

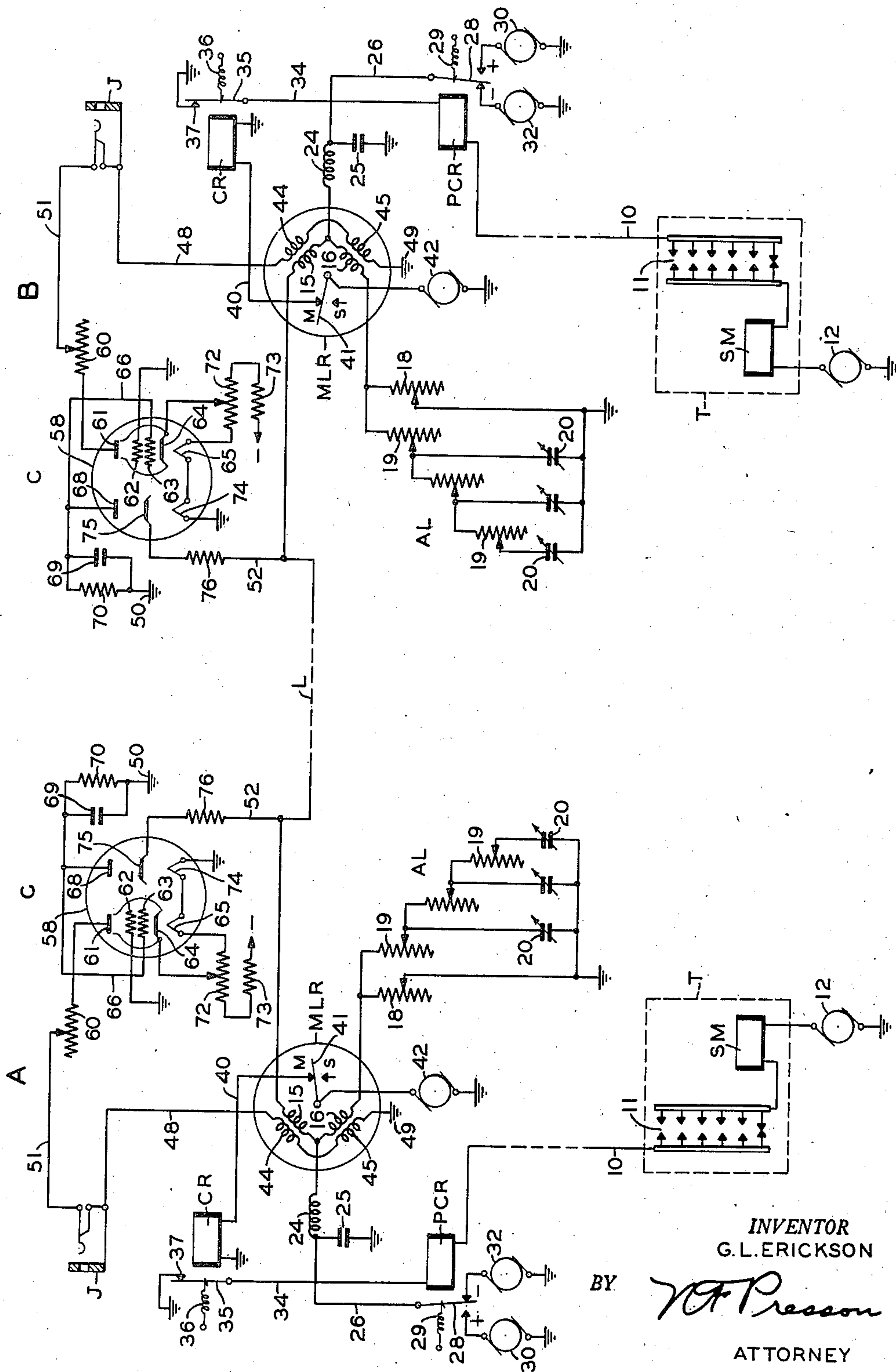
June 4, 1946.

