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TRANSMISSION REGULATOR SYSTEM

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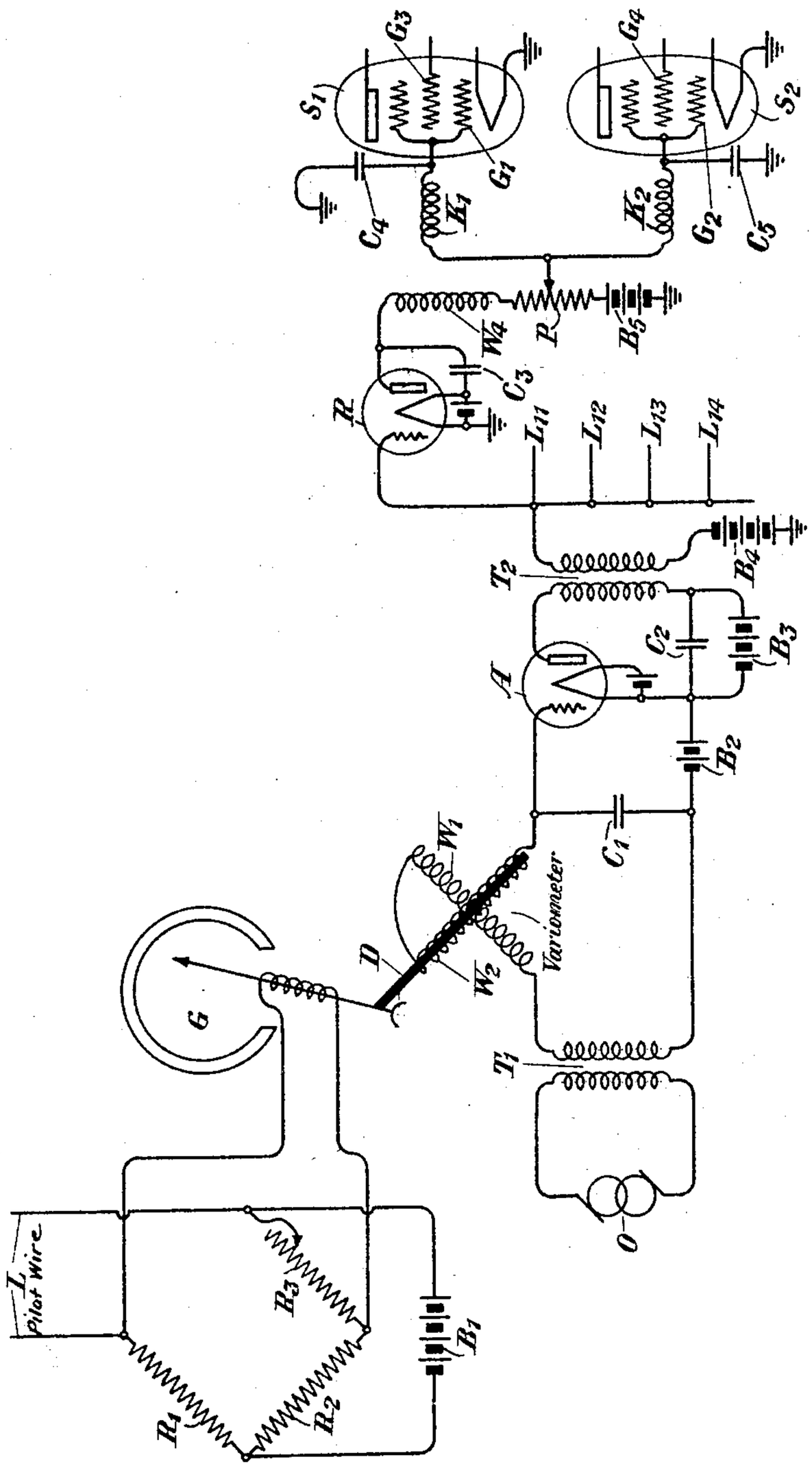

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TRANSMISSION REGULATOR SYSTEM

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This invention relates to signaling systems and particularly to those employing repeaters to adjust the gain of transmitted signals. More particularly, this invention relates to arrangements for automatically adjusting the gain of a repeater to compensate for variations in the transmission equivalent of one or more conductors forming a circuit when the temperature of these conductors changes under varying atmospheric conditions.

