Aug. 30, 1932. W. H. T. HOLDEN 1,874,530

TRANSMISSION REGULATING SYSTEM

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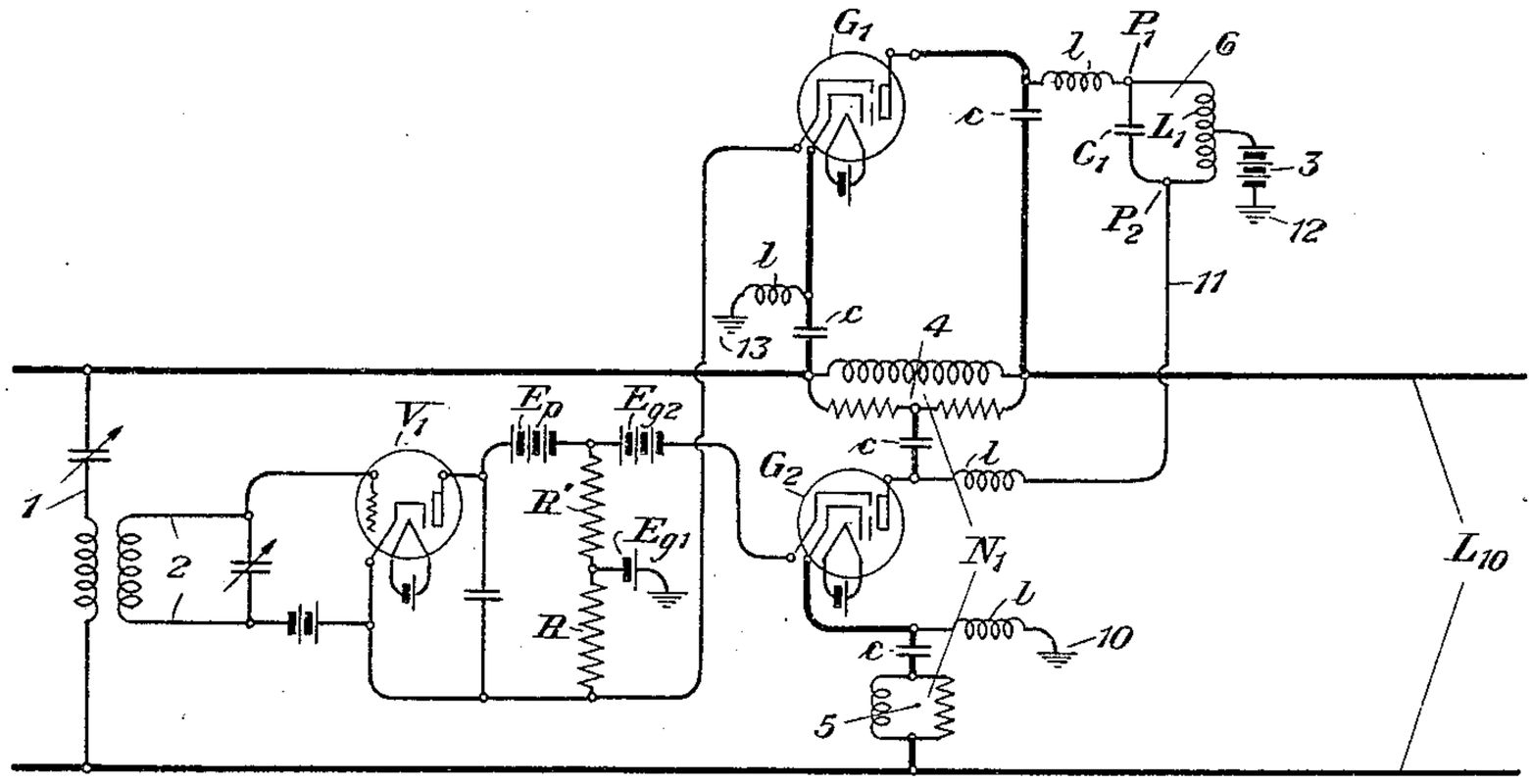