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2,401,343

AUTOMATIC SIGNAL BIAS CORRECTION

Filed May 16, 1944



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2,401,343

AUTOMATIC SIGNAL BIAS CORRECTION

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Application May 16, 1944, Serial No. 535,814

13 Claims. (Cl. 178—69)

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The invention relates to a method and means for compensating for signal bias which may be introduced in telegraph signals due to variation in leakage resistance or reduced insulation values of the line occasioned by fog, wet weather or other adverse conditions, and more particularly to compensate automatically for spacing bias effects appearing in signals repeated by a relay in a half-duplex telegraph circuit.

Long line telegraph circuits which are satisfactory during favorable weather conditions are apt to become difficult to operate during wet weather periods due to leakage of current from the line conductor to earth or to other conductors. Ordinarily, circuits over which signals are sent by reversals of current are not so seriously affected by such conditions as are circuits over which the signals are sent by making and breaking the circuit. It often proves advantageous, therefore, in the case of long Morse or telegraph printer lines, to so arrange the telegraph apparatus that polar transmission is used over the longer sections, although the operators or subscribers at the various stations may send and receive single current signals on Morse sets or telegraph printers.

Generally, in such arrangements the operator's equipment, while initially generating single current signals, is also operating a polechanger relay which in turn is sending reversals of current to the line and to a distant polar relay capable of being actuated by reversals of current. A local circuit at the distant terminal reproduces the single current signals originally generated by the other station for actuating the receiving Morse or teleprinter apparatus. To make the circuit operative in both directions, recourse is had to duplex equipment, and in the case of telegraph printers it is often desirable to operate them by means of half-duplex polar operation in which sending is in but one direction at a time. In such arrangements marking current is transmitted against the received signals, and if wet weather occurs and the ohmic balance ordinarily obtained by an artificial line network is not corrected, then marking current to the line increases, causing a spacing bias to appear in the received signals.

An object of the invention is an improved method and means for automatically compensating for bias that appears in telegraph signals due to variation in leakage resistance of the telegraph line.

A further and more specific object is to provide means for automatically compensating for the spacing bias which normally appears in the signals repeated by a relay in a half-duplex circuit due to variation in leakage resistance of the telegraph line.

Another object is to maintain centered the signals on trunks or other open fire circuits with-

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out the necessity of maintaining an accurate ohmic balance of the artificial line networks associated therewith.

Other objects and advantages will appear from the following detailed description of an illustrative embodiment of the invention, taken in connection with the accompanying drawing which shows a half-duplex teleprinter circuit embodying the principles of the invention.

In the circuit illustrated there are shown two identical sending and receiving stations A and B connected by a telegraph line L. Each of the stations comprises, among other elements, a main line receiving polar relay MLR, and a loop or subscriber's line 10 from a telegraph printer T, the printer having suitable sending contacts 11 for energizing a polechanger relay PCR. Each station also has a control relay CR which is energizable by the receiving relay MLR, and an artificial line network AL for balancing the telegraph line L in known manner. The telegraph line is connected to one of the operating windings 15 of the main line relay MLR, another winding 16 of the relay being connected through the artificial line network AL to ground. The artificial line network has a line rheostat 18 for obtaining a preliminary ohmic balance, and other sections comprising adjustable resistances 19 and adjustable condensers 20 for obtaining capacity balance.

The apex of the windings 15 and 16 of relay MLR is connected preferably to an anti-noise, low pass filter comprising an inductance 24 and a capacity 25, and thence by conductor 26 to an armature 28 of the polechanger relay PCR. Armature 28 has a biasing spring 29 which tends to hold the armature against the back contact of the relay when deenergized, which back contact has positive or spacing polarity applied thereto from any suitable source, as from a generator 30. When relay PCR is operated, the armature 28 is attracted to the front contact of the relay, which front contact has negative or marking polarity applied thereto, as from a generator 32.

One end of the winding of relay PCR is connected to the teleprinter drop or line 10, the other end of the winding being connected by a conductor 34 to an armature 35 of the control relay CR. A biasing spring 36 tends to hold armature 35 away from the grounded contact 37 of the relay when the relay is deenergized. One end of the winding of relay CR is connected to ground; the other end is connected by a conductor 40 to the marking contact *m* of the relay MLR. The armature 41 of the latter relay is connected to a source of current 42 which may be either positive or negative.

