April 12, 1932. D. MITCHELL 1,853,070

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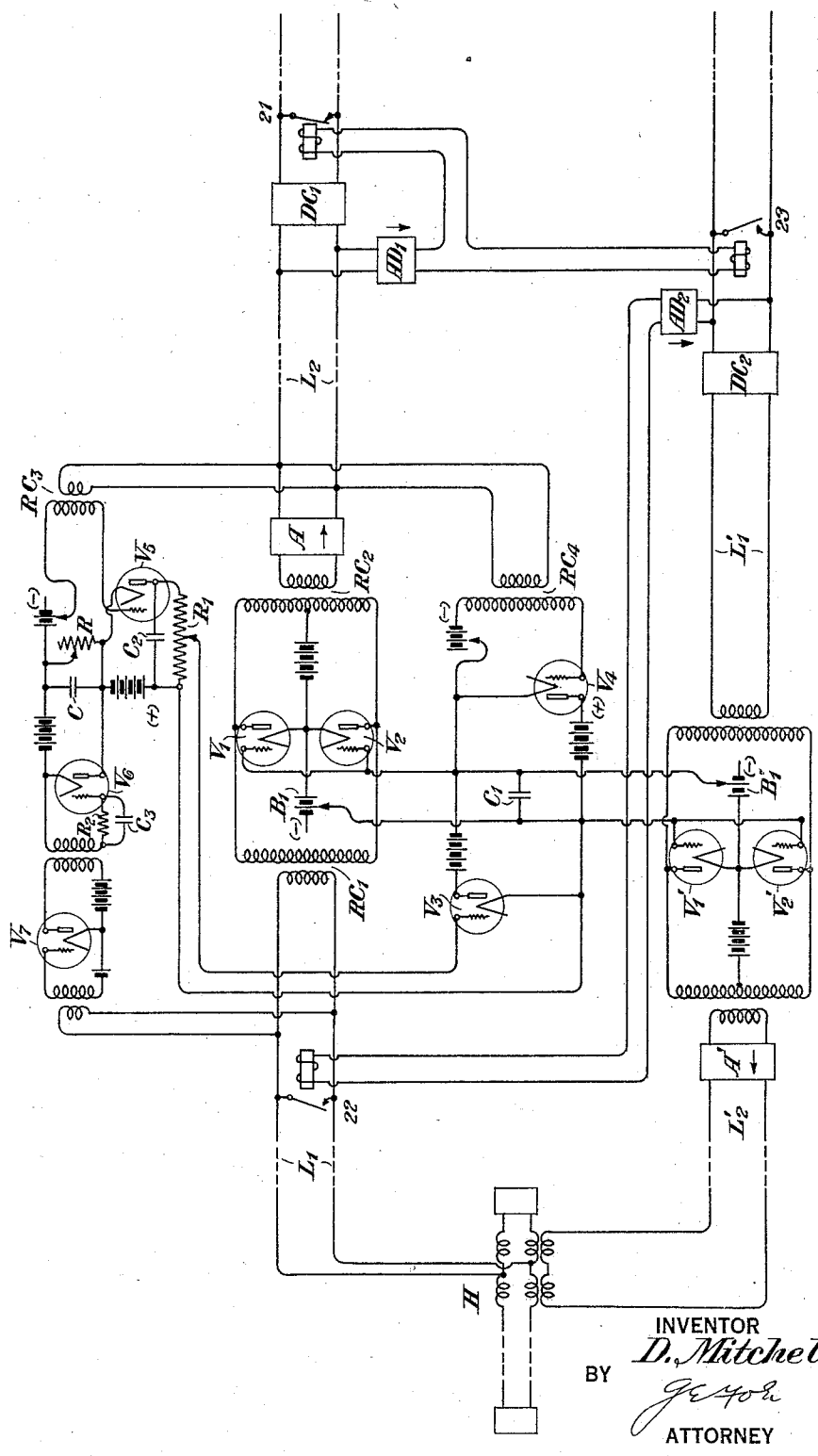
Filed Dec. 29, 1928



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Patented Apr. 12, 1932 1,853,070

UNITED STATES PATENT OFFICE

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EQUALIZATION OF POWER LEVEL IN A SIGNAL TRANSMITTING SYSTEM

Application filed December 29, 1928. Serial No. 329,203.

An object of my invention is to provide for automatic adjustment of the volume or power level in a signal transmitting system. Another object of my invention is to provide means at a certain point in a signal transmitting system to effect adjustment of a condenser charge applied so as to correct a tendency for the signals to depart from a desired power level at that point. Another object of my invention is to provide for keeping the power level adjuster to a desired standard value in a telephone transmission system. In one aspect, a device according to my invention operates by virtue of the power in the signaling currents and thereby adjustment of a suitably connected condenser is effected to hold the power level at a desired value. My invention may be practiced by means of three-electrode vacuum tubes without the use of relays having make-and-break contacts.