In signaling systems employing cable circuits for the transmission of energy and amplifiers are located at repeater points for increasing the level of transmitted energy to overcome the attenuation of the conductors, it has been determined that variable temperature is an important factor in changing the effective attenuation of the circuits. At high temperatures, the attenuation is quite large and conversely, it is low at low temperatures. A pilot wire is often set aside in a cable and this wire forms a circuit which is connected to a repeater so that the gain of the repeater may be changed in accordance with variations in the temperature of the pilot wire. It is the purpose of the arrangement to increase the gain of the repeater when the resistance changes by virtue of an increase in temperature and to decrease its gain with a decrease in temperature.

It is an object of this invention to provide a pilot wire regulating system intended for use with the repeaters of signaling systems to automatically adjust the gain of the repeater to take care of temperature variations in the transmission equivalent of the conductors forming the signaling circuit. This object may be carried out with the apparatus shown in the drawing, the details of which will now be described.

Referring to the drawing, the reference character L designates two conductors forming a cable pair or circuit. Such a pair or circuit is known as a pilot wire. It may be said of this pilot wire, as well as of each of the other conductors of the cable, that its resistance changes in accordance with temperature. As the temperature increases, the transmission loss increases and conversely, the transmission loss decreases with a decrease in temperature.

The conductors L form one arm of a Wheatstone bridge of a familiar type, the other arms of which are designated R_1 R_2 and R_3. A battery B_1 forms one diagonal of the bridge and a galvanometer G, which will be subsequently described, forms the other diagonal.

The arm R_3 may be changed in its magnitude of resistance to produce a condition of balance in the bridge.

The galvanometer G connected diagonally in the bridge is a good deal similar to those known in the art. This galvanometer may be of the D'Arsonval type in which a coil is moved angularly in the field of a fixed magnet, or this galvanometer may be of a fixed coil type in which a magnet is the only moving element.

In connection with the galvanometer, it is necessary to consider a variometer or variable inductance which is mechanically, but not electrically, associated therewith. The variometer includes a fixed winding W_1 and a movable winding W_2, both connected in series relationship. Winding W_2 is mechanically coupled to the movable element of the galvanometer G. An insulating member D on which winding W_2 may be mounted is, by virtue of its mechanical connection to the movable element of galvanometer G, rotated through an angle which depends upon the movement of the galvanometer. It is important to note that, although the winding W_2 of the variometer is under the control of the galvanometer by virtue of the presence of the coupling member D, this winding is, however, electrically insulated from all of the elements forming galvanometer G. It will be apparent that the effective inductance of the variometer is determined by the position of winding W_2 with respect to winding W_1. Thus, as the pointer of the galvanometer is deflected, so the effective inductance will be changed.

The reference character O may represent any source of alternating voltage. It produces a voltage of constant frequency and magnitude. The frequency of the generated voltage may preferably be higher than those

frequencies ordinarily involved in signaling over the conductors of the cable having the pilot wire L.

A transformer T_1 of any well known type couples the source O with a resonant circuit which includes the secondary winding of transformer T_1, windings W_1 and W_2 of the variometer and the condenser C_1. The major element of inductance in this circuit is provided by the variometer. This circuit is so arranged that it is resonant at the frequency of the source O when winding W_2 is rotated until it is in one of its extreme positions. When winding W_2 is so situated with respect to winding W_1 as, for example, to establish a maximum of inductance, resonance will occur and the flow of current through the resonant circuit will be a maximum. Under these conditions, the potential which is impressed upon the condenser C_1 will also be a maximum.

A three-element vacuum tube which is arranged to act as an amplifier is designated A. A battery B_2 is connected between the filament of this tube and its grid electrode through the inductive elements of the resonant circuit. Battery B_2 is of such voltage that the tube may operate on the straight portion of its plate current-grid voltage characteristic curve. A battery B_3 is connected between the filament of tube A and its plate electrode through the primary winding of a transformer T_2. Battery B_3 provides the proper operating potential for the plate electrode of the tube. A condenser C_2 is connected across the terminals of battery B_3, this condenser freely transmitting the alternating current which flows in the circuit including the plate and filament electrodes of tube A.

A number of tubes of the three-electrode type are coupled by transformer T_2 to the output circuit of the tube A. One of these tubes, designated R, is shown for the purpose of illustration and it will be apparent that other tubes of similar characteristics may be connected to the conductors L_{11}, L_{12}, L_{13} and L_{14}.