When transmission is not taking place in either direction, steady marking potential, of negative polarity in a conventional system, is applied to

both ends of the circuit L, and the armatures or tongues 41 of the polar relays MLR remain in their marking positions *m*. At such time the control relay CR at each station is operated by a circuit which may be traced from ground at one end of its winding, conductor 40, marking contact *m* and armature 41 to a source of energizing current 42. Relay PCR also is operated over a circuit which comprises a source of energizing current 12, which may be either positive or negative, closed contacts of the teleprinter T, conductor 10, winding of relay PCR, conductor 34 and armature 35 and contact 37 of operated relay CR to ground. The negative marking current maintained on the line is supplied from the source 32, through the armature 28 and front contact of operated relay PCR, conductor 26, inductance 24 of the filter circuit, and winding 15 of relay MLR.

Assume now that the teleprinter T associated with one of the stations, such as station A, starts transmission, in which case a spacing signal is transmitted over line L from station A. This is effected by reason of the fact that the operating circuit for the polechanger relay PCR is opened by the operation of the teleprinter, and armature 28 of the relay is actuated against the back contact of the relay so that spacing battery is supplied from the source 30 through the armature 28, conductor 26, inductance 24 of the filter, and coil 15 of relay MLR to the line L. Since the signaling current from station A passes through the winding 16 of relay MLR in a direction to neutralize the current passing through winding 15, the armature 41 of relay MLR at station A remains in its marking position. At station B the spacing signal of positive polarity passes through the winding 15 of the main line relay and thence through filter circuit 24, conductor 26, armature 28 and front contact of relay PCR to the negative source of current 32 to ground. The spacing signal causes the armature 41 of relay MLR at station B to be actuated to its spacing contact *s*, and this interrupts the energizing circuit for control relay CR. Armature 35 of relay CR is actuated, by spring 36, out of engagement with the grounded contact 37, thereby opening the circuit comprising conductor 34 and conductor 10 to the teleprinter T associated with station B, thus transmitting a spacing or start signal to the teleprinter.

A following marking signal received from the line L causes the tongue of the relay MLR at station B to return to its marking contact. Transmission from the teleprinter T associated with station B to the teleprinter of station A is effected in like manner.

Each of the relays MLR also has an auxiliary compensating winding comprising coils 44 and 45 which are in inductive relation with windings 15 and 16. Preferably, and as shown, the compensating winding is connected by a conductor 48, which passes through the normally closed contacts of a test jack J to enable readings of the compensating current to be taken, and thence by conductor 51 to a bias compensator C, the line L also being connected by a conductor 52 to the bias compensator. The other end of the compensating winding is connected to ground at 49. In the embodiment illustrated, conductor 51 is connected to the slider of a variable rheostat 60 which is in circuit with the anode or plate 61 of the amplifier section of an electron discharge tube 58 which preferably, although not necessarily, comprises in the same envelope a rectifier and an amplifier element. The tube preferably,

although not necessarily, is of the type known as No. 117L7GT. This tube has a screen grid 62 connected to ground, a control grid 63, and a cathode 64 which is heated by a filament 65. The control grid 63 is connected by a conductor 66 to the anode or plate 68 of a rectifier, which may be the rectifier section of the tube shown. Conductor 66 also extends to a storage circuit comprising a condenser 69 which is shunted by a high resistance 70 for purposes hereinafter set forth.

The cathode 64 of the amplifier is connected to the slider of a potentiometer 72 for controlling the cathode potential. One end of the potentiometer is connected to the heating filament 65 of the amplifier; the other end is connected through a current limiting resistance 73 to a source of negative battery supply. The cathode 75 of the rectifier section of the tube is connected through a high resistance 76 and the conductor 52 to the line L. A heating filament 74 is provided to activate the rectifier cathode 75.