Fig. 1

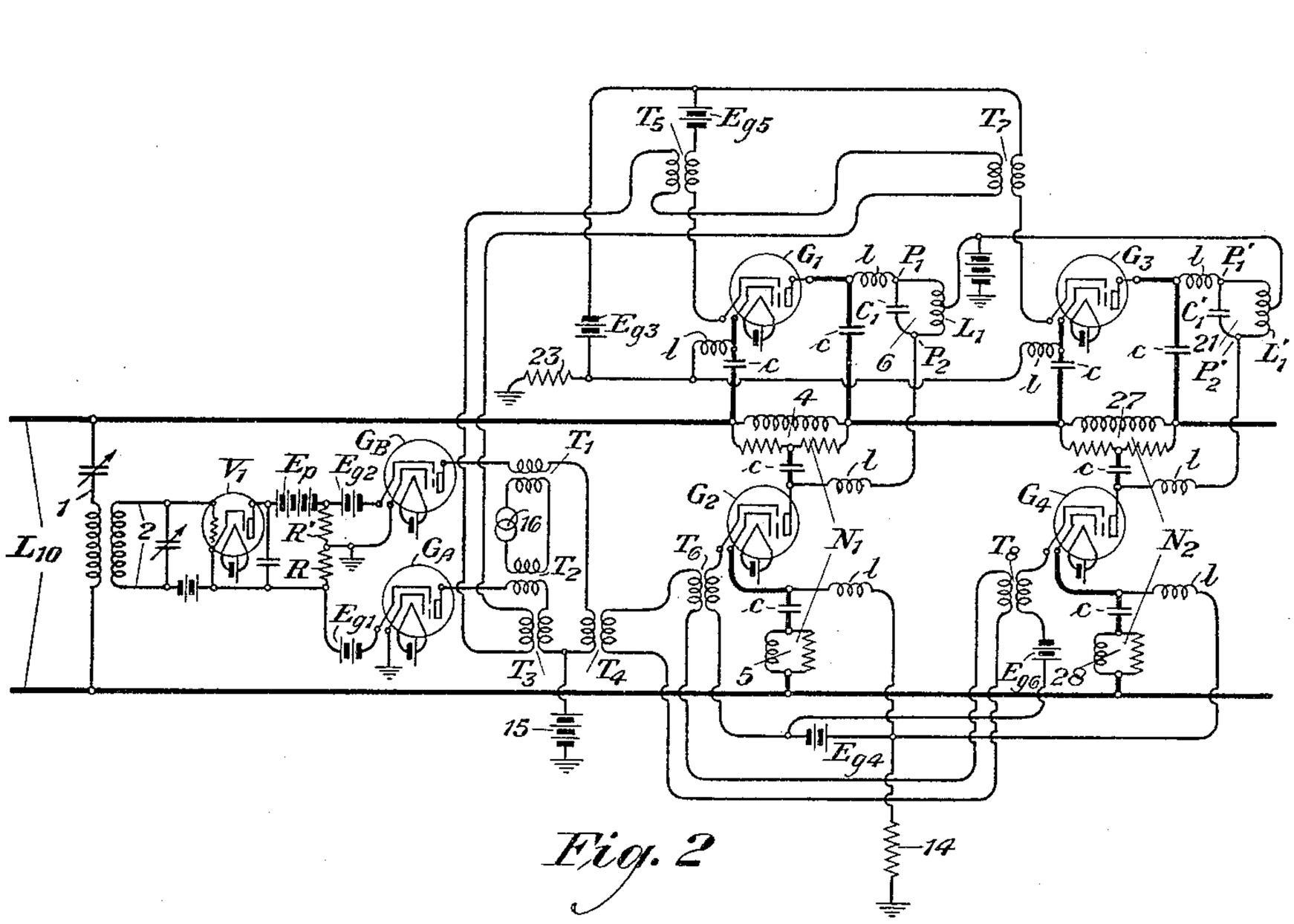

Fig. 2

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UNITED STATES PATENT OFFICE

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TRANSMISSION REGULATING SYSTEM

Application filed December 26, 1931. Serial No. 583,381.

This invention relates to transmission systems, and more particularly to means for regulating transmission on the lines of such systems.

In telephone or telegraph transmission systems, particularly of the carrier type, it may be desirable to automatically regulate the transmission over lines of such systems so that the current at the end of the line will be of constant output or of an output between desired levels. This has been accomplished by transmitting a pilot channel over a line and utilizing increases or decreases in said pilot channel to cut in or out of the line elements of networks or artificial lines to regulate transmission to keep the output between desired levels. The means for switching in and out of the line the elements of these networks have heretofore been relays. In such systems, particularly those utilizing a number of carrier channels, it is necessary to effect very dependable operation of these relays as their contacts may be directly in the transmission circuit. Accordingly, careful attention to their mechanical adjustment has been necessary. The arrangements of the invention provide a means for automatically controlling the transmission in a line by means of a pilot channel without the use of relays and hence afford the particular advantage of providing a device which eliminates mechanical moving parts in such a system.

In a copending application filed in the name of Charles S. Demarest, Serial No. 574,207, is shown an arrangement wherein a pilot channel current is transmitted through the variable network or artificial line to the receiving circuit with the desired volume as determined by the number of pads or elements of the artificial lines which may be connected in the circuit. The connection of these pads or elements to the line is controlled by switching units employing gas-filed thermionic tubes to perform the functions heretofore performed by relays. The arrangement is such that the number of pads or elements of the artificial lines to be cut into the circuit will be dependent upon the voltage of the received pilot channel current. The arrangements of the present invention provide in a system of the above type improved arrangements for controlling the operation of the switching units employing gas-filled tubes and more particularly to improved arrangements for controlling the sequential operation of these switching units. Other objects and features of the invention will appear more fully from the detailed description thereof hereinafter given.

The invention may be more fully understood from the following description, together with the accompanying drawing in the Figures 1 and 2 of which the invention is illustrated. In Fig. 1 is shown a circuit diagram illustrating a switching unit of the invention for cutting in or out of a line an artificial line having a single set of pads or elements. In Fig. 2 is shown a circuit diagram illustrating a plurality of switching units of the invention and means for operating them sequentially to cut in or out of the line a number of artificial lines. Similar reference characters have been utilized to denote like parts in both figures.

In the drawing is shown a transmission line L_{10} in which it may be automatically desired to regulate transmission by means, for example, of a pilot channel current transmitted over the line. Accordingly, there will be included in the line L_{10} an artificial line or network N_1. This network would comprise series and shunt elements. The series element 4 would comprise inductance and resistance. The shunt element 5 would comprise a circuit including inductance and resistance. Networks of this type are well known in the art. The connection in the line L_{10} of the series and shunt elements of the network N_1 is controlled by a switching unit comprising the gas-filled thermionic tubes G_1 and G_2. These gas-filled tubes have the characteristic that when the input voltage applied to the grids is of a certain value, the tubes will operate and an arc of relatively low resistance will be formed between the cathode and plate elements of the tubes. Obviously, when the tubes are in a non-operative condition and no low resistance arc exists, the resistance between cathode and

plate is very high. When the tube G_1 discharges and a low resistance arc is formed in the cathode-plate circuit thereof, the cathode-plate circuit of the tube will close a shunt about the series element 4 of the network N_1. When the tube G_1 is in a non-operative condition the shunt circuit will be effectively opened and the series element 4 will be included in the line. When the tube G_2 operates and a low resistance arc is formed in the cathode-plate circuit of this tube, the cathode-plate circuit will connect the shunt element 5 of the network N_1 across the two sides of the line L_{10}. When the tube G_2 is in a non-operative condition its plate circuit will be effectively opened and the shunt element 5 will not be connected across the sides of line L_{10}.

Each of the tubes would comprise a grid, a cathode, a heating element for the cathode and a plate, as shown. The battery supply circuit for the cathode plate circuit of tube G_2 would be completed from the ground 10, cathode and plate elements of the tube, conductor 11, battery 3 and ground 12. The battery supply circuit for the cathode plate circuit of tube G_1 would be completed from the ground 13, cathode and plate elements of tube G_1, to the battery 3 and ground 12. The operating voltages for the grids of the tubes G_1 and G_2 will be obtained from a circuit including the rectifying tube V_1 whose input will be connected through the selective circuits 2 and 1 across the line L_{10}. A plurality of condensers such as C and inductances such as L have been illustrated. In all cases these elements are to separate the battery plate circuits for the tubes from the transmission path.

The operation of the arrangement of Fig. 1 is as follows: A pilot channel current will be transmitted over the line L_{10} and thence over the selective circuits 1 and 2 to the input circuit of the rectifying tube V_1. The plate circuit of tubs V_1 includes the plate battery E_p and the resistance elements R and R'. It is also connected to the batteries E_{g1} and E_{g2} which supply voltage to the grids of tubes G_2 and G_1, respectively. If the equivalent of line L_{10} is within desired limits, the pilot current in the input circuit of the tube V_1 will be of a normal value. This will produce a current flow in the output circuit of this tube through the resistances R' and R. The current flowing through the resistance R' will produce a voltage drop across said resistance which will be subtracted from the voltage drop of the battery E_{g2} and the current flowing through the resistance R will produce a voltage drop which will be added to the voltage of the battery E_{g1}. When the pilot current is of normal value, the voltage on the grid of the tube G_1 due to the voltage of the battery E_{g1} augmented by the voltage drop across resistance R is of a negative value small enough so that the tube G_1 will discharge. Also, under these conditions, the voltage on the grid of tube G_2 due to the voltage of the battery E_{g2} decreased by the small drop in resistance R' will be of a negative value sufficiently large so that the tube G_2 will be blocked. Under these conditions the plate circuit of the tube G_1 will effectively close a short-circuit about the series element 4 of network N_1 and the plate circuit of the tube G_2 will open the circuit across line L_{10} which includes the shunt element 5 of the network N_1. In other words, when the pilot current is of normal value the network N_1 will be disconnected from the line L_{10}.

If the equivalent of line L_{10} should now change so that the pilot current in the input of the tube V_1 should increase, an increase in the current flowing through the resistance R' will take place. Accordingly, the negative voltage applied to the grid of tube G_2 from the battery E_{g2} will be decreased by a greater potential drop in resistance R'. In other words, the negative potential on the grid of tube G_2 will be so reduced that this tube will now discharge. The increase in the current in the plate circuit of tube V_1 will at the same time increase the potential drop across the resistance R. This will further increase the voltage supplied to the grid of tube G_1 by the battery E_{g1} to such a point where the tube G_1 would not break down if it had not been operated. The tube G_1, however, would not be stopped from its operating condition by this increase in the negative voltage applied to its grid because it has the characteristic that when once broken down, it will discharge regardless of the grid voltage. The break-down and operation of the tube G_2 will cause a current to flow in the plate circuit of this tube. As has been pointed out, this plate circuit is connected by conductor 11 to a point P_2 of a circuit including a combination of capacity C_1 and inductance L_1. Due to the action of the circuit 6 when the current begins to flow in the plate circuit of the tube G_2, the potential at point P_1 in said circuit will be lowered. The lowering of the potential at point P_1 will reduce the current flow in the plate circuit of tube G_1 so that the tube G_1 will cease to discharge. The tube G_1 will remain in an operative condition due to the large negative potential impressed on its grid as heretofore pointed out by the increase in the pilot current. The operation of the tube G_2 will complete a circuit across the sides of the line L_{10} for the shunt element 5 of the network. The deenergization of the tube G_1 will open the short circuit about the series element 4 of the network N_1 and accordingly, the network N_1 will be included in the line when the pilot current increases.

The pilot current coming into the tube V_1 over the line L_{10} will now be decreased by the

inclusion in the line of the network N_1. If the pilot current is sufficiently decreased by the inclusion in the line of the network the pilot level and hence the plate current of V_1 will be within normal limits. If a change in line equivalent causes further reduction of the pilot channel, the voltage on the grid of tube G_1 will be reduced to the point where said tube will break down and operate. This will cause a current to flow in the plate circuit of said tube, which circuit has been pointed out as connected to the point P_1 of the circuit arrangement 6. Due to the action of the circuit 6 when current begins to flow in the plate circuit of tube G_1, the potential at point P_2 will be lowered. The lowering of the potential at point P_2 will stop the flow of current in the plate circuit of the tube G_2. The tube G_2 will then cease to function because the negative potential impressed on its grid has been sufficiently increased by the decrease in the pilot current. Under such conditions the elements of the network N_1 will again be cut out of line L_{10}.

In Fig. 2 is shown a modification of the arrangement of Fig. 1, in which a plurality of artificial lines or networks N_1 and N_2 may be cut in or out of the line in sequence by means of changes in the pilot current and hence compensate for changes in the line equivalent. Similar reference characters have been used in Fig. 2 to denote like parts with respect to Fig. 1. Associated with the line L_{10} would be the networks N_1 and N_2. The network N_1 would have series and shunt elements 4 and 5 adapted to be connected to or disconnected from the line by the cathode plate circuits of the gas-filled tubes G_1 and G_2 in a manner similar to the arrangements of Fig. 1. The network N_2 would have series and shunt elements 27 and 28 adapted to be connected to or disconnected from the line in a similar manner by the cathode plate circuits of the gas-filled tubes G_3 and G_4. The operation of these gas-filled tubes are controlled by the action of the gas-filled tubes G_B and G_A, which in turn are controlled by the currents in the plate circuit of the detector tube V_1. The detector tube V_1 is connected to the line, as in Fig. 1, by the tuned circuits 1 and 2 and is operated by the pilot channel currents transmitted over the line.

The arrangements of Fig. 2 may be more fully understood from the description of their operation, which is as follows:

The pilot current transmitted over line L_{10} will be transmitted over the selective circuits 1 and 2 and applied to the detector tube V_1 and will control the flow of current in the plate circuit of tube V_1 and hence the potential drop in the resistances R′ and R. When the level of the pilot current is within normal limits the potential drop in resistances R′ and R combined with the voltages of batteries E_{g2} and E_{g1} will produce a potential on the grids of tubes G_B and G_A such that these tubes will not break down and operate.

An increase in the pilot current will increase the potential drop in resistance R′ and, as this drop is subtracted from the voltage of battery E_{g2}, the negative voltage applied to the grid of tube G_B will be so reduced that the tube will break down and operate. The plate circuit of tube G_B is completed over a winding of transformer T_1 and battery 15 to ground. Connected to another winding of transformer T_1 is a circuit including a source 16 of alternating current. This alternating current source 16 may be used for quenching the arc in tube G_B when the grid voltage becomes more negative than the critical value. When the tube G_B breaks down and operates the alternating current from source 16 is applied through transformers T_4 and T_6 and T_8 to the grids of tubes G_2 and G_4. On the other hand if the pilot current decreases beyond its normal level a decrease will take place in the potential drop in resistance R and, as this drop is added to the voltage of battery E_{g1}, the negative voltage applied to the grid of tube G_A will be so reduced that the tube will break down and operate. It is pointed out that this reduction in the pilot current will at the same time increase the negative potential applied to the grid of tube G_B beyond the critical value and it will cease to operate. When the tube G_A operates alternating current from the source 16 will be applied thorugh transformers T_3, T_5 and T_7 to the grids of tubes G_1 and G_3. Thus it will be seen that an increase or decrease in the pilot current will cause one of the tubes G_B or G_A to operate and the other to be extinguished. Also the operation of one of said tubes will cause an alternating current potential to be applied to the grids of tubes G_2 and G_4 and the operation of the other of said tubes will cause an alternating current potential to be applied to the grids of tubes G_1 and G_2.

In a manner similar to that heretofore pointed out with respect to Fig. 1 when tubes G_1 and G_3 are operated and tubes G_2 and G_4 are not operated the networks N_1 and N_2 will be cut out of the line. If under the above conditions the pilot current increases, an alternating current potential will be applied to the grids of tubes G_2 and G_4 in the manner heretofore pointed out. This alternating current potential will now operate tube G_2 but will not operate tube G_4 as tube G_4 has a higher negative grid potential normally applied thereto, the grid potential of G_2 being that of battery E_{g4} and the grid potential of G_4 being that of battery E_{g4} and plus battery E_{g6}. The operation of tube G_2 will connect the shunt element 5 of network N_1 across line L_{10}. The operation of tube G_2 will due to circuit 6 cause tube G_1 to be extinguished in a manner similar to that pointed out with respect to Fig. 1. The extinguishing of tube

G_1 will open the short circuit around element 4 and allow this element to be connected in the line. Thus the network N_1 will be cut into the line.

The operation of tube G_2 will cause a current to flow through resistance 14. The potential drop in this resistance 14 will compensate for the voltage of battery E_{g4}. In other words, the voltage drop of resistance 14 will reduce the negative voltage applied to the grid of tube G_4 so that it will now be the same as that applied to the grid of tube G_2. The tube G_4, however, will not necessarily operate at this time because the cutting in of the network N_1 has so reduced the pilot current that tube G_B will not be operated. If the level of the pilot current increases even with network N_1 in the line to the point where tube G_B again operates, then the alternating potential applied to tube G_4 will cause it to operate. In a manner similar to that heretofore described the operation of tube G_4 will deenergize tube G_3 and the network N_2 will be cut into the line.

If, with both the networks N_1 and N_2 cut into the line, the level of the pilot current now decreases the tube G_A will be operated and an alternating current potential will be applied to the grids of tubes G_1 and G_3 as heretofore pointed out. The grid of tube G_1 normally has a higher negative voltage applied thereto than the grid of tube G_3, the voltage on G_1 being that of batteries E_{g2} and E_{g5} and the voltage on G_3 being that of battery E_{g3}. Accordingly, the alternating potential applied to the tubes will operate tube G_3 first. The operation of G_3 will close a short circuit about element 27 and in a manner similar to that heretofore described will through circuit 21 deenergize tube G_4. This will disconnect the network N_2 from the line.

When the tube G_3 operates a current will flow through the resistance 23 and cause a potential drop therein which will compensate for the voltage of battery E_{g5}. In other words the voltage drop in resistance 23 will reduce the voltage applied to the grid of tube G_1 to the same level as that applied to the grid of tube G_3. The tube G_1, however, will not necessarily operate at this time because the cutting out of the network N_2 has so increased the pilot current that tube G_A will not be operated. If the pilot current continues to decrease even with network N_2 cut out of the line to the point where tube G_A again operates, then the alternating current applied to the grid of tube G_2 will cause it to operate. This will cause the deenergization of tube G_2 and will cut out of the line the network N_1.

While the line has been shown with only two artificial lines or networks connected thereto, it is pointed out that additional artificial lines might be provided together with additional switching units similar to those shown for connecting said artificial lines to the transmission line. Accordingly, while the arrangements of the invention have been shown as embodied in certain specific forms which are deemed desirable, it is understood that they are capable of embodiment in many and other widely varied forms without departing from the spirit of the invention as defined by the appended claims.

What is claimed is:

1. A transmission line, a network comprising an element adapted to be connected in series in said line and an element adapted to be connected in shunt in said line, two gas filled thermionic tubes, means for completing the circuit for said shunt element over the cathode plate circuit of the first of said tubes, a short circuit about said series element completed over the cathode plate circuit of the second of said tubes, means controlled by the operation of either one of said tubes for deenergizing the other of said tubes, and means controlled by the voltage of currents transmitted over said line for operating one of said tubes and for supplying a blocking potential for the grid of the other of said tubes.

2. A transmission line, a network comprising an element adapted to be connected in series in said line and an element adapted to be connected in shunt in said line, two gas filled thermionic tubes, means for completing the circuit for said shunt element over the cathode plate circuit of the first of said tubes, a short circuit about said series element completed over the cathode plate circuit of the second of said tubes, means controlled by the operation of either one of said tubes for deenergizing the other of said tubes, and means controlled by an increase in the voltage of currents transmitted over said line for supplying an operating potential for the grid of the first of said tubes and a blocking potential for the grid of the second of said tubes and controlled by a decrease in the voltage of currents transmitted over said line for supplying a blocking potential for the grid of the first of said tubes and an operating potential for the grid of the second of said tubes.

3. A transmission line over which a pilot current is transmitted, a network comprising an element adapted to be connected in series in said line and an element adapted to be connected in shunt in said line, two gas filled thermionic tubes, means for completing the circuit for said shunt element over the cathode plate circuit of the first of said tubes, a short circuit about said series element completed over the cathode plate circuit of the second of said tubes, means controlled by the operation of either one of said tubes for deenergizing the other of said tubes, a rectifier connected across said line by a circuit selective for said pilot current, and means controlled by potential variations in the plate circuit of

said rectifier for varying the operating voltages applied to the grids of said thermionic tubes.

4. A transmission line over which a pilot current is transmitted, a network comprising an element adapted to be connected in series in said line and an element adapted to be connected in shunt in said line, two gas filled thermionic tubes, means for completing the circuit for said shunt element over the cathode plate circuit of the first of said tubes, a short circuit about said series element completed over the cathode plate circuit of the second of said tubes, means controlled by the operation of either one of said tubes for deenergizing the other of said tubes, a rectifier connected across said line by a circuit selective for said pilot current, resistance elements in the plate circuit of said rectifier, and battery supply circuits for the grids of said thermionic tubes connected to said resistance elements whereby the potential drop in said resistance elements may supplement the voltages of said battery supply circuits.

5. A transmission line over which a pilot current is transmitted, a network comprising an element adapted to be connected in series in said line and an element adapted to be connected in shunt in said line, two gas filled thermionic tubes, means for completing the circuit for said shunt element over the cathode plate circuit of the first of said tubes, a short circuit about said series element completed over the cathode plate circuit of the second of said tubes, means controlled by the operation of either one of said tubes for deenergizing the other of said tubes, a rectifier connected across said line by a circuit selective for said pilot current, two resistance elements in the plate circuit of said rectifier, and battery supply circuits for the grids of said thermionic tubes, the battery supply circuit for said first tube being so connected to one of said resistances that the potential drop therein due to the rectified currents will be subtracted from the voltage of said battery supply circuit, the battery supply circuit for said second tube being so connected to the other of said resistances that the potential drop therein due to the rectified currents will be added to the voltage of said battery supply circuit.

6. A transmission line over which a pilot current is transmitted, a network, a switching unit for connecting said network in said line, a rectifier connected across said line by a circuit selective for said pilot current, two gas filled thermionic tubes connected to the plate circuit of said rectifier, means controlled by voltages in the plate circuit of said rectifier for operating either of said thermionic tubes, and means controlled by said tubes for operating said switching unit.

7. A transmission line over which a pilot current is transmitted, a plurality of networks, a plurality of switching units for connecting said networks in said line, a rectifier connected across said line by a circuit selective for said pilot current, two gas filled tubes connected to the plate circuit of said rectifier, means controlled by an initial variation in voltage in the plate circuit of said rectifier for causing the initial operation of one of said tubes, means controlled by the initial operation of one of said tubes for operating one of said switching units, means controlled by the operation of said switching unit for releasing said operated tube, means controlled by a subsequent variation in voltage in the plate circuit of said rectifier for causing the subsequent operation of one of said tubes, and means controlled by the subsequent operation of one of said tubes for operating another of said switching units.

8. A transmission line over which a pilot current is transmitted, a network, a switching unit for connecting said network in said line, a rectifier connected across said line by a circuit selective for said pilot current, two resistance elements in the plate circuit of said rectifier, two gas filled thermionic control tubes, battery supply circuits for the grids of said control tubes, the battery supply circuit for the grid of said first control tube being so connected to one of said resistances that the potential drop therein due to the rectified currents will be subtracted from the voltage of said battery supply circuit and the battery supply circuit for the grid of the other of said control tubes being so connected to the other of said resistances that the potential drop therein due to the rectified currents will be added to the voltage of said battery supply circuit, said switching unit comprising two gas filled thermionic tubes and means whereby the cathode plate circuits of said tubes will control connection in said line of the elements of said network, and means controlled by the operation of said control tubes for applying potentials to the tubes of said switching unit to control their energization.

9. A transmission line over which a pilot current is transmitted, a plurality of networks, each of said networks comprising elements adapted to be connected in series in said line and elements adapted to be connected in shunt in said line, a plurality of switching units for controlling the connection of said networks in said line, each of said switching units comprising two gas filled thermionic tubes, the cathode plate circuits of first of the tubes of each unit controlling the connection in the line of the series elements of said networks, the cathode plate circuits of the second of the tubes of each unit controlling the connection in the line of the shunt elements of said networks, battery supply circuits for the grids of the first set of tubes controlling said series elements,

battery supply circuits for the grids of the second set of tubes controlling said shunt elements, said first mentioned battery supply circuit being adjusted so that when none of the first set of tubes are operated the negative voltage applied by the battery supply circuit to one tube will be less than that applied to the preceding tube and when said one tube is operated the negative voltage applied by the battery supply circuit to the preceding tube will be reduced, said second mentioned battery supply circuit being adjusted so that when none of the second set of tubes are operated the negative voltage applied by the battery supply circuit to one tube will be less than that applied to the succeeding tube and when said one tube is operated the negative voltage applied by the battery supply circuit to the succeeding tube will be reduced, and means controlled by the voltages of the pilot current transmitted over said line for applying voltages to the grids of either of said sets of tubes.

In testimony whereof, I have signed my name to this specification this 23rd day of December, 1931.

WILLIAM H. T. HOLDEN.