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A. L. MATTE
SYSTEM FOR TESTING AND ADJUSTING ENERGY
LEVELS IN THE TRANSMISSION OF SIGNALS
Filed Dec. 24, 1928

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3 Sheets-Sheet 1

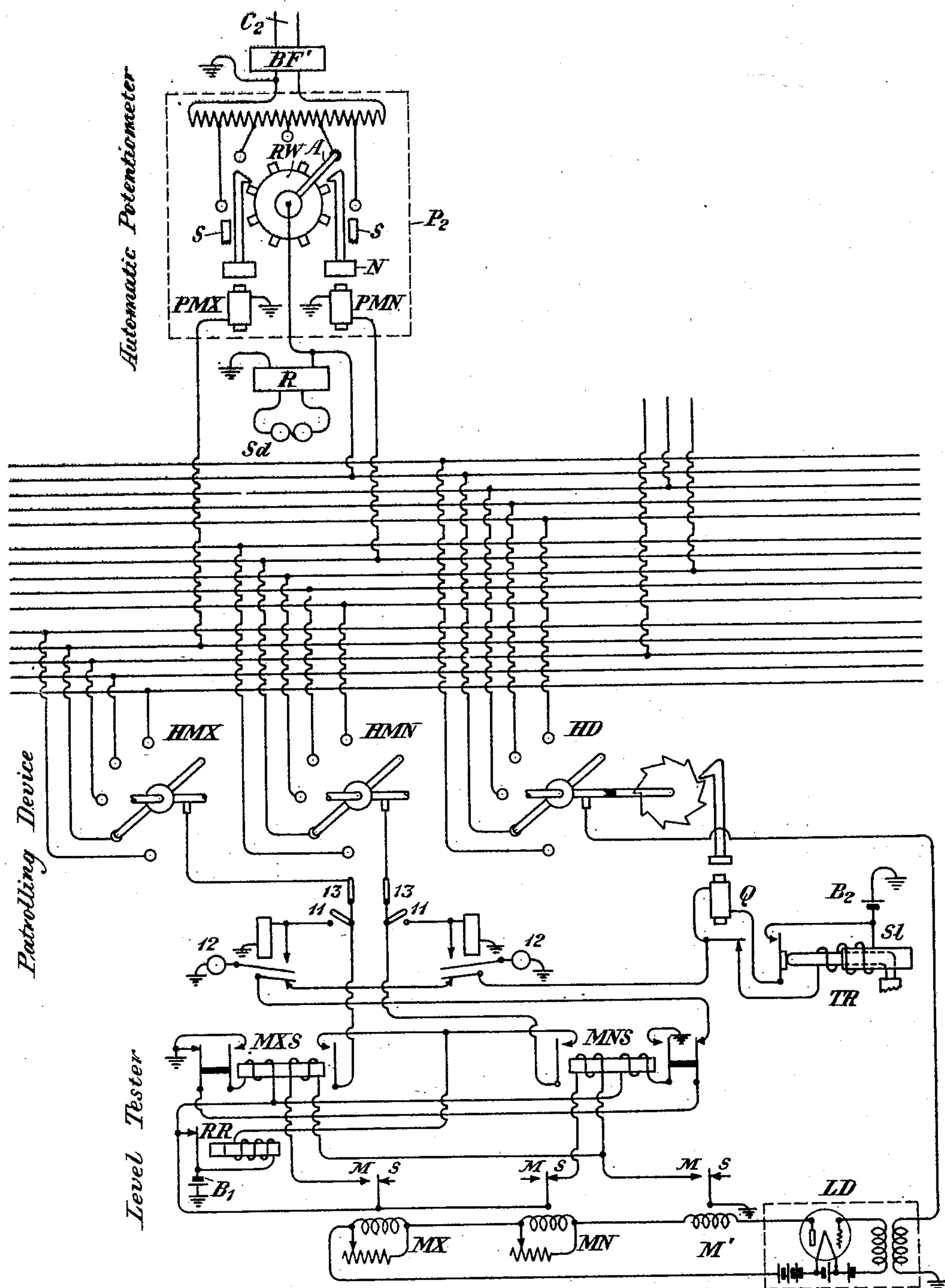


Fig. 1

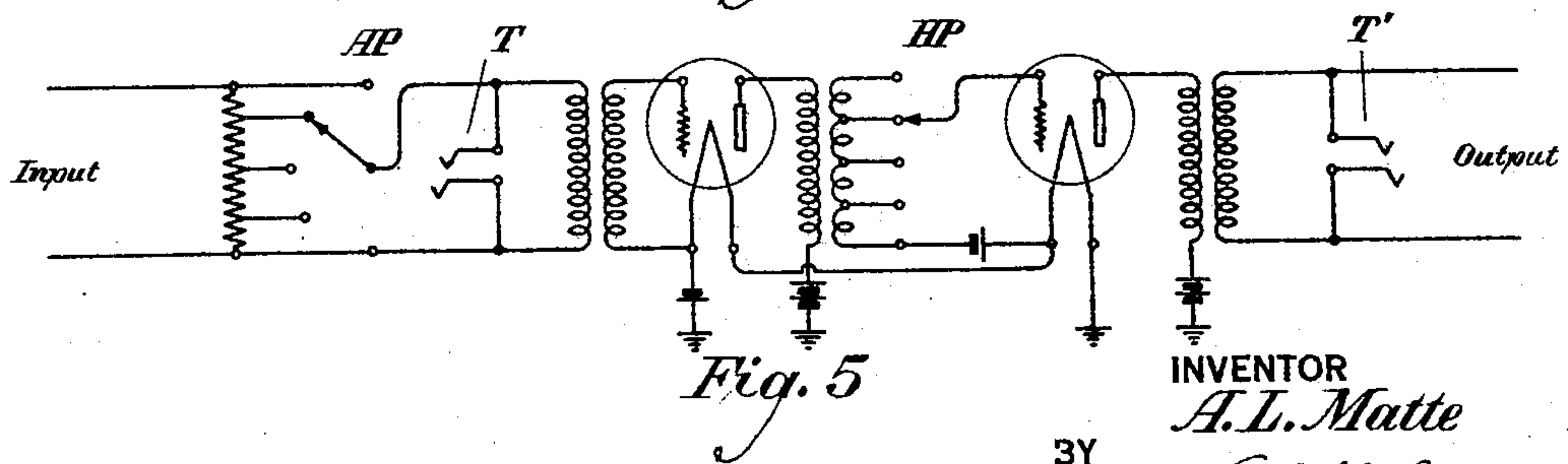
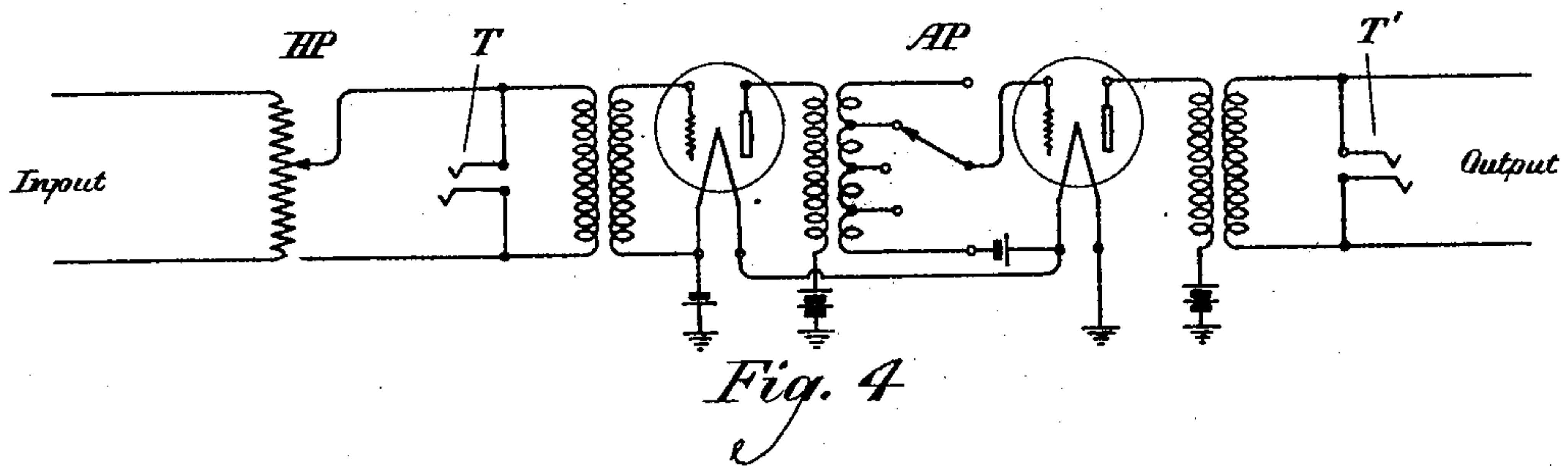
