

May 29, 1928.

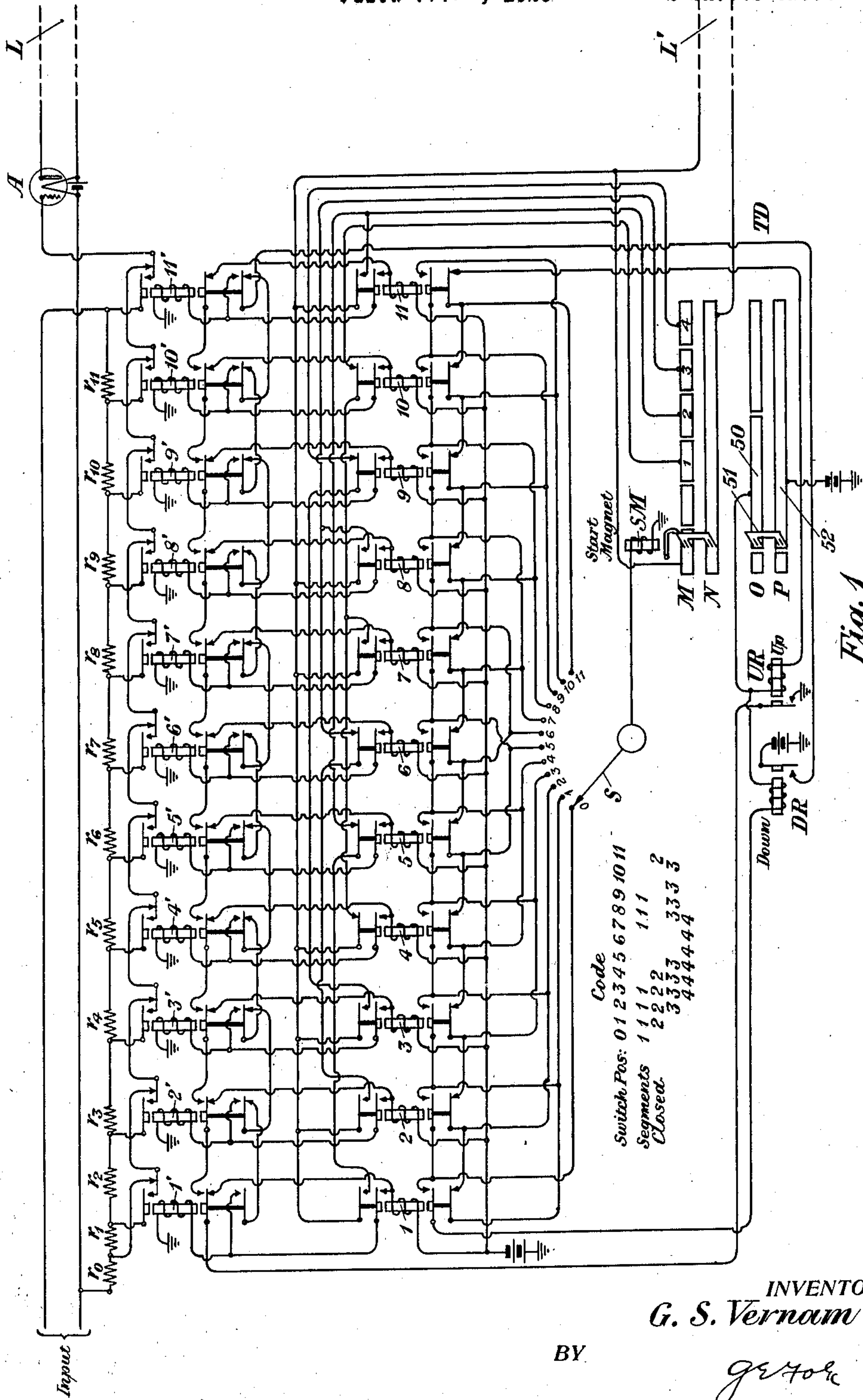
1,671,172

G. S. VERNAM

VOLUME CONTROL APPARATUS

Filed Oct. 1, 1925

2 Sheets-Sheet 1



INVENTOR
G. S. Vernam

BY

Attorney

May 29, 1928.