The bias compensator illustrated automatically compensates for the spacing bias which normally appears in signals repeated by the main line relay of a half-duplex circuit of the character illustrated when leakage or escape of current from any cause takes place from the line L to ground, for example, as a result of fog, wet weather or similar adverse conditions. The compensation provided is not a correction of the ohmic balance and therefore obviates the necessity for attempting to readjust the artificial line network AL as weather changes or other variation in leakage occurs. The difficulties of attempting to compensate, during wet weather, by adjusting the network will be apparent, since such an adjustment usually requires interruption of the circuit for a considerable period of time, and in the meantime it is possible that a great many distorted signals will have been received. In accordance with the instant invention, the auxiliary compensating windings 44 and 45 of the main line relay are connected in series and are caused to carry a current in a direction to produce a suitable marking bias in relay MLR. The value of this current is controlled so that in dry weather, with an accurate balance of the artificial line obtaining, it is very low and has practically no effect on the performance of the main line relay, since under this condition no compensation is required. As the current flowing to the line increases, however, because of wet weather or other leakage conditions, the compensating current in the auxiliary windings is increased to counteract the spacing bias produced by the increased marking current on the line, and the ohmic balance normally provided by the artificial line is not altered when the bias compensator is in use.

The automatic control of the compensating current is obtained by utilizing the voltage existing between the incoming line L and ground when both ends of the circuit are applying negative marking battery to the line. Under this condition the voltage of the line with respect to ground is negative and has a higher value than is the case when the distant end is on spacing. When the home end spaces, the voltage of the line becomes positive with respect to ground. The voltage from line to ground, when both ends of the circuit mark, varies with the presence of leakage on the line, being of highest negative value when there is no leakage and becoming lower in value, although remaining negative, as leakage increases. In the bias compensator the

change in this value of voltage between line and ground is used to change the voltage on the grid of the vacuum tube 58. As the negative potential of the line with respect to ground decreases as a result of the leak on the line increasing, the negative voltage on the grid 63 of the tube with respect to its cathode 64 decreases, and this permits the plate current of the vacuum tube to increase. This plate current is passed through the auxiliary windings 44 and 45 of the relay MLR and compensates for the spacing bias caused by the increase in line current.

When the half-duplex circuit is idle, steady marking current is applied at both ends of the circuit, and the line to ground voltage could be used directly to control the compensating current. During periods of signaling from either end, however, it is necessary to provide means whereby the bias compensator can pick out the voltage existing under the marking against marking condition. This is done by two features of the arrangement illustrated. The first of these is the insertion of the rectifier between the line and the compensator connected so that the rectifier conducts only when the potential of the line is negative with respect to ground. Thus, whenever the home station spaces, making the line L positive with respect to ground, the compensator is cut off from the line. Since, with the home end marking, the voltage between line and ground is greater when the distant end marks than when it spaces, a peak voltage detecting and storing arrangement may be used to pick out and store the higher voltage. This may comprise condenser 69, which is shunted by the high resistance 70; in the specific circuit illustrated the condenser may be of the order of 4 microfarads, and the resistance may be of the order of 20 megohms. The condenser 69 is charged by the highest negative voltage appearing between line and ground and discharges slowly through the high resistance shunt whenever the compensator is cut off from the line by the rectifier section of the tube, which occurs whenever the voltage between line and ground falls below the voltage to which the condenser is charged. In ordinary teleprinter signaling, the marking against marking condition occurs frequently enough to maintain the charge on the condenser approximately at the highest voltage.

The characteristics of the vacuum tube employed in the bias compensator preferably are such that, when used on an average line, the compensating current is of the correct value with no resistance in the plate circuit of the tube except the relay windings. Under some conditions, generally where a considerable amount of cable separates the set with which the compensator is used from the open line on which the leakage occurs, additional resistance may be required in the plate circuit, and this may be effected by adjustment of the plate rheostat 60.

In order to place the cathode 64 of the tube at the proper potential with respect to the grid 63, which is at peak negative line potential, the cathode is connected to the slider of the potentiometer 72 which is inclined in the heater circuit of the tube. The heater circuit is supplied from a suitable source of negative current, such as a 160 volt line battery, preferably through a suitable current limiting resistance 73. The cathode is, therefore, at a negative potential with respect to ground and may be adjusted by means of the potentiometer 72 to a proper value with respect

to the grid of the tube to limit the compensating current to a very low value in dry weather. Since the cathode is at a rather high negative potential with respect to ground, the plate circuit may terminate at ground potential, as shown. The plate will then be at a positive potential with respect to the cathode, and under proper conditions of grid bias plate current will flow.