One end of the secondary winding of transformer T_2 is connected to ground through a battery having a large negative voltage. A battery of such voltage causes the tube R to act as a rectifier. The other end of the winding of this transformer is connected to the grid electrode of tube R as well as to the grid electrodes of such tubes as are employed in connection with lines L_{11}, L_{12}, L_{13} and L_{14}. The plate circuit of tube R includes an inductance W_4, a potentiometer P and a battery B_5. A condenser C_3 is connected between the plate and filament electrodes of tube R and this condenser bypasses such alternating current as may become impressed upon the plate electrode of this tube.

The application of an increasing alternating potential to the grid electrode of tube R increases the flow of current in the plate circuit of this tube, above described, and conversely, a decreasing alternating potential correspondingly decreases the flow of current in this plate circuit. Therefore, the potential set up across the outer terminals of potentiometer P varies with the increase or decrease in the value of the alternating voltage applied to the grid electrode of tube R. It is to be noted that the value of the alternating voltage impressed upon the grid of tube R is determined by the setting of the variable inductance.

The reference characters K_1 and K_2 represent chokes which prevent alternating currents from being impressed on the screen grids G_1 and G_2 of two four-element vacuum tubes designated S_1 and S_2, respectively. The chokes K_1 and K_2 substantially free the amplifying system with which tubes S_1 and S_2 are associated, from noise and interference. It seems hardly necessary to state that the tubes S_1 and S_2 include, in addition to the screen grid electrodes G_1 and G_2, the ordinary plate, filament and grid electrodes, the ordinary grid electrodes being designated G_3 and G_4, respectively. It will be apparent that an input circuit is connected between the grid electrode G_3 and the filament electrode of tube S_1 through suitable biasing means and that an output circuit is connected between the plate and filament electrodes through a source of direct current voltage, such as a battery. Similar circuits are associated with the electrodes of tube S_2. The screen grid G_1 is connected to ground through a condenser C_4. The screen grid G_2 is similarly connected to ground through a condenser C_5.

It may be briefly stated that the pilot wire L forming one arm of the Wheatstone bridge changes in resistance with any change in temperature. The galvanometer G, forming a diagonal of the bridge, responds to changes in the magnitude of the resistance of pilot wire L and this galvanometer correspondingly deflects the movable coil W_2 of the variometer which is mechanically coupled to the moving element of the galvanometer. The variable inductance is changed by an amount determined by the variation in the resistance of the pilot wire L, hence, the circuit including the condenser C_1 is modified so as to be more nearly in or out of resonance with the frequency of the source O. The voltage across condenser C_1, which varies rapidly with changes in the inductance, is applied to the grid electrode of the amplifier A. The output of this amplifier is rectified by the tube designated R and the resulting direct current voltage becomes impressed upon the fourth electrodes or screen grids of vacuum tubes S_1 and S_2. The latter vacuum tubes form parts of respective repeaters to be regulated and the variations of potential

applied to each fourth electrode varies the gain of the associated repeater in a direction calculated to offset the effect of changes in the temperature of the conductors forming the cable to which the repeater is connected.

One of the novel features of this invention lies in the use of a galvanometer to vary inductance. This is accomplished by interconnecting the movable member of the galvanometer with the movable member of the variometer, the interconnection being provided by a rigid, insulating member D. In order that the galvanometer may serve as a motor to vary the adjustable inductance, it must be supplied with a relatively large amount of power. This power may be derived from the battery B_1 which is diagonally connected to the Wheatstone bridge. Battery B_1 would necessarily be one of high voltage and preferably of large capacity. With a battery of high voltage, it will be apparent that the currents in the bridge circuit may be greatly increased and the galvanometer therefor properly operated.

Another of the important features of the invention consists in the use of oscillating current derived from the source O as a coupling means whereby a change in the magnitude of direct current, even if this change be of small value, will cause a substantial change in the potential applied to the fourth element of one or more screen grid vacuum tubes. Thus, the arrangement associated with source O permits any small change in the current flowing over pilot wire L to produce a corresponding modification of the rectified current derived from source O and this rectified current is impressed upon each of the screen electrodes of tubes S_1 and S_2.

Another of the important features of this invention may be found in the use of the fourth element of a screen grid tube for the purpose of varying the gain obtained from the tube. It will be apparent that any variations in the direct current potential applied to the screen grid electrodes of the vacuum tubes S_1 and S_2 will cause corresponding variations in the gain of the energy flowing through the circuits associated with these tubes.