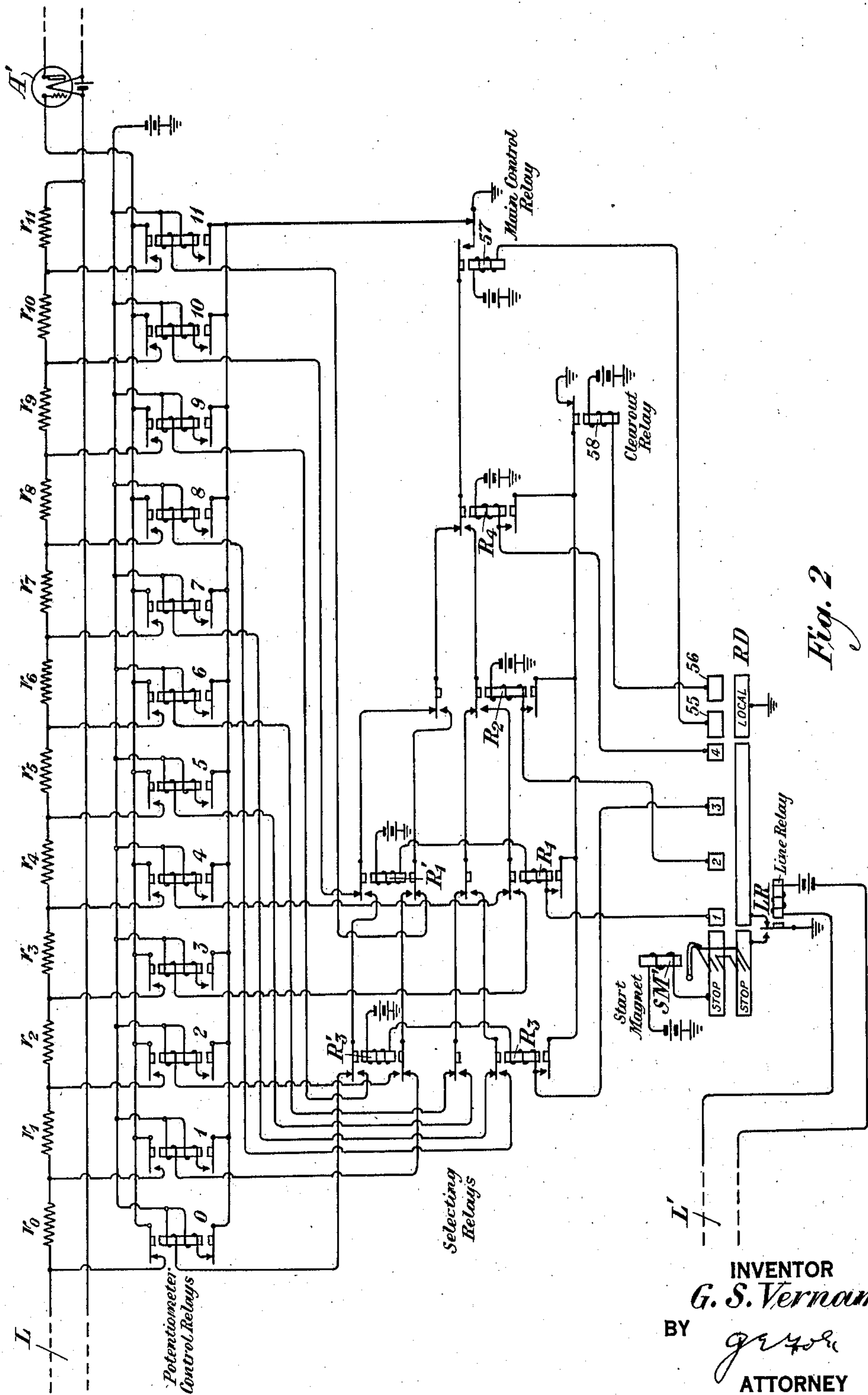
1,671,172

G. S. VERNAM

VOLUME CONTROL APPARATUS

Filed Oct. 1, 1925

2 Sheets-Sheet 2



INVENTOR
G. S. Vernam
BY
G. S. Vernam
ATTORNEY

UNITED STATES PATENT OFFICE.

GILBERT S. VERNAM, OF RIVER EDGE, NEW JERSEY, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

VOLUME-CONTROL APPARATUS.

Application filed October 1, 1925. Serial No. 59,964.