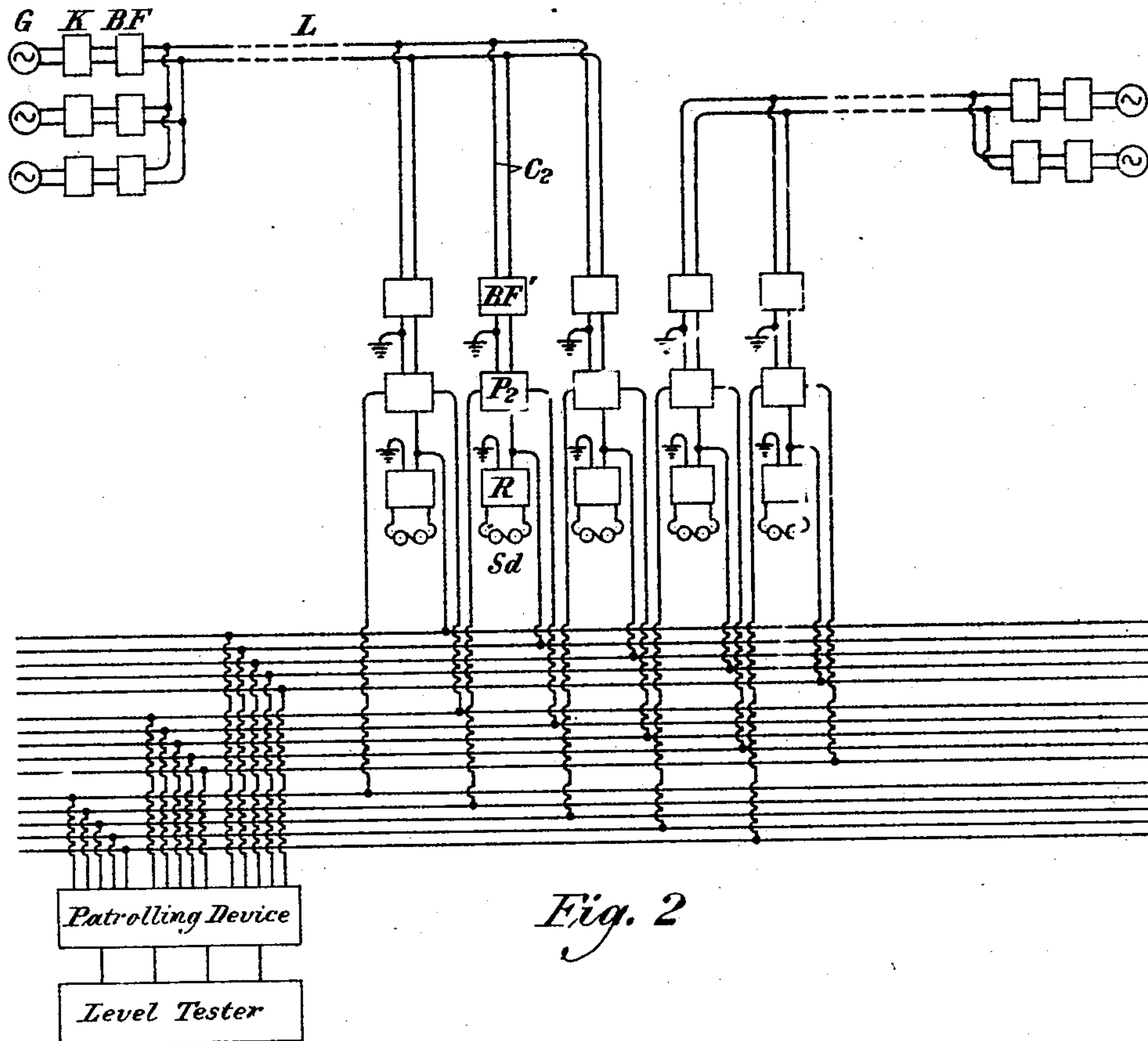
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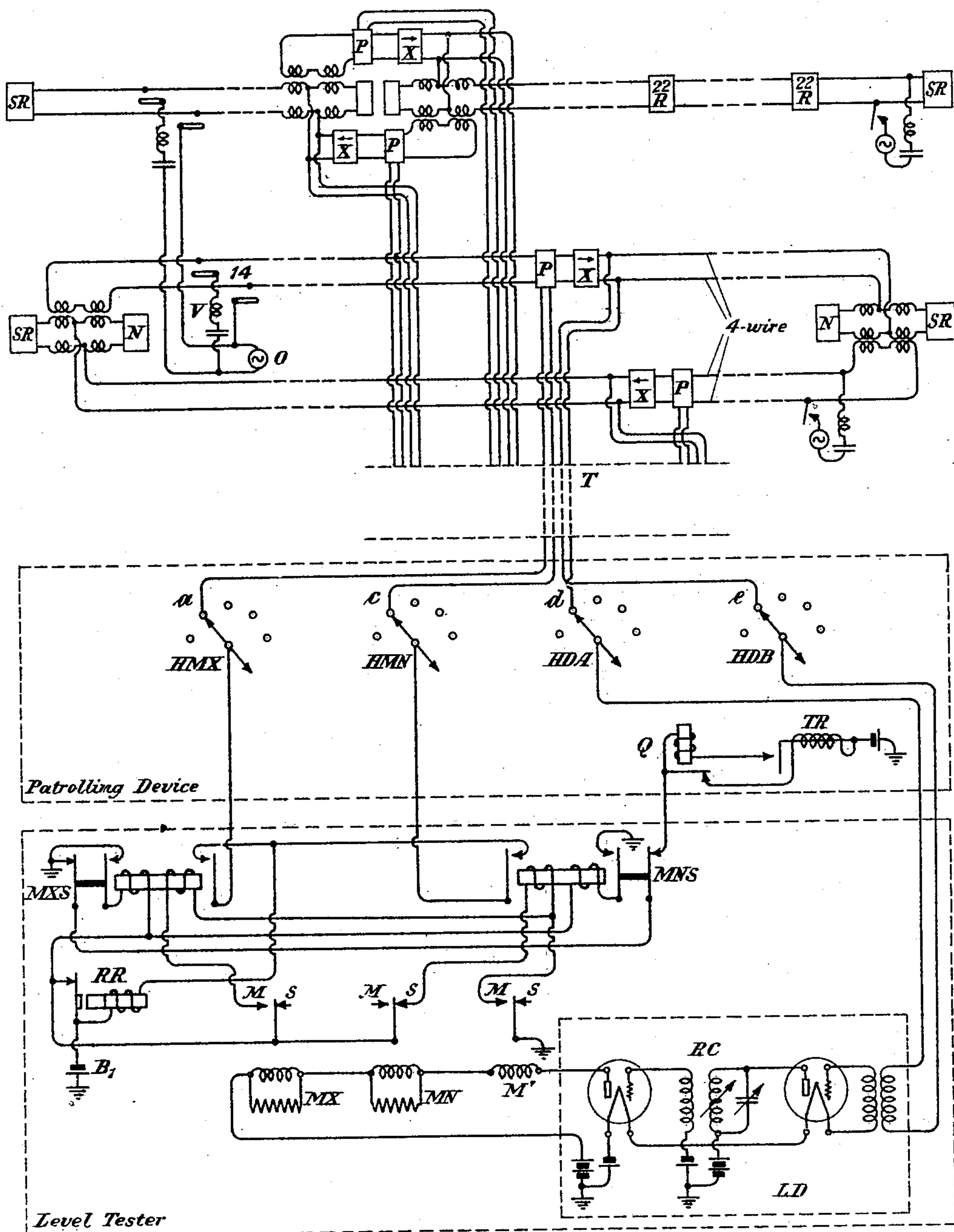