The compensator may be connected to and removed from the set with which it is used either by the provision of separate disconnecting plugs or switches, in a manner well-known in the art.

The initial adjustment of the compensator may be made when the line L is dry. A good balance is first taken on the set; with the resistance of the rheostat 60 cut out, that is, in its 0 position, an adjustment of the cathode potentiometer 72 will produce a variation of the compensating current, as may be seen from a local milliammeter when connected into the compensating circuit jack J. The cathode potentiometer is then set so that the compensating current is just sufficient to be read on the meter, usually not over two and one-half millamperes. On most lines this will be the only adjustment required, the plate rheostat remaining at 0. The accuracy of compensation may be checked by observing the received line current on marking and spacing signals from the distant end of the circuit at a time when leakage is present on the line. The value of the compensating current ordinarily should be approximately one-half of the difference between the received marking and spacing currents. On some lines, generally where a considerable amount of cable separates the office where the compensator is used from the leaky line, it may be found that when leakage occurs the compensating current will be too high, and an adjustment of the plate rheostat 60 will take care of this condition. Such an adjustment should be made in very wet weather, and once made may be left untouched for less severe conditions. Should the compensator set be transferred to another line, changes in the settings of the potentiometers 60 and 72 may be required.

The specification so far has described the application of the unbalance correcting device to the relay at the receiving end of the circuit, where the device applies a marking bias in opposition to the spacing bias, which tends to arise as wet weather leakage causes an increase in current from the terminal set into the line. Consider, however, the condition which prevails when the half-duplex terminal set corrected as described turns to sending. Under this condition the tongue of the relay MLR should remain fixed on its marking contact under all conditions of the armature of the sending polechanger. The unbalance corrector, however, continues to function and to supply a marking bias which serves to hold the armature of relay MLR more securely on its marking contact and unaffected by any unbalance component.

When the line is affected by leakage to ground because of wet weather, the peak voltage occurring between line and ground decreases roughly one volt for each mil of resultant unbalance. In the particular circuit illustrated, the constants of the tube circuit are adjusted so that for each mil of unbalance a mil of correcting current is caused to flow through the auxiliary windings 44 and 45. This adjustment will, of course, be varied to suit individual circumstances, such as large cable sections at one end or the other, and once adjusted is corrected for a typical distribution of

escape. The operating potentials of the bias corrector are so chosen that the device primarily is responsive to the peak potential between the line and ground of the marking signals. This adjustment largely excludes the effects of the interference currents which are usually present on grounded telegraphy lines. For brevity in the claims, the term "instant" is employed to refer to the voltage or potential obtaining on the line with respect to ground under the signaling conditions specified therein.

Various modifications of the circuit arrangement and apparatus shown, and various equivalents or substitutes of the devices illustrated, will readily occur to those versed in the art without departing from the spirit and scope of the present invention. For example, and by way of illustration only, separate tubes may be employed instead of the composite tubes 58, and other known types of amplifier, relay and rectifier devices suitable for the purpose may be employed instead of those shown. Also, the compensator may be employed with various different kinds of telegraph lines, either of one wire or two wire types, and either grounded or metallic circuits. Moreover, the compensator connections may comprise known types of detachable plug or switch arrangements so that one compensator may be employed at various times with different telegraph circuits. The disclosure, therefore, is for the purpose of illustrating the principles of the invention which is not to be regarded as limited except as indicated by the scope of the appended claims.

I claim:

1. A telegraph system comprising a telegraph line subject to variable leakage resistance, sending apparatus for transmitting marking and spacing signals over said line, receiving apparatus connected to the line and responsive to the marking and spacing signals, and means for automatically compensating for bias which appears in the incoming signals due to variation in leakage of the line, said means comprising a winding inductively coupled to said receiving apparatus, and means responsive to and controlled by the instant voltage existing between the line and ground for producing in said winding a compensating current of a magnitude and in a direction to counteract the bias appearing in said signals due to varying leakage resistance, said means maintaining the value of said compensating current continually proportional to the voltage existing between the line and ground during the reception of marking signals by said receiving apparatus.