This invention relates to arrangements for controlling the volume of energy transmitted over a signal transmitting circuit, and more particularly to arrangements for effecting a remote control of the volume.

Where programs are to be transmitted either by wire or radio, particularly where a program consists of musical numbers, the range of volume variation which may be transmitted is limited. The volume must not fall below a minimum level because of noise on the circuit, and it may not exceed a maximum level for the reason that it might overload vacuum tube apparatus, such as repeaters included in the circuit. If the range of variation of the volume of the signal is greater than that for which the medium is suitable, it has been proposed to regulate the volume at the transmitting end by means of a potentiometer or the like to bring it within the volume range of the circuit and to make a compensatory adjustment of a similar potentiometer at the receiving end of the system in order to bring the volume as received back to normal. By such an arrangement, the overall gain of the system may be maintained constant and yet the volume actually transmitted may be varied to bring it within the limits of the system, without affecting the range of volume received.

The purpose of the present invention is to provide an arrangement whereby, when the transmitting potentiometer is adjusted, signals may be transmitted to the receiving end to cause the compensating adjustment of the receiving potentiometer. Specifically, the invention comprises an arrangement which identifies each individual adjustment of the transmitting potentiometer and transmits a signal characteristic of any particular setting so that the receiving apparatus may not only respond to the direction of the setting, but also to the particular amount of adjustment regardless of the number of adjusting steps involved.

The invention may be more fully understood from the following description thereof when read in connection with the accompanying drawing, in which Figure 1 is a circuit diagram of the apparatus at the transmitting station, and Fig. 2 is a circuit diagram of the apparatus at the receiving station.

Referring to Fig. 1, which shows the transmitting circuit, it will be seen that the apparatus comprises three principal elements,—first, a potentiometer circuit including resistances R_0 to R_{11} , inclusive, second, a potentiometer control and counting relay circuit comprising adjusting switch S and counting relays 1 to 11, inclusive, and 1' to 11', inclusive, and third, a telegraph signal circuit including a start-stop distributor TD for transmitting code impulses to the telegraph circuit to identify the adjustments made in the potentiometer. The potentiometer is connected in the circuit of vacuum tube amplifier A in the usual manner, so as to regulate the input to the amplifier. The amplifier is, of course, provided at the transmitting end of the transmission circuit L . The counting relays perform the dual function of adjusting the setting of the potentiometer in response to the operation of the control switch S , and of determining the code signal to be transmitted by the start-stop distributor TD to identify at the receiving station the adjustment of the potentiometer at the transmitting station.

The receiving apparatus comprises a similar potentiometer having corresponding resistance elements R_0 to R_{11} , inclusive, said potentiometer being included in the input side of the receiving amplifier A' and relay circuit comprising relays 0 to 11, inclusive, to adjust the setting of the potentiometer. The received signals from the transmitting station are received by a start-stop distributor RD and a pyramid relay circuit is provided by which the various combinations received by the receiving distributor may be set up to control the potentiometer control relays to effect the desired adjustment.

Further details of the apparatus will be clear from a description of the operation which is as follows: Assume that the potentiometer control switch S is in zero position as shown, then all the counting relays are released and the distributor brushes will be held in the normal position. The potentiometer connections to the grid and filament of the amplifier A are then connected across the resistance R_0 , giving the lowest volume control.

Suppose, now, the potentiometer control switch is moved from point 0 to point 2, the

circuit is then closed to operate distributor start magnet SM and the up relay UR. This circuit may be traced from ground through the winding of the magnet SM over the arm of switch S, contact 2 of said switch, lower back contact of relay 2, and corresponding lower contacts of relays 3 to 11, inclusive, and thence through the winding of the up relay UR, segment 50, brush 51 and ring 52 of the distributor to battery. The start magnet is operated and releases the brush arm to allow it to rotate one revolution. The up relay is energized at the same time and closes a circuit to operate the counting relay 1. This circuit may be traced from ground through the front contact and armature of the up relay UR, inner lower back contact of the counting relay 1' and through the winding of counting relay 1 to battery.

Counting relay 1, upon being operated, at its outer upper contact closes a circuit to change the selection previously set up on the segments of the M ring of the distributor, so that as the brush passes over segments 1 and 2, the telegraph loop will be closed. Referring to the insert on Fig. 1, showing the code, it will be seen that in the normal condition of the circuit, with the switch S on the zero contact, a connection is established from the upper conductor of the line L' to the first segment of the distributor over the upper normal contact of relay 4. Counting relay 1, upon being operated, closes an addition connection, as already described, to the segment 2. The various code combinations corresponding with the different settings of the switch, as given in the chart, may be traced in an obvious manner and need not be described in further detail.