Fig. 3

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SYSTEM FOR TESTING AND ADJUSTING ENERGY LEVELS IN THE TRANSMISSION OF
SIGNALS

Application filed December 24, 1928. Serial No. 328,227.

An object of my invention is to provide new and improved apparatus and a corresponding method for facilitating the adjustment to proper values of the energy levels in signal transmitting systems. Another object of my invention is to provide for automatic testing of the energy level in a signal transmitting system and indication of the result given by the tests. Another object of my invention is to provide for making such tests and automatically effecting compensatory adjustment to keep the energy level at a proper value. Another object of my invention is to provide for the use of one energy level tester for a plurality of circuits or channels. These objects and various other objects of my invention will become apparent on consideration of a limited number of specific examples of the invention which I have chosen to present in the accompanying drawings and the following specification. It will be understood that this disclosure relates principally to these examples of the invention and that the scope of the invention will be indicated in the appended claims.

Referring to the drawings, Figure 1 is a diagram showing my invention in connection with a multiplex telegraph system; Fig. 2 is a diagram showing further how the apparatus of Fig. 1 may be employed; Fig. 3 is a diagram showing the use of my invention in connection with telephone circuits; and Figs. 4 and 5 are diagrams showing how my improved automatic potentiometer may be used in connection with a manually operated potentiometer.

Referring to Fig. 1, this shows at C_2 a pair of conductors of a circuit for receiving telegraph signals of alternating current within a limited range of frequencies. A complete multiplex telegraph signaling system of which the conductors C_2 may form a part is indicated in Fig. 2; referring thereto, the alternating current generators G are of different frequencies within the voice frequency range. Their output currents are controlled by the respective senders K and go through respective band filters BF each of appropriate narrow frequency range and are superposed on the line L . At the receiving end,

the currents are separated by corresponding band filters BF' and go to respective receivers R , with respective associated sounders Sd . One such receiving band filter BF' is shown in Fig. 1 with its receiver R and sounder Sd .

Fig. 1 shows a "level tester" at the bottom, a "patrolling device" at the middle of the figure, and an "automatic potentiometer" at the top. This automatic potentiometer is associated with the branch receiving circuit C_2 . The level tester is connected in cyclic order by the patrolling device with various branch receiving circuits, such as C_2 , and tests the energy level in each circuit to which it is connected and automatically effects adjustment of the corresponding potentiometer, if that is required.

The structure of the apparatus will become apparent on consideration of the following description of its operation in sequential order. Suppose the brushes of the patrolling device have previously reached and made the contacts shown in Fig. 1. Thus, the circuit is established from one side of the line C_2 through the potentiometer brush A , the patrolling switch bank HD and the primary of the repeating coil in the level detector LD to ground. The other side of the branch circuit C_2 being grounded, this puts the repeating coil referred to in parallel with the receiver R shown at the upper part of Fig. 1. The level detector LD is constructed of high impedance so that its connection in parallel with the normal receiver R does not affect its operation.

In the output circuit of the level detector LD are the windings of three marginal relays in series, M' , MN and MX . These are adjusted so that M' operates on any current slightly greater in intensity than the normal interference found in the line, MN operates on any current greater than the minimum permissible signaling current desired for the receiving detector comprised in R , and MX operates on any current greater than the maximum current suitable for operation of that detector. For each of these three relays, its operation puts its armature on the respective contact M , but when the corresponding relay

is deenergized, the armature goes to the contact S.

Suppose, first, that the signaling current on the circuit C_2 is too low, but above the normal interference value. Accordingly, relay M' will be operated but MN and MX will not be operated and a circuit will be formed from ground through the armature of relay M' , winding of relay MNS, contact S of relay MN and battery B_1 . The consequent energization of magnet MNS will close a holding circuit through its other winding from the battery B_1 and will also close a circuit from the battery B_1 through the winding of release relay RR, switch bank HMN and potentiometer operating magnet PMN. The latter magnet will operate and the movement of its armature N will step the potentiometer arm A to the right, thus adjusting the potentiometer P so as to put greater current strength from the circuit C_2 through the receiving filter BF' into the associated detector comprised in R and the level detector LD in parallel therewith.

As already noted, the circuit for the magnet PMN comprises the release relay RR which is slow-acting. Presently it opens both the pick-up and holding circuits for the relay MNS whose armatures fall back, one of them opening the circuit for the magnet PMN, traced heretofore.

If the adjustment of the potentiometer, made as described above, is sufficient, then immediately upon that adjustment being made, the current in the level detector LD will increase enough to operate the relay MN and thus open at this relay the pick-up circuit for the relay MNS. Eventually in this case the release relay RR will close its armature but no effect will follow because all circuits from the battery B_1 will now be open.