2. A telegraph system comprising a telegraph line subject to variable leakage resistance, apparatus for transmitting marking and spacing signals over said line, a repeating relay having a winding connected to the line and responsive to the marking and spacing signals, and means operatively associated with the repeating relay for automatically compensating for bias which appears in the signals due to variation in leakage of the line, said means comprising a biasing winding inductively coupled to the winding of said repeating relay and means responsive to and controlled by the instant voltage existing between the line and ground for producing in said biasing winding a compensating current of a magnitude and in a direction to counteract the bias appearing in said signals due to varying leakage resistance.

3. A telegraph system comprising a telegraph line subject to variable leakage resistance, appa-

ratus for transmitting marking and spacing polar signals over said line, receiving apparatus connected to the line and responsive to the marking and spacing signals, and means operatively associated with the receiving apparatus for automatically compensating for spacing bias which appears in the signals due to variation in leakage of the line, said means comprising a biasing winding inductively coupled to said receiving apparatus and means responsive to and controlled by the instant voltage existing between the line and ground for introducing in said winding a compensating current of a magnitude and in a direction to produce a marking bias to counteract the spacing bias appearing in said signals due to varying leakage resistance.

4. A telegraph system comprising a telegraph line subject to variable leakage resistance, apparatus for transmitting marking and spacing polar signals over said line, receiving apparatus comprising a half duplex repeater connected to the line and responsive to the marking and spacing signals, and means operatively associated with said repeater for automatically compensating for spacing bias which appears in the signals due to variation in leakage of the line, said means comprising a biasing winding inductively coupled to said repeater and means responsive to and controlled by the instant voltage between the line and ground for introducing in said winding a compensating current of a magnitude and in a direction to produce a marking bias to counteract the spacing bias appearing in said signals due to varying leakage resistance.

5. A telegraph system comprising a telegraph line subject to variable leakage resistance, apparatus for transmitting marking and spacing signals comprising negative and positive current pulses, respectively, over said line, receiving apparatus connected to the line and responsive to the marking and spacing signals, and means operatively associated with said receiving apparatus for automatically compensating for spacing bias which appears in the signals due to variation in leakage of the line, said means comprising a biasing winding inductively coupled to said receiving apparatus and means responsive to and controlled by the value of the instant negative voltage on the line with respect to ground for introducing in said winding a compensating current of a magnitude and in a direction to produce a marking bias to counteract the spacing bias appearing in said signals due to varying leakage resistance.

6. A telegraph system comprising a telegraph line subject to variable leakage resistance, apparatus for transmitting marking and spacing pulse signals over said line, receiving apparatus connected to the line and responsive to the marking and spacing signals, and means operatively associated with the receiving apparatus for automatically compensating for bias which appears in the incoming signals due to variation in leakage of the line, said means comprising a winding inductively coupled to said receiving apparatus and means responsive to and controlled by the instant value of the negative voltage on the line with respect to ground for producing in said winding a compensating current which varies in magnitude as the instant value of said negative voltage on the line varies, which compensating current flows in a direction to counteract the bias appearing in said signals due to varying leakage resistance.

7. A telegraph system comprising a telegraph

line subject to variable leakage resistance, apparatus for transmitting marking and spacing polar signals over said line, receiving apparatus connected to the line and responsive to the marking and spacing signals, and means operatively associated with the receiving apparatus for automatically compensating for bias which appears in the incoming signals due to variation in leakage of the line, said means comprising a winding inductively coupled to said receiving apparatus and means responsive to and controlled by the instant value of the negative voltage on the line with respect to ground for producing in said winding a compensating current which increases and decreases in magnitude as the instant value of said negative voltage on the line decreases and increases, which compensating current flows in a direction to counteract the bias appearing in said signals due to varying leakage resistance.