In the normal condition of the line L₁, when the start-stop distributor is at rest, the line circuit is maintained closed over the first segment of the ring M and over the brush of the distributor and the ring N of the distributor, so that the receiving line relay LR is maintained energized. As soon as the brush is released by the starting magnet SM, it passes on to the second or open segment of the ring M of the distributor, and transmits an open circuit impulse to the line relay to release the start magnet of the receiver RD, as will be described later. The counting relay 1 having changed the code setting to that corresponding to position number 1 of the switch, a code consisting of closed circuit impulses for the first two units of the code, and open circuit impulses corresponding to the last two units of the code, are transmitted to the line L₁.

Returning, again, to the counting relays 1 and 1', counting relay 1 at its inner lower front contact, prepares a circuit for the down relay DR, which, however, is not completed at this time. By opening its outer lower

contact, it opens the circuit to the first contact of the switch S. This is also without effect, as the switch arm is not resting upon the first segment at this time. At its inner upper front contact, relay 1 completes a locking circuit for its own winding through the winding of the counting relay 1'. The latter relay will not operate as its winding is short circuit by the ground at the contact of relay UR. When relay UR releases, as described later, relay 1' will be energized in series with relay 1, and then at its inner lower front contact, relay 1' transfers the circuit to ground at the contact of the up relay UR to the counting relay 2', and at its outer lower front contact, relay 1' prepares a down circuit to be controlled by the down relay DR whenever the switch S is adjusted for a downward setting, as will be described later. At its upper front contact, counting relay 1' changes the setting of the potentiometer so that the input side of the amplifier A is bridged across resistances R₀ and R₁ in series. This increases the gain of the amplifier one step.

In the meantime, the sending distributor has transmitted the code combination set up to the receiving station over the line L'. As soon as the brush 51 of the distributor passed from the segment 50, the up relay UR was released, thereby permitting relay 1' to operate as previously described. The brush finally comes to rest against the pawl of the start magnet SM, the start magnet having been deenergized at the same time that the circuit of the relay UR was opened when the brush 51 passed from the segment 50. As soon as the brush comes to rest, however, after completing its revolution, the brush 51 again completes, over the segment 50 and the ring 52, the circuit previously traced for the start magnet SM and the up relay UR. The start magnet at once releases the brush for a second rotation, and the up relay UR connects ground over the inner lower back contact of the counting relay 2' to the winding of counting relay 2, energizing the latter counting relay. Counting relay 2, upon being energized, changes the code combination so that segments 1, 2 and 3 of the ring M are connected to the line L'. Said relay 2 also opens the connection to the second contact of the switch S so that when the brush arm comes to rest after the second revolution, the circuit of the start magnet SM and the up relay UR will not again be completed, and the transmission of signals will cease. Relay 2 also completes the circuit for the counting relay 2' in a manner similar to that described for counting relay 1'. This results in connecting the grid of the vacuum tube A to the terminal of the resistance r₂ instead of to the terminal of the resistance r₁. When the distributor comes to rest after having transmitted the code

combination, the circuit remains with the counting relays 1, 1' and 2, 2' energized to hold the potentiometer in its adjusted setting until the switch S_1 is adjusted to some other position.

It will be observed that when the switch S is adjusted to any setting higher than its previous setting, the counting relays are operated successively, and as each group of counting relays is actuated, a code combination corresponding to that group is transmitted. Each code combination transmitted, therefore, corresponds to a momentary setting of the potentiometer, and results, as will be described later, in a corresponding step-by-step setting of the potentiometer at the receiving station. All of the code combinations corresponding to the settings between the original setting and the setting to which the switch is adjusted are transmitted one after the other until the final setting represented by the shifted position of the switch S has been transmitted.

Two code combinations were transmitted as a result of shifting the switch S . The first combination consisted of marking impulses for the first and second units of the combination, and the second combination consisted of the marking impulses for the first three units, with a spacing impulse for the last unit. Each combination is followed by a closed circuit condition as the distributor comes to rest, this condition being the normal condition of the circuit, and each combination is preceded by an open circuit impulse, which is for the purpose of releasing the receiving distributor.