On the other hand, if the adjustment of the potentiometer P_2 was not enough, then when the armature of the release relay RR falls back, it will again close the pick-up circuit for magnet MNS through the back contact of relay MN, and the cycle of operations will ensue, as before described, and the potentiometer P_2 will be given another step of adjustment like the first step, and this action will be repeated until the potentiometer P_2 has been adjusted to put enough current into the detector and the level detector LD in parallel therewith so that marginal relay MN will be operated whereupon no further operation of the relays will ensue.

We have now considered the supposed case where the incoming current is too low. If the current in the branch circuit C_2 is too strong, then the output current from the level detector LD will operate all three of the marginal relays M' , MN and MX, thus opening the pick-up circuit for relay MNS and closing the pick-up circuit for relay MXS which may readily be traced from battery B_1 through

the back contact of the release relay RR, front contact of relay MX, winding of MXS and front contact of relay M to ground. In view of the detailed description that has been given for operating the potentiometer P_2 one way through the magnet MNS, it will be sufficient to say that similarly the potentiometer P_2 will be operated the other way through the magnet MXS as many steps as necessary to reduce the received currents to proper value in the detector comprised in R and the level detector LD.

If the incoming current is of proper value, then the output current from level detector LD will operate both marginal relays M' and MN, thus opening the pick-up circuit for relays MNS and MXS so that no such operation as described above will take place.

A thermal relay TR is provided with its heating circuit shown closed through back contacts on magnet Q and relays MNS and MXS. With the current flowing in this circuit, the expansible element of the thermal relay TR is expanded and eventually closes the contact shown associated therewith, thus closing through Q a branch circuit to the one last traced. The consequent energization of the magnet Q opens the circuit of the heating element of the thermal relay TR so that its expansible member cools and contracts and eventually opens the circuit for the magnet Q. Thus the magnet Q is energized periodically at intervals of the order of a half-minute, say, by the operation of the thermal relay TR, assuming that the armatures of magnets MNS and MXS remain on their back contacts.

At each energization of the magnet Q, the switches HMX, HMN and HD are stepped along one step. At the beginning of our description of the operation of the apparatus of Fig. 1, we assumed that these switches had just engaged the terminals with which they are shown in contact; this means that the thermal relay TR had just closed its contact and made the circuit through the magnet Q which in turn had operated to break the circuit through the heating coil of the thermal relay TR. Eventually the expansible element of the thermal relay TR will cool off and contract so as to open the circuit for the magnet Q which, upon its release, will close the circuit for the heating element of TR, provided the armatures of MNS and MXS are on their back contacts. Thereupon the expansible member of thermal relay TR will again expand and eventually close the circuit for the magnet Q which will step the switches HMX, HMN and HD along to another set of contacts for another branch receiving circuit different from C_2 but similar thereto. That is, the thermal relay TR having connected the switches HMX, HMN and HD for branch receiving circuit C_2 long enough for any necessary adjustments to be made in its potenti-

ometer, this thermal relay TR then shifts these switches to another circuit for another similar period, with similar results.

The back contacts of relays MNS and MXS that are found in the circuit of magnet Q in Fig. 1 give assurance that the operation of these magnets MNS and MXS shall have been completed as often as required, and that they shall have released before the magnet Q steps the patrolling switches HD, HMN and HMX along for connection with another branch receiving circuit.

Referring to Fig. 2, it will be seen that one level tester and one hunting device can be used at a station for a plurality of different lines and channels coming into that station, and these lines and channels may be more or less independent of each other except that their receiving ends are at the one station and all are served by the one level tester and patrolling device.

Attention is directed to the switches 11 in Fig. 1. By closing these, the system is put in condition so that whenever a potentiometer adjustment is required, it will be indicated by the signal lamps or bells 12, and thus an attendant will be notified of the situation. If desired, at the same time that the switches 11 are closed, the switches 13 may be opened, thus cutting off the automatic potentiometer and leaving its adjustment to be performed manually by an attendant guided by the signals 12 and 13.

The thermal relay TR may be adjusted as to its period by shifting the heat insulating sleeve SZ. The more this sleeve covers the expansible element, the more slowly will it expand and contract, thus lengthening the period of this relay.