8. A telegraph system comprising a telegraph line subject to variable leakage resistance, apparatus for transmitting marking and spacing polar signals over said line, receiving apparatus connected to the line and responsive to the marking and spacing signals, and means operatively associated with the receiving apparatus for automatically compensating for bias which appears in the incoming signals due to variation in leakage of the line, said means comprising an electron discharge tube having an output electrode connected to a winding inductively coupled to said receiving apparatus and a control electrode in said tube energized in accordance with the instant value of the negative voltage on the line with respect to ground, for producing in said winding a compensating current which varies in magnitude as the instant value of said negative voltage on the line varies and which flows in a direction to counteract the bias appearing in said signals due to varying leakage resistance.

9. A telegraph system comprising a telegraph line subject to variable leakage resistance, apparatus for transmitting marking and spacing polar signals over said line, receiving apparatus connected to the line and responsive to the marking and spacing signals, and means operatively associated with the receiving apparatus for automatically compensating for bias which appears in the incoming signals due to variation in leakage of the line, said means comprising an electron tube amplifier having an output circuit connected to a winding inductively coupled to said receiving apparatus and a control grid in said tube energized in accordance with the instant value of the negative voltage on the line with respect to ground, for producing in said winding a compensating current which varies in magnitude as the instant value of said negative voltage varies and which flows in a direction to counteract the bias appearing in said signals due to varying leakage resistance.

10. A telegraph system comprising a telegraph line subject to variable leakage resistance, apparatus for transmitting marking and spacing polar signals over said line, receiving apparatus connected to the line and responsive to the marking and spacing signals, and means operatively associated with the receiving apparatus for automatically compensating for bias which appears in the incoming signals due to variation in leakage of the line, said means comprising an electron discharge tube having an output electrode connected to a winding inductively coupled to said receiving apparatus and a control electrode in said tube energized in accordance with the

instant value of the negative voltage on the line with respect to ground for producing in said winding a compensating current which varies in magnitude as the instant value of said negative voltage on the line varies and which flows in a direction to counteract the bias appearing in said signals due to varying leakage resistance, and means for causing said compensator to respond only to the voltage existing under a marking against marking condition on said line comprising a rectifier interposed between the line and compensator and connected so that the rectifier conducts only when the potential of the line is negative with respect to ground.

11. A telegraph system comprising a telegraph line subject to variable leakage resistance, apparatus for transmitting marking and spacing polar signals over said line, receiving apparatus connected to the line and responsive to the marking and spacing signals, and means operatively associated with the receiving apparatus for automatically compensating for bias which appears in the incoming signals due to variation in leakage of the line, said means comprising an electron discharge tube having an output electrode connected to a winding inductively coupled to said receiving apparatus and a control electrode in said tube energized in accordance with the instant value of the negative voltage on the line with respect to ground for producing in said winding a compensating current which varies in magnitude as the instant value of said negative voltage on the line varies and which flows in a direction to counteract the bias appearing in said signals due to varying leakage resistance, means for causing said compensator to respond only to the voltage existing under a marking against marking condition on said line comprising a rectifier interposed between the line and compensator and connected so that the rectifier conducts only when the potential of the line is negative with respect to ground, and a peak voltage storage device comprising a condenser shunted by an impedance, said storage device being connected to the output circuit of said rectifier and to the control electrode of said discharge tube.

12. The method of compensating for spacing bias introduced in telegraph marking and spacing signals due to variation in leakage of a telegraph line over which the signals are transmitted to signal repeating apparatus, which comprises generating a compensating current of a magnitude dependent upon the instant negative voltage on the line with respect to ground, and inductively applying said compensating current to the repeating apparatus in a direction to counteract the bias appearing in the signals repeated by said apparatus.

13. The method of compensating for spacing bias introduced in telegraph marking and spacing signals in a half duplex circuit due to variation in leakage of a telegraph line over which the signals are transmitted to repeating relay apparatus, which comprises applying marking current of negative polarity to said line, generating a compensating current of a magnitude dependent upon the instant value of the negative voltage on the line with respect to ground, and inductively applying said compensating current to the repeating relay apparatus in a direction to counteract the spacing bias appearing in the signals repeated by said apparatus.