The accompanying drawing is a diagrammatic representation showing an example of the practice of my invention. It will be understood that the following specification relates principally to this particular example of the invention and that its scope will be indicated in the appended claims.

Referring to the drawing, this shows a four-wire telephone system which may be a link connecting with a two-way radio telephone system. Transmission from west to east is over the line L_1 through the amplifier A and on over the line L_2. Transmission from east to west is similarly through the line L'_1, amplifier A' and line L'_2. The amplifiers A and A' constitute a four-wire repeater.

The system shown in the drawing tests the power level on the output side of the amplifier A and shunts more or less of the energy passing from L_1 to L_2 so as to correct for a departure from a proper standard value in the energy level at the output of the amplifier A.

It will be seen that the two vacuum tubes V_1 and V_2 afford a shunt path across the line L_1—L_2, and the adjustment referred to is made by varying the dynamic impedance of the shunt path through these two tubes, as will be explained farther along in this specification. For reasons which will appear, a reverse adjustment is made in a corresponding shunt in the line L'_1—L'_2.

The four-wire system shown in the drawing is arranged so that transmission in one direction cuts off the system for transmission in the opposite direction, and vice versa. Thus objectionable echo effects are prevented. Normally, the line L_1—L_2 is short-circuited at 21 so that the system stands in readiness only for transmission from east to west. When transmission from east to west occurs, a little of the voice current energy goes by a branch circuit to the amplifying detector AD_2 which operates a relay to short-circuit the line L_1—L_2 at 22. The delay circuit DC_2 gives assurance that the relay 22 will be operated before energy from east to west can get around and operate the amplifying detector AD_1; a path for such energy might be afforded by some degree of unbalance at the three-winding transformer or hybrid coil H.

When voice currents are put on the system from west to east, they operate the amplifying detector AD_1 and operate both relays at 21 and 23, thus short-circuiting the line from east to west at 23, and opening the short-circuit from west to east at 21. The delay circuit DC, gives assurance that the short-circuit at 21 will be opened before the voice currents reach this point on their way from west to east on the line L_2.

Proceeding from west to east along the line L_1—L_2, the repeating coil RC_1 gives a high ratio step up and the repeating coil RC_2 gives an equal ratio step down. Hence, between these two coils the circuit is of high impedance. Normally, direct currents are flowing in the plate circuits of the two vacuum tubes V_1 and V_2, and the path from plate to filament in V_1 and from filament to plate in V_2 is a high impedance shunt path across the two sides of the line between the two repeating coils RC_1 and RC_2. The shunt impedance here in view is a dynamic impedance and is the ratio of voltage increment to current increment. This ratio is the slope on the volt-ampere characteristic of the tubes V_1 and V_2, which is of varying slope along its length.

The point of this characteristic that is involved is determined by the voltage on the grids of the tubes V_1 and V_2, and this is determined by the charge on the condenser C_1.

Normally, there will be no charge on the condenser C_1. This condenser might receive a charge in the plate circuit of either tube V_3 or V_4, but the grid of the tube V_4 is at such a negative value that no condenser charging current will flow in the plate circuit of V_4. Also, as will be shown presently, there is a potential drop in the resistance R_1 that puts a sufficient negative voltage on the grid of the tube V_3 to prevent any charging of the condenser C_1 in the plate circuit of that tube.

Normally, a considerable current is flowing in the plate circuit of the tube V_5 and this gives the potential drop in the resistance R_1 that was mentioned above. Although the grid battery for the tube V_5 is negative, its electromotive force is counter-balanced in the grid circuit by an opposite potential drop along the resistance R due to current flowing in the plate circuit of the tube V_6.

This is the normal condition for the apparatus mentioned in the foregoing description. Now, suppose voice currents come from the west over the line L_1—L_2. These currents are amplified in the tube V_7 and affect the detector tube V_6. Due to the blocking condenser C_3 and resistance R_2 in the grid circuit of the tube V_6, their only action is to reduce the plate current of the tube V_6. This allows the condenser C to discharge and reduces the potenial drop through the resistance R, thus permittting the grid circuit battery of the tube V_5 to become effective.

The tubes V_6 and V_7 and the transformers between the line L_1 and the tube V_7 and between the two tubes are so chosen that the discharge of the condenser C can be just brought about by the peaks of speech current from the weakest voice for which the system is designed to operate, but not by the noise currents normally present. Stronger voice waves can produce no greater change than this because the space current of tube V_6 cannot become negative. The change of potential of the grid of the vacuum tube V_5, due to the removal of the drop in the resistance R due to the space current of tube V_6, thus occurs suddenly on the arrival of speech waves but is substantially independent of the magnitude of these waves.