Referring to Fig. 3, this shows a system adapted for regulating the gain at repeaters on telephone transmission lines or any other circuits equipped with amplifiers or boosters. The boxes marked SR are telephone sending and receiving stations. The upper line in the figure is a two-wire system with 22-type repeaters along its length, one of which is shown diagrammatically; others are indicated by the boxes marked 22R. The two conductor pairs marked "4-wire" belong to a four-wire system with one-way repeaters in each conductor pair. In the 22-type repeaters and in the one-way repeaters, the amplifying elements are marked X, and each such amplifying element has an automatic potentiometer P on its input side whereby the intensity of the input to the corresponding amplifier X can be adjusted. Also, it will be seen that a branch circuit is taken off on the output side of each amplifier X. Where the dotted lines occur at T in Fig. 3, there will be a system of trunks like those shown at the middle of Fig. 1.

One set of conductors to a potentiometer P and from the output side of the correspond-

ing amplifier X are shown in Fig. 3 connected down through a patrolling device to a level tester at the bottom of Fig. 3. Whereas Fig. 1 showed grounded circuits and hence only one side of the circuit had to be carried through the patrolling device, Fig. 3 shows metallic circuits and both sides of the circuit are carried through the patrolling device. Accordingly, there is one more wiper and set of contacts in the patrolling device of Fig. 3 than in Fig. 1, that is, HDA and HDB in Fig. 3 take the place of HD in Fig. 1.

The level tester in Fig. 3 is made with a level detector LD in two stages with an adjustable tuned circuit between them at RC. The reason for making this level detector LD in two stages instead of in one stage, as in Fig. 1, is so that the level detector LD shall be selective to frequency and yet offer very high impedance across the transmission line.

At a distance from the repeater X, along the line toward the corresponding sending station, an oscillator O is provided with a corresponding tuned circuit V and its output is applied to the line and received through the branch circuit on the output side of the amplifier X. The tuned circuit at RC is tuned to the same frequency, and hence the current of this frequency is detected in the level detector LD and operates the level tester of Fig. 3 in the same manner as described for Fig. 1.

It will readily be seen that on the line transmitting into the amplifier X taken with said amplifier, as the overall loss varies, the intensity of the component current of frequency determined by the apparatus V will also vary, and this variation will be detected in the level detector LD, and the level tester will be operated accordingly to effect compensatory adjustment of the corresponding potentiometer P. The patrolling device operates in the same way as for Fig. 1 to connect the level tester in cyclic order with various amplifying units X and their associated adjustable potentiometers P. The apparatus can take care of twenty repeater units, for example, reaching them in fifteen-minute cycles.

In the case of a telephone system, the testing frequency, as determined at V, may be just outside the voice range and continually present, in which case the switches at 14 will remain closed. If the system is a multiplex telegraph system, with a plurality of channels in the voice frequency range, then the test frequency may be taken midway between two of the channels. Again, for telephone transmission, the test frequency may be taken within the voice range and applied only at times when the corresponding circuit is not in use for voice transmission. In this case, the switch 14 will normally be open, but will be closed only when the testing frequency is to be applied. Also, in this case, the level tester will leave the corresponding potenti-

ometer undisturbed while the circuit is in use for talking.

While I have illustrated my invention in the drawings for wire transmission systems, it will be readily understood that it is applicable for radio telephone transmission, in which case the test frequency may be taken outside the carrier band and the receiving terminal repeater adjusted automatically to take care of the wide variations in energy level commonly known by the term "fading."

Of course, it may happen that in the system of Fig. 3 there will sometimes be a voice current component of the same frequency as that determined by the apparatus V, but the tuning within the level detector LD can be made very close and such a voice component will be of comparatively seldom occurrence, and even if it should on rare occasions cause the level tester to give a step of adjustment, this step of adjustment would soon be corrected by a normal adjustment.

In a system such as that shown in Fig. 3, not all the repeaters need be controlled, but only enough of them to keep the system within proper limits of energy level throughout.

It should be noticed that in Fig. 1 the system is operated according to the strength of the signaling currents themselves, and no auxiliary currents or channels are required. In all the modifications shown in my drawings, the adjustment takes care of changes of energy level due to whatever cause, whether temperature changes along the line, or changes in the repeaters or receiving apparatus, or changes in voltage supply.

