control circuit for operating the first relay to change the potentiometer from

its lowest setting point to its highest setting point when signals are first transmitted, said starting circuit including means for holding the first relay a limited period after operation thereof, a secondary control circuit for holding the operated relays in set position a limited period after operation thereof, and a main control circuit for operating said relays after the operation of the first relay to maintain the volume of the transmitted signals substantially constant.

17. In a signal transmission system, a signal channel, a potentiometer in said channel for controlling the volume of the transmitted signals, said potentiometer being divided into sections, and means comprising relays for controlling said potentiometer sections to maintain the volume of the transmitted signals substantially constant, said relays serving to effect the change in the potentiometer setting when the relay armatures leave the contacts upon which they normally rest.

In witness whereof, I hereunto subscribe my name this 21st day of June, 1929.

ROBERT C. MATHES.

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