While this invention has been shown in one particular embodiment merely for the purpose of illustration, it will be understood that this invention may be applied to other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. The combination of a pilot circuit the resistance of which changes with temperature, a tube having plate, filament, grid and screen grid electrodes, and means including a rectifier interconnecting said circuit and said tube and responsive to the changes in resistance of said circuit to automatically control the direct current potential applied to the screen grid of said tube in accordance with the resistance of said circuit.

2. The combination of two vacuum tubes each having plate, filament, grid and screen grid electrodes, a circuit interconnecting one screen grid electrode with the other screen grid electrode, a source of direct current potential, a pilot wire of variable resistance, means including a rectifier interconnecting said pilot wire and said source of direct current potential for controlling the effective potential of said source, and means for applying the effective potential of said source to said circuit.

3. The combination of two vacuum tubes each having plate, filament, grid and screen grid electrodes, two choke coils connected in series between the screen grid electrodes of said tubes, a source of direct current potential applied to both of the screen grid electrodes through said choke coils, a pilot wire the resistance of which varies with temperature, and means including a rectifier whereby variations in the resistance of said pilot wire will change the effective potential of said source.

4. The combination of a pilot circuit the resistance of which varies with temperature, a tube having plate, filament, grid and screen grid electrodes, a source of direct current potential in common with the screen grid electrode, and means including a rectifier coupling the pilot circuit with said source in order to vary the potential applied to the screen grid electrode in accordance with the variations in the resistance of said pilot circuit.

5. The combination of a source of alternating current of definite frequency and voltage, a circuit coupled to said source resonant at the frequency of said source, an element which varies in resistance with changes in temperature conditions, and means coupling said element with said circuit and responsive to the changes in resistance of said element in order to detune said circuit by an amount corresponding to the magnitude of the resistance of said element.

6. The combination of variable inductance, an instrument having a movable element, a circuit coupled to said instrument which continuously varies in resistance, said circuit continuously changing the position of the movable element of said instrument, means mechanically coupled to the movable element of said instrument to vary said inductance, and a circuit including said inductance the frequency of resonance of which is controlled by said inductance.

7. The combination of a variable inductance, a measuring instrument comprising a movable element, a circuit continuously varying in resistance coupled to the movable element of said instrument, means to vary said inductance in accordance with the angular

displacement of said movable element, and a circuit including said inductance the frequency of resonance of which is controlled by said inductance.

8. The combination of an instrument of the moving coil type, a circuit continuously varying in resistance coupled to the moving coil of said instrument, inductance mechanically coupled to the moving coil of said instrument, means to vary the reactance of said inductance in accordance with the angular displacement of the moving coil, and a circuit controlled by said inductance which becomes detuned in accordance with the changes in the reactance of said inductance.

9. The combination of a source of alternating current of definite frequency, a tuned circuit consisting of inductance and capacity receiving current from said source, a device having a moving coil, an independent circuit including the moving coil of said device the position of which changes as the current through said circuit changes, and means to vary the inductance of said tuned circuit in accordance with the displacement of the moving coil of said device.

10. The method of maintaining the gain of a vacuum tube system constant under widely varying conditions of temperature which consists in generating an alternating current of definite frequency, rectifying the alternating current, modifying the voltage of the rectified current in accordance with temperature variations, and controlling the gain of the vacuum tube system in accordance with the voltage of the rectified current so as to maintain the gain constant.

11. The combination of a source of alternating voltage of constant frequency and amplitude, a circuit having an adjustable frequency coupled to said source and normally having a frequency of resonance equal to that of said source, a pilot circuit which changes in resistance under different weather conditions, and means coupling said pilot circuit with said circuit of adjustable frequency and responsive to instantaneous changes in the resistance of said pilot circuit to detune the circuit of adjustable frequency by an amount which is dependent upon the resistance of said pilot circuit.

12. The combination of a pilot circuit, an inductance, means coupling said circuit and said inductance to vary the effective value of said inductance in accordance with changes in the resistance of said circuit, a tube having a screen grid electrode, and means to vary the potential applied to the screen grid electrode of said tube in accordance with the effective value of said inductance.

In testimony whereof, I have signed my name to this specification this 23d day of Dec. 1929.

ROY C. CORDERMAN.