In case it is desired to provide for manual potentiometer adjustment in addition to the automatic potentiometer adjustment, and with the two adjustments more or less independent of each other, this may be accomplished by means of the apparatus shown in Fig. 4 or Fig. 5. In each of Figs. 4 and 5 there is a two-stage amplifier. In Fig. 4 there is an automatic potentiometer AP between the stages and a manual potentiometer HP on the input side of both stages, but in Fig. 5 these potentiometers are interchanged. In Fig. 4 changes in the setting of HP have the same effect as loss changes in the line connected to the input. If in Fig. 4, the power level is tested at T', then HP may be adjusted to bring the arm of AP to a desired normal, and AP will be affected by changes in repeater gain etc. and will compensate therefor. Referring to Fig. 5 suppose first that the power level is tested at T. This means that the automatic potentiometer AP is governed by the power level across the line at T and any changes affecting transmission beyond T in the direction of transmission are without effect on AP. Hence in this case the manual potentiometer HP will effect a superposed adjustment of power level at T'. This facilitates making compensation for minor dif-

ferences of gain among different detectors of a set of telegraph detectors all subject to adjustment in cyclic order as disclosed earlier in this specification. On the other hand in Fig. 5, suppose the automatic test of the power level is at T', then the automatic potentiometer AP is controlled by the level at that point, and hence any adjustment of the manual potentiometer HP will lead to an opposite automatic adjustment of AP. It follows that HP may be adjusted to bring AP to a desired intermediate normal adjustment.

I claim:

1. In combination, a signal transmitting system to be held at a certain standard energy level at a certain place and subject to a variable loss from that level, an automatic level tester of high impedance, means to connect said level tester intermittently to said system to measure this loss, an adjustable device to compensate the loss, and means controlled by said level tester to effect a compensatory adjustment of said device.
2. In combination, a signal transmitting system subject at a certain point therein to variation of energy level, high impedance means intermittently to connect with said system at this point and test for departures from a certain standard level, adjustable means to bring the level to the standard, and means controlled by said testing means to effect suitable adjustment of said level adjusting means.
3. In combination, a plurality of signal transmitting systems each to be maintained at a respective proper energy level, respective potentiometers, a level tester, and a patrolling device to connect the level tester to the said systems in cyclic order to test them for departures from their proper level and also to connect the level tester to the corresponding potentiometers to adjust them to keep the levels at their proper values, said level tester being constructed so that its connection to said systems will not alter the line conditions of the systems at any useful frequency.
4. In combination, a signal transmitting system subject at a certain point therein to variation of energy level, a set of marginal relays connected to be actuated according to the said energy level without substantially altering the operative condition of the system, whether connected or not, a potentiometer in said system, and means to operate said potentiometer by said marginal relays.
5. In combination, a plurality of signal transmitting systems, each to be maintained at a respective proper energy level, respective potentiometers, a set of marginal relays, means to connect this set of relays in cyclic order with said systems and at each such connection to operate them according to the energy level in the connected system, said means being adapted to preserve the operative condition of the systems unchanged by

reason of the connection, and means to operate the corresponding potentiometer by said marginal relays.

6. In combination, a signal transmitting system, an automatic level tester to test the power level of signaling currents at a certain point in said system without substantial reaction in the system, means intermittently to connect said level tester to the system and an automatic potentiometer controlled by said tester to effect compensatory adjustment for departures of said level from a standard value.

7. In a signaling system subject to intermittent transmission of elements of signal current, high impedance means to test the power level in such elements unaffected by intervening conditions of no transmission of signal elements, means intermittently to connect said testing means to the said system, and a potentiometer controlled by said testing means to effect compensatory adjustment for departures of said level from a standard value.

8. In a signal system, means for putting signal currents through the system, means for putting other superposed currents through the system, high impedance means for testing the power level of the said other currents unaffected by the signal currents, and a potentiometer controlled by said last mentioned means.

9. In an alternating current system subject to variation of voltage level at a certain point, automatic high impedance means to test the voltage level at that point for departure thereof from a standard value, means to connect said automatic testing means to the system intermittently, and means to effect a compensatory adjustment to hold the voltage level at said standard value, said adjusting means being controlled by said testing means.

10. In combination, a plurality of signal transmitting systems, respective adjustable means to vary the level in the said systems, a high impedance automatic level tester, and means to connect it in cyclic order to test the departure of the levels in said systems from normal and thereby to effect compensatory adjustments of said adjustable means so as to hold said levels near normal.

11. A plurality of alternating current systems each subject to variation of power level at a certain place, respective means to effect compensatory adjustments for departures of level from normal values, and high impedance means to test the levels in cyclic order and thereby to make the adjustments to hold said levels near normal.

In testimony whereof, I have signed my name to this specification this 17th day of December, 1928.

ANDREW L. MATTE.