But the voice currents from amplifier A to line L_2 go through the repeating coil RC_3 into the grid circuit of the tube V_5 and affect the tube V_5 as a detector and counteract the effect of the negative battery in the grid circuit mentioned in the preceding paragraph.

Thus, if the power level is correct at the output from the amplifier A, and if adjustments have been made accordingly, removal of potential drop across the resistance R will be counter-balanced in the grid circuit of the tube V_5 by the impulses received through the repeating coil RC_3, and the current in the plate circuit of the tube V_5 will remain unchanged. Thus, there will be no tendency for the condenser C_1 to become charged by current in the plate circuit of the tube V_3.

The adjustment of the plate circuit battery of the tube V_4 is such that currents in the repeating coil RC_4, due to a normal power level at the output of amplifier A, will not be sufficient to overcome the negative bias on the grid of the tube V_4, and therefore the condenser C_1 will not tend to charge by current in the plate circuit of the tube V_4.

Now, suppose the power level is too low at the output of amplifier A, as, for example, if the speaker at the station on the west speaks in too low a voice. The result will be a subnormal transfer of energy into the grid circuit of the tube V_5 through the repeating coil RC_3; accordingly, the grid battery for that tube will put higher negative potential on the grid, and the plate circuit current in the resistance R_1 will be decreased, thus cutting down potential in the grid of the tube V_3 and permitting a charging current for the condenser C_1 to flow in its plate circuit. The condenser C_1 will charge slowly. This will make the grids of the tubes V_1 and V_2 more negative and increase the dynamic impedance in the shunt branch through the two tubes V_1 and V_2 in series. Hence, more of the speech current energy on the line will be transmitted through the repeating coil RC_2 into the amplifier A, and the tendency of a low power level on the output side of this amplifier A will be corrected.

On the other hand, suppose the power level on the output side of the amplifier A is too high, this will have no effect in the plate circuit of the tube V_5, but will operate on the tube V_4 as a detector through the repeating coil RC_4, and accordingly a current will flow in the plate circuit of the tube V_4 and charge the condenser C_1 slowly in a direction to take negative potential off the grids of the tubes V_1 and V_2. This will lower the impedance of the shunt through the tubes V_1 and V_2 and hence more of the voice current energy coming in over the line L_1 will be shunted and less will go through the repeating coil RC_2 into the amplifier A, and thus a compensatory adjustment will be effected on the output side of the amplifier A.

The line from east to west, from L'_1 through the amplifier A' to L'_2 has a high impedance section like the line the other way, with two tubes V'_1 and V'_2 corresponding to V_1 and V_2. In the line L_1—L_2, we have seen that adjustment is effected by varying the potential on the grids of the tubes V_1 and V_2. It will be seen at once from the

drawing that any variation of this potential on the grids of tubes V_1 and V_2 means an opposite variation of the potential on the grids of the tubes V'_1 and V'_2. The result is that whenever the over-all amplification is raised or lowered from L_1 to L_2, then the over-all amplification from L'_1 to L'_2 is lowered or raised accordingly. In this respect, the system works as follows. If the person at the west end stops talking, the shunt at 23 will open after the lapse of a certain hang-over interval. Suppose that at once voice currents come from east. Due to the likelihood of some degree of unbalance at H, some of the energy of these voice currents will get into the line L_1, and with high over-all amplification from L_1 to L_2, there would be a tendency to diversion of energy through AD_1 and an undesirable operation of relays 21 and 23. But when there is high over-all amplification from L_1 to L_2, there will be low over-all amplification from L'_1 to L'_2, and thus the tendency to cause such false operation will be counteracted.

It will be understood that all impedance elements, batteries, etc. are adjustable; certain of these for which adjustment is most important have the adjustability indicated diagrammatically in the drawing.

It may be noticed that with suitable adjustment of the apparatus shown in the drawing no action will take place when correct volume is being delivered at the output from the amplifier A. The proper adjustments involve certain time constants and the relative gains in the system. According to these adjustmnts, when any speech whatever is going through the system from west to east the tube V_6 will be blocked, thus tending to interrupt the plate current in the tube V_5 and permitting the charging current to flow in the plate circuit of the tube V_3 to the condenser C_1. However, the condition for correct volume is that the speech current impulses operating in the grid circuit of the tube V_5 through the repeating coil RC_3 shall be just strong enough to overcome the grid bias so that the current in the plate circuit of the tube V_5 shall be maintained and keep a potential drop through the resistance R_1, and thus prevent the flow of a charging current for the condenser C_1 in the plate circuit of the tube V_3. A further condition for correct volume is that energy delivered to the grid circuit of tube V_4 through the repeating coil RC_4 shall be too weak to overcome the effect of the grid battery for the tube V_4, and hence no charging current for the condenser C_1 will flow in the plate circuit of the tube V_4. If these adjustments are properly made no action of the device will take place for speech currents of correct volume.

As to the time actions, the measure of the capacity of the condenser C_1 determines the speed with which regulation is accomplished. If the volume departs from standard by a large amount the initial regulation will take place faster than if the volume departs to a less degree. This advantageous feature of operation is due to the fact that the impedance through which the condenser will charge will be less if the volume departs from the standard by a large amount than if it departs by a small amount.

The system shown in the drawing is "back acting"; this means that regulation is accomplished by the use of energy taken from the point at which standard volume is desired, that is, at the output from the amplifier A, and adjustment to preserve constancy of volume occurs when the volume at this point tends to change.

The system shown in the drawing is also "full neutral", that is, it does not regulate unless speech currents (or currents due to interference, for example) are entering the system, but the system stays at the gain last set until such currents again enter the sytem, or until the charge on condener C_1 has slowly leaked away.

However, by changing the grid bias on either of the tubes V_3 or V_4 it is easy to make these tubes draw a slight plate current under normal conditions and thus cause the device to creep back to a predetermined setting. For this purpose the principal adjustments will be made at the resistance R_1 and at the grid battery of the tube V_4. In this way the system can be made to assume a desired adjustment of normal gain after the end of any conversation.

I claim:

1. In the transmission of signals by electric currents, the method of adjusting over-all gain at an amplifier which consists in shunting part of the current adjacent to the amplifier through a vacuum tube, varying its grid potential to adjust the proportion of the current shunted through the tube and effecting the variation of said grid potential by varying the charge on a condenser in accordance with the output from said amplifier.

2. In the transmission of signals by electric currents over a pair of conductors, the method of adjusting loss or gain which consists in stepping the voltage up over a short stretch of the conductor pair and then down, and in this short stretch shunting part of the current through a vacuum tube, and varying its impedance by varying its grid potential to adjust the proportion of the current shunted to that transmitted.

3. In a four-wire two-way signal transmitting system, vacuum tube shunts for each pair of wires and means to change the grid potentials in opposite directions for the two shunts to increase or decrease the impedance of one shunt and simultaneously decrease or increase the impedance of the other shunt.

4. In a four-wire two-way signal transmit-

ting system, means for cutting off transmission one way while it occurs the other way, amplifiers respectively for the two ways, vacuum tube shunts respectively on the two pairs of the four-wire system, and means to increase the grid potential in one such shunt and simultaneously decrease it in the other so that as the over-all amplification for one pair is increased or decreased, the over-all amplification for the other pair will be simultaneously decreased or increased.

5. A conductor pair for transmitting signals, step-up and step-down transformers to increase the impedance between them, a vacuum tube shunt across the pair between these transformers and means to vary the grid potential in this shunt to adjust the shunt impedance and thereby adjust the proportion of current that is shunted to the proportion transmitted.

6. A signal transmitting circuit comprising a pair of conductors, a vacum tube shunt across the conductors, means to test the amplitude of the signaling current on the output side of said shunt, and means operated thereby to adjust the grid potential of the vacuum tube to compensate for changes of power level acording to the test.

7. In a four-wire two-way signal transmitting system, vacuum tube shunts across each pair of wires, means to test the power level on the output side of one such shunt, and means to adjust the grid potentials of the vacuum tubes to compensate a tendency to change the power level for the pair on which it is tested and to effect an opposite change in the power level in the other pair.

8. In a four-wire two-way signal transmitting system, means to cut off transmission one way when it is in course the other way comprising amplifiers respective to the two ways of transmission, two vacuum tube shunts, one associated with each amplifier, means to test the power level on the output side of one amplifier, and means to adjust the grid potentials in said vacuum tubes shunts thereby so as to keep the power level at the point of test substantially constant but to vary the power level by opposite adjustment in the other pair of the system.

9. In a four-wire two-way signal transmitting system, a voice operated detector-amplifier set to block transmission one way on one pair of wires when signal transmission the other way on the other pairs is in progress, vacuum tube shunts for each pair of wires and means to change the grid potentials in opposite directions for the two shunts to increase or decrease the impedance of one shunt and simultaneously decrease or increase the impedance of the other shunt.

In testimony whereof, I have signed my name to this specification this 28th day of December, 1928.

DOREN MITCHELL.