

Oct. 27, 1942.

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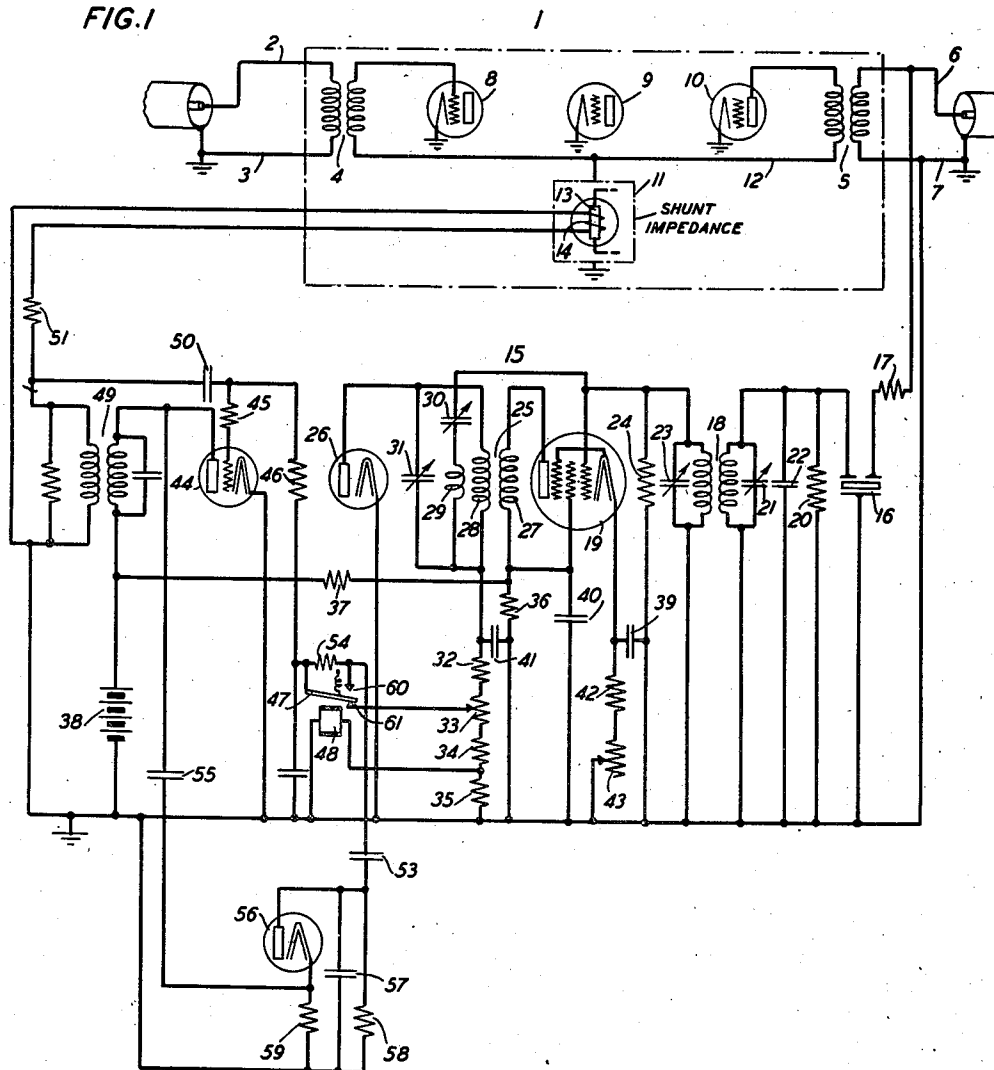
2,300,366