As soon as the first open circuit impulse occurs, the line relay LR (Fig. 2) releases and completes a circuit for the start magnet SM' at the receiving station. The start magnet releases the distributor arm so that the brush passes over the segments 1, 2, 3 and 4 at the same time that the signals are received over the line L resulting from the fact that the brush of the sending distributor is passing over the corresponding segments 1, 2, 3 and 4 at the sending station. Normally, the counting relays are all deenergized, as shown in the diagram, except the zero counting relay which is locked up as a result of some previous adjustment of the sending switch to its zero contact. The locking circuit extends through the lower winding and lower front contact of the zero counting relay and over the normal contact of the main control relay 57. The grid and filament of the amplifier A' are thus connected across the terminals of all resistances r_0 to r_{11} in series, this corresponding to the condition of maximum gain.

As a marking impulse arrives at the time the brush is passing over the segment 1 of the distributor RD, the circuit is completed from the front contact of the line relay LR

over the brush of the distributor and through the pyramid relays R_1 and R_1' to battery. The second impulse is also a closed impulse and completes a circuit for the pyramid relay R_2 . The third and fourth impulses are open circuit impulses and are without effect. Just after the brush of the receiving distributor leaves its fourth segment, it passes over the segment 55, completing a local circuit for the main control relay 57. This relay completes a circuit from ground over its front contact, over the upper back contact of relay R_4 , upper front contact of relay R_2 , lower front contact of relay R_1' and lower back contact of relay R_3' through the upper winding of the potentiometer control relay 1 to battery. The circuit thus traced causes the energization of the potentiometer control relay 1, which at its upper contact connects the grid of the amplifier between the resistance r_0 and r_1 , so that the grid and filament are bridged across all of the resistance elements of the potentiometer, except the resistance r_0 . At its lower front contact, relay 1 prepares a locking circuit through its lower winding, said locking circuit being controlled by the contacts of relay 57. The contacts of relay 57 are of the make-before-break type, and just after the initial energizing circuit of the relay 1 is closed, as above described, the relay 57 opens its normal contact and removes the ground from the locking windings of all of the potentiometer control relays, thereby releasing the relay 0. The relay 1 is therefore energized before the relay 0 is released, so that there is no possibility of momentarily disabling the amplifier.

As the brush arm leaves the segment 55, relay 57 is deenergized and opens the initial energizing circuit for the relay 1. The normal contact of relay 57 is, however, closed before the other contact is opened, so that the locking circuit already described is completed through the lower winding of the relay 1. As the brush arm passes over the segment 56, a circuit is completed for the clear-out relay 58, which unlocks all of the pyramid relays which have been previously energized, so that the pyramid relays are ready to receive another selection.

Upon receiving the second code combination, pyramid relays R_1 , R_1' , R_2 , R_3 and R_3' are energized in response to the first three closed circuit impulses. The relay 57 then completes the circuit prepared by the pyramid relays for the potentiometer control relay 2, and immediately afterward, releases the potentiometer control relay 1, thus reducing the gain an additional step. Relay 2 is locked up in the same manner as described in connection with the relay 1, and the clear-out relay 58 is then energized to restore the pyramid relays to normal. The

potentiometer remains as now adjusted until the switch arm S at the transmitting station is shifted to a new position.

Suppose, now, the switch arm S should be shifted back from its second contact to its zero contact, a circuit is at once closed from ground to the start magnet SM, over the switch arm of the switch S and the zero contact of said switch, over the inner lower front contact of counting relay 1, through the winding of the down relay DR and over the segment 50, brush 51 and ring 52 of the distributor TD to battery. The distributor is at once released and transmits the open circuit start impulse to the line L'. At the same time, the down relay DR closes a circuit from battery over its front contact, over the outermost lower back contacts of counting relays 11' to 3', inclusive, and thence over the outermost lower front contact of the counting relay 2', through the winding of the counting relay 2' to ground. This short-circuits the counting relay 2, which is at once released, but the counting relay 2' remains energized. Relay 2, at its upper contact, breaks the connection previously traced to the third segment of the ring M of the distributor, thereby changing the code combination set up from one involving marking impulses for the first three units to one involving marking impulses for only the first two units. As the distributor continues to rotate, the changed code combination is now transmitted to the receiving station over the line L'.

In the meantime, the brush 51 passes from the segment 50, thereby releasing the down relay DR. This disconnects the battery which was previously traced to the circuit of the counting relay 2', so that said counting relay is released. At its upper contact, the counting relay 2' connects the grid of the amplifier A to the upper front contact of the counting relay 1', and thence to the right-hand terminal of resistance r_1 , thus decreasing the gain one step.

After the distributor completes its revolution and comes to rest, the circuit for the start magnet SM and the down relay DR is again completed, as previously traced via the segment 50 and brush 51. The distributor is then released for its second rotation, and the down relay DR connects battery over its front contact and over the lower back contacts of all of the relays 11' to 2', inclusive, and thence over the lower front contact of counting relay 1' to the junction point between the windings of the relays 1 and 1'. Counting relay 1 is short circuited and released, but counting relay 1' still remains energized. The release of counting relay 1 changes the code combination to be transmitted from one involving two closed circuit impulses corresponding to the first two units to one involving a closed circuit

impulse for the first unit only. This code combination corresponds to the zero position of the switch, and is transmitted by the distributor as it rotates. In the meantime, the brush arm 51 passes from the segment 50 and releases the down relay DR, thereby removing battery from the winding relay 1' and releasing said relay. This results in connecting the grid of the amplifier A to the junction between resistances r_0 and r_1 , this setting corresponding to minimum gain. When the distributor comes to rest after having transmitted the code combination, it remains at rest for the reason that the release of counting relay 1 opened the circuit for its start magnet and the down relay DR.

At the receiving station, the first code combination energizes the pyramid relays R_1 , R_1' and R_2 , thereby completing an energizing circuit for the potentiometer control relay 1 upon the energization of the main control relay 57, and immediately thereafter releasing the potentiometer control relay 2. When the relay 57 is released, the relay 1 is locked up and thereafter the clear-out relay 58 is actuated to restore the pyramid relays to normal. The last code combination actuates only the pyramid relays R_1 and R_1' . When the main control relay 57 is energized, the circuit of the zero relay is completed, and relay 1 is released. As soon as the main control relay releases, the relay zero is locked up and remains locked up until the switch arm S at the transmitting station is again changed. The potentiometer is now set for maximum gain at the receiver. The clear-out relay 58 is actuated as before to restore the pyramid relays to normal.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated, without departing from the spirit of the invention, as defined in the following claims.

What is claimed is:

1. A volume control system comprising a potentiometer at the transmitting station and a potentiometer at the receiving station, means to adjust one of said potentiometers and means to operate in response to the adjustment of said last mentioned potentiometer over a plurality of steps to transmit signals characteristically different for each step of adjustment to the other station, and means at said other station to adjust the potentiometer thereat in response to said signals.

2. A volume control system comprising a potentiometer at the transmitting station and a potentiometer at the receiving station, means to adjust the potentiometer at one of said stations, means at said last mentioned station responsive to the adjustment of the potentiometer thereat over a plurality of steps to successively transmit a plurality of

code combinations, one individual to each step of adjustment, and means at the other station responsive to said code combinations to adjust the potentiometer thereat step by step in correspondence to the adjustment at the first station.

3. A volume control system comprising a potentiometer at the transmitting station and a potentiometer at the receiving station, means at one of said stations to adjust the potentiometer thereat, a rotary distributor at said station to transmit code combinations in response to an adjustment of said potentiometer over a plurality of steps to transmit a plurality of code combinations in succession, said code combinations being characteristic of the various steps over which the potentiometer is adjusted, a rotary distributor at the other station, and selective devices controlled by said rotary distributor in response to the code combinations to produce a step-by-step adjustment of the potenti-

ometer at the other station in correspondence to the adjustment at the first station.

4. A volume control system comprising a potentiometer at the transmitting station and a potentiometer at the receiving station, means to adjust the potentiometer at one of said stations, a rotary distributor responsive to an adjustment of the potentiometer at said last mentioned station to transmit a code combination characteristic of the position to which said potentiometer is adjusted, a rotary distributor at the other station, a selective arrangement at said station controlled by said rotary distributor and responsive to said code combination to produce a similar adjustment of the potentiometer at said second station.

In testimony whereof, I have signed my name to this specification this 29th day of September, 1925.

GILBERT S. VERNAM.