SIGNAL TRANSMISSION SYSTEMS

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2 Sheets-Sheet 1

FIG. 1



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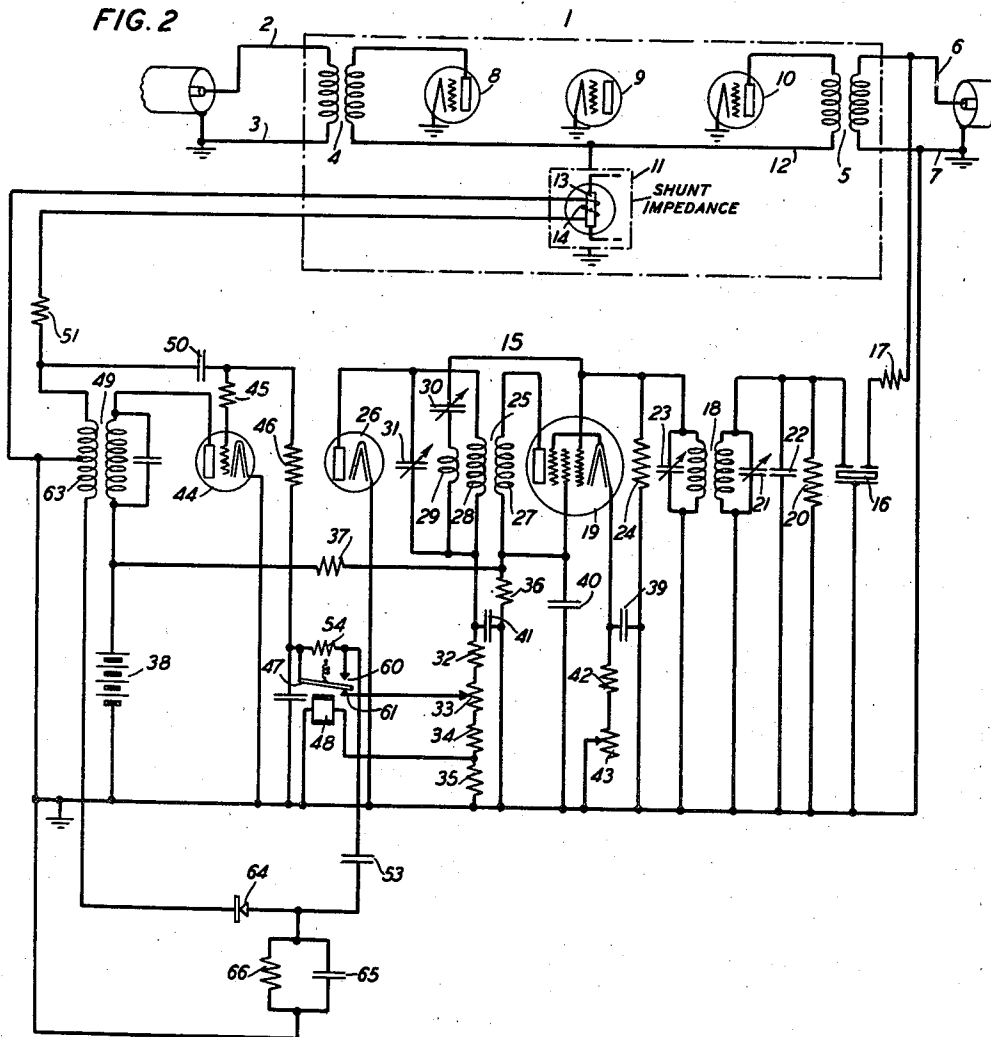
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2 Sheets-Sheet 2



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SIGNAL TRANSMISSION SYSTEM

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Application November 28, 1940, Serial No. 367,515

10 Claims. (Cl. 178-44)

This invention relates to signal transmission systems having gain control amplifiers therein and particularly to signal transmission systems having gain control amplifiers governed by pilot currents.

One object of the invention is to provide a gain control regulator circuit governed by a pilot current that shall hold the regulator circuit in the last operated position to maintain a fixed gain in case of failure of the pilot current.

Another object of the invention is to provide a signal system with a gain control regulator circuit having an oscillator governed by a rectified pilot current that shall have a condenser in circuit across the oscillator input circuit and charged according to the difference between the potential of the rectified pilot current and rectified potential from the oscillator output circuit to maintain the oscillator in a fixed operating position and a fixed gain on the system in case of failure of the pilot current.

A further object of the invention is to provide a signal system having a gain control regulator circuit of the above indicated character that shall disconnect the circuit of the rectified pilot current from the oscillator input circuit in case of pilot current failure and hold the oscillator in a fixed operating position to maintain the gain constant.

In a carrier signal system employing dynamic regulators controlled by pilot current it very often happens that transmission is stopped if there is a failure of the pilot current. The dynamic regulators attempt to restore the pilot strength upon failure of the pilot current so that all the line amplifiers raise to maximum gain. In a long system this results in a large excess gain which causes overloading due to noise or signals and the possibility of singing around part or all of the system through cross-talk paths.

In a signal system provided with a gain control regulator circuit constructed in accordance with the invention a failure of the pilot current does not interfere with the transmission of the signals over the system. Upon failure of the pilot current the regulator circuit is held in its last operated position and no further change in the gain takes place. The regulator circuit is held in this condition for a reasonable length of time until the pilot current is restored.

In one form of the invention a gain control amplifier is provided on the transmission line for controlling the strength of the signal currents. A regulator circuit which is connected to the transmission line beyond the amplifier is pro-

vided for controlling the amplifier in accordance with the amplitude of a pilot current on the line. The regulator circuit comprises a pilot filter connected to the transmission line beyond the amplifier, means for amplifying and rectifying the pilot current from the filter output and an oscillator which is controlled in accordance with the rectified pilot current. The oscillator has a characteristic output-input curve with a sharp or steeply inclined cut-off portion and is operated along the steeply inclined cut-off portion of the curve. The output from the oscillator controls a heater coil, which in turn governs a resistance element in the feedback circuit of the amplifier to control the amplifier gain. The resistance element in the amplifier feedback circuit has a negative temperature coefficient of resistance and may, for example, be composed of silver sulphide.

In a circuit constructed as above set forth a failure of the pilot current will raise the amplifier to maximum gain. In order to prevent raising the amplifier to maximum gain a condenser is connected in series with a resistance element across the input circuit of the oscillator. This condenser is charged in accordance with the negative bias impressed on the grid of the oscillator. The negative bias impressed on the grid of the oscillator in the middle of the oscillator range may be of the order of 4 volts. The condenser connected across the oscillator input circuit is also subjected to a charge from the oscillator output circuit. A portion of the output from the oscillator is rectified and impressed on the above mentioned condenser in opposition to the bias impressed on the grid of the oscillator. This potential obtained from the oscillator output circuit may be of the order of 50 volts so that the condenser has a charge impressed on it of the order of 46 volts, which is the difference between the bias impressed on the oscillator grid and the rectified potential obtained from the oscillator output circuit.

If the pilot current suddenly fails the regulator circuit connection to the input circuit of the oscillator is broken and the voltage difference between that on the above mentioned condenser in the input circuit of the oscillator and the voltage obtained from the rectified output of the oscillator maintains the bias on the oscillator grid. Moreover, if the oscillator output tends to increase due either to a slight loss of charge on the plate of the condenser connected to the grid or to a change in plate voltage supplied to the oscillator, a relatively large increase takes place in the voltage impressed on the condenser from

the oscillator output circuit. This increase in voltage is passed on to the oscillator grid through the condenser which acts in the nature of a bucking battery with a very precisely set voltage and biases the oscillator grid more negatively and hence opposes the rise in the oscillator output. An opposite effect takes place in case the oscillator output tends to decrease.

A relay controlled according to the rectified pilot current on the regulator circuit may be provided for disconnecting the input circuit of the oscillator from the regulator circuit whenever the pilot current fails.

In the accompanying drawings

Fig. 1 is a diagrammatic view of a signal system in accordance with the invention; and

Fig. 2 is a diagrammatic view of a modification of the system shown in Fig. 1.

Referring to Fig. 1 of the drawings an amplifier 1 of the feedback type is shown on a coaxial cable. The input circuit of the amplifier is connected to the cable by input conductors 2 and 3 and a transformer 4. The output circuit of the amplifier is connected to the cable by a transformer 5 and output conductors 6 and 7. The amplifier may be of the type disclosed in the patent of H. S. Black, 2,102,671, December 21, 1937. The amplifier 1 is shown comprising three tubes 8, 9, and 10 which may be of any suitable type. An impedance pad 11 is shown connected across the beta circuit 12 of the amplifier. One element of the impedance pad 11 comprises a resistance element 13 having a high negative temperature coefficient of resistance. This resistance element may be composed of silver sulphide if so desired. The resistance element 13 is controlled by a heater coil 14 in a manner to be hereinafter described to control the gain of the amplifier 1. An increase in the current flow through the heater element 14 decreases the resistance of the resistance element 13 for decreasing the feedback through the beta circuit 12 to increase the gain of the amplifier. A decrease in the current flow through the heater coil 14 produces an opposite action.

A regulator circuit 15 which is controlled by a pilot current on the coaxial cable is provided for controlling the heater element 14 to maintain the pilot output from the amplifier 1 substantially constant. The coaxial cable transmits not only carrier currents but also a pilot current. The pilot current controls the operation of the regulator circuit 15 which in turn controls the gain of the amplifier 1.

The regulator circuit 15 comprises a crystal filter 16 which is connected by a resistance element 17 across the output conductors 6 and 7 of the amplifier 1. The crystal filter 16 selects the pilot current operating the regulator circuit 15. The output circuit of the crystal filter 16 is connected by a double tuned transformer 18 to a pentode amplifier tube 19. A resistance element 20 provides terminating impedance for the crystal filter 16 and the resistance 17 prevents the crystal filter from placing a heavy shunt on the coaxial cable at any frequency. Condensers 21 and 22 effect tuning of the primary circuit for the transformer 18. The secondary circuit of the transformer 18 is tuned by a condenser 23. A resistance 24 provides terminating impedance for the transformer 18. The pentode amplifier 19 is connected by a transformer 25 to a diode rectifier 26. Transformer 25 is provided with a primary winding 27, a secondary winding 28 and an auxiliary winding 29 which is connected by

an adjustable condenser 30 to control grid of the pentode 19 for neutralization purposes. The secondary winding 28 of the transformer 25 is tuned by means of an adjustable condenser 31.

The rectifier circuit for the diode 26 may be traced from the anode of the diode 26 through the secondary winding 28 of the transformer 25 and resistance elements 32, 33, 34 and 35 to the cathode of the diode. Potential for the anode and the screen grid of the amplifier tube 19 is provided by the potential drop across a resistance element 36. The resistance element 36 is connected in circuit with a resistance element 37 to the battery 38. Condensers 39, 40 and 41 associated with the amplifier tube 19 and rectifier 26 serve as by-pass condensers. The resistance element 42 determines the minimum bias on the control grid of the amplifier tube 19 and the adjustable resistance element 43 provides an adjustable bias.

A three-element oscillator tube 44 is coupled to the rectifier circuit in order to control the oscillator tube in accordance with the strength of the pilot current on the coaxial cable. The input circuit to the oscillator 44 may be traced from the oscillator grid through a resistance element 45, resistance element 46, armature 47 of a relay 48, a portion of the resistance element 33, resistance element 34, and the resistance element 35 to the cathode of the oscillator 44. The oscillator 44 is adjusted to have an output-input characteristic curve with a sharply inclined cut-off portion. The oscillator is operated along the sharply inclined cut-off portion of its characteristic curve so that a small change in bias on the grid of the oscillator causes a more than proportional change in the output from the oscillator. A control circuit having an oscillator of this type is disclosed in the patent to R. R. Blair 2,179,915, November 14, 1939. The oscillator 44 is an audio frequency oscillator and preferably oscillates at approximately 2500 cycles per second.

A transformer 49 couples the oscillator output circuit to the heater coil 14. The transformer also provides the necessary grid excitation for the oscillator through a condenser 50. An inductance 51 in the secondary circuit of the transformer 49 is a radio frequency choke which may be a part of a cross-talk filter in the feedback amplifier 1.

In a regulator circuit constructed as above set forth an increase in the strength of the pilot current on the coaxial cable will increase the potential appearing across the resistance elements 33, 34 and 35 to increase the negative bias on the control grid of the oscillator 44. The pilot current as above set forth is selected by the filter 16, amplified by the pentode tube 19 and rectified by the diode tube 26. An increase in the negative bias on the grid of the oscillator tube 44 reduces the oscillator output to reduce the current flow through the heater element 14. This reduces the temperature of the resistance element 13 to increase the feedback through the beta circuit 12 of the amplifier 1. This reduces the gain of the amplifier to reduce the energy level of the signals.

If the energy level of the pilot current and the signals on the cable beyond the amplifier 1 fall below normal value a lower potential drop appears across the resistance elements 33, 34 and 35. Accordingly the negative bias on the grid of the oscillator tube 44 is reduced to increase the current flow through the heater element 14. An

increase in the current flow through the heater element 14 increases the temperature of the resistance element 13 to decrease the resistance thereof. The feedback of the amplifier 1 is thereby reduced to increase the gain of the amplifier on the coaxial cable.

In a regulator circuit constructed as above described without the operation of the relay 48 the failure of the pilot will produce maximum gain by the line amplifier 1. In order to prevent maximum gain in case of pilot failure a memory circuit is provided which holds the regulator circuit in its last-operated position in case of failure of the pilot current. The gain of the amplifier is thus held constant until the return of the pilot current.

A condenser 53 in series with a resistance element 54 is connected to the input circuit of the oscillator 44 so that the condenser 53 has a potential impressed on it according to the negative bias on the control grid of the oscillator 44. The resistance 54 allows the condenser 53 to assume the proper value of charge without heavily damping the oscillator bias. This prevents hunting action. Provision is also made for impressing potential on the condenser 53 according to the output from the oscillator 44. A circuit comprising a condenser 55, a diode 56 and a condenser 57 shunted by resistance element 58 is connected across the output circuit of the oscillator 44. The diode 56 rectifies potential in the oscillator output for impressing the same on the condenser 53. A resistance element 59 is provided for completing the rectifier circuit of the diode 56. In one regulator arrangement the condenser 57 had a potential of the order of +50 volts impressed thereon when the oscillator was in the middle of its operating range. At the same time a bias of -4 volts is impressed on the grid of the oscillator. Under such circumstances the condenser 53 has a potential of 46 volts impressed thereon. The condenser 53 controlled according to the rectified output from the oscillator maintains the negative bias on the grid of the oscillator 44 substantially fixed in case of failure of the pilot current. The relay 48 which operates the armature 47 between contact members 60 and 61 serves to disconnect the resistance elements 33, 34 and 35 and the first part of the regulator circuit 15 from the oscillator 44 in case of pilot failure. The relay 48 also short-circuits the resistance element 54 in case of pilot failure.

If the pilot current suddenly fails the relay 48 is released because no potential appears across the resistance element 35. The armature 47 is then disconnected from the contact member 61 and moved into engagement with the contact member 60. Upon separation of the armature 47 from the contact member 61 the resistance elements 33, 34 and 35 are disconnected from the grid of the oscillator 44. The engagement of the armature 47 with the contact member 60 short-circuits the resistance element 54 and permits the control of the oscillator 44 by the charge on the condenser 53 and the rectified output from the oscillator.

If the oscillator output tends to increase due to a slight loss of charge on the plate of the condenser connected to the grid 53 or to a change in voltage supplied to the oscillator a relatively large increase takes place in the voltage across the resistance element 58. This increase in voltage on the resistance element 58 is passed on to

the oscillator grid through the condenser 53. In this case the condenser 53 acts as a bucking battery with a very precisely set voltage. The above operation biases the grid of the oscillator more negatively to oppose any rise in the oscillator output. In case the oscillator output tends to decrease an opposite action to that described above takes place. The oscillator is operated in this manner according to the charge on the condenser 53 to hold the gain of the amplifier 1 fixed.

Referring to Fig. 2 of the drawings a modified memory circuit is illustrated. The regulator circuit shown in Fig. 2 is the same as the regulator circuit 15 shown in Fig. 1 of the drawings. The same is true of the connections of the regulator circuit to the amplifier on the coaxial cable. Accordingly like parts shown in Fig. 2 to those shown in Fig. 1 have been indicated by similar reference characters. The transformer 49 shown in Fig. 2 of the drawings is provided with an auxiliary secondary winding 63 which serves to energize the memory circuit according to the oscillator output. In the memory circuit shown in Fig. 1 of the drawings the condenser 53 has a potential impressed thereon directly in accordance with the oscillator output potential. In the circuit shown in Fig. 2 the auxiliary secondary winding 63 of the transformer 49 is provided in order that the charge obtained from the oscillator output may be adjusted and to eliminate the potential drop across the resistance 59 shown in Fig. 1.

The relay 48 in Fig. 2 of the drawings operates in exactly the same manner as the relay 48 shown in Fig. 1 of the drawings and the condenser 53 has potential impressed thereon according to the bias on the grid of the oscillator in the same manner as described with respect to the circuit shown in Fig. 1. The circuit connected to the secondary winding 63 of the transformer 49 for impressing a potential on the condenser 53 according to the output from the oscillator 44 comprises a rectifier 64 which is preferably of the copper oxide type and a condenser 65 shunted by a resistance element 66. The memory circuit shown in Fig. 2 operates in the same manner as the memory circuit shown in Fig. 1, the condenser 53 being charged according to the difference between the rectified potential from the oscillator output circuit and the bias impressed on the grid of the oscillator. It may be noted that greater voltage may be impressed on the condenser 53 from the oscillator output in the circuit of Fig. 2 by reason of the blocking condenser 55 and the resistance 59 shown in the circuit of Fig. 1 being eliminated.

Modifications in the systems and in the arrangement and location of parts may be made within the spirit and scope of the invention and such modifications are intended to be covered by the appended claims.

What is claimed is:

1. A signal transmission line carrying signal and pilot currents, an amplifier on said line for controlling the strength of the signal currents, a regulator circuit comprising an oscillator having output and input circuits and controlled by pilot current on said line for governing said amplifier to control the strength of the signal currents, and means comprising a holdover condenser charged according to the difference between the potential across the oscillator input circuit and rectified oscillator output for con-

trolling said oscillator in case of failure of the pilot current.

2. A signal transmission line carrying signal and pilot currents, an amplifier on said line for controlling the strength of the signal currents, a regulator circuit comprising a pilot filter connected to the line beyond said amplifier, means for amplifying and rectifying the output from said filter and an oscillator having an input circuit controlled by the rectified pilot current for governing said amplifier according to the oscillator output, and means comprising a condenser charged from the input and output circuits of said oscillator for controlling said oscillator in case of failure of the pilot current to hold the oscillator output fixed.

3. A signal transmission line carrying signal and pilot currents, an amplifier on said line for controlling the strength of the signal currents, a regulator circuit comprising a pilot filter connected to the line beyond said amplifier, means for amplifying and rectifying the output from said filter and an oscillator having an input circuit controlled by the rectified pilot current for governing said amplifier according to the oscillator output, means comprising a condenser connected to and charged according to the potential across the oscillator input circuit for governing the oscillator in case of failure of pilot current and means for maintaining the oscillator output constant in case of pilot current failure.

4. In a regulator circuit, an oscillator having input and output circuits, a condenser in series with resistance connected across the oscillator input circuit, means for impressing direct current on the oscillator input circuit for controlling the oscillator and for controlling the charge on said condenser and means for impressing rectified current from the oscillator output on said condenser to hold the oscillator output constant in case of failure of the direct current supplied to the oscillator input circuit.

5. In a regulator circuit, an oscillator having input and output circuits, a condenser connected in circuit across the oscillator input circuit, means for impressing direct current on the oscillator input circuit to charge said condenser and control the oscillator operation and means including said charged condenser for holding the oscillator output fixed in case of failure of the direct current impressed on the oscillator input circuit.

6. In a regulator circuit, an oscillator having input and output circuits, a condenser connected in circuit across the oscillator input circuit, means for impressing direct current on the oscillator input circuit for controlling the oscillator operation, means for rectifying a portion of the oscillator output for charging the condenser in opposition to the direct current impressed on the oscillator input circuit so that the oscillator is held in its last operating position in case of failure of the direct current impressed on the oscillator input circuit.

7. In a regulator circuit for controlling the gain of an amplifier on a transmission line, an oscillator having input and output circuits, a condenser connected in series with resistance across the oscillator input circuit, a source of variable pilot current in accordance with which the gain of said amplifier is to be controlled, means for rectifying pilot current from said source and impressing the rectified pilot current on said oscillator input circuit for controlling the oscillator and for controlling the charge on said condenser, and means for rectifying a portion of the oscillator output and for impressing the rectified current on said condenser in opposition to the charge from the rectified pilot current.

8. A transmission line carrying signal and pilot currents, an amplifier on said line for controlling the strength of the signal currents, a regulator circuit connected to the line and comprising a filter for selecting the pilot current, an oscillator controlled by the rectified pilot current, and means for controlling said amplifier according to the oscillator output, a condenser connected in circuit across the oscillator input circuit and having potential impressed thereon according to the rectified pilot current, means for rectifying a portion of the oscillator output and for impressing the rectified output current on the condenser in opposition to the rectified pilot current, and means for breaking the circuit of the rectified pilot current to the oscillator input upon failure of the pilot current.

9. A transmission line carrying signal and pilot currents, an amplifier on said line for controlling the strength of the signal currents, a regulator circuit connected to said line and comprising an oscillator for controlling said amplifier and means for impressing rectified pilot current on the oscillator input circuit, means for rectifying a portion of the oscillator output, a condenser charged according to the difference between rectified pilot current impressed on the oscillator input circuit and the oscillator rectified output, and means for opening the circuit of the rectified pilot current to the oscillator input upon failure of the pilot current to effect operation of the oscillator according to the charge on said condenser.

10. In a regulator circuit, an oscillator having input and output circuits, a condenser connected in circuit across the oscillator input circuit, means for impressing direct current on the oscillator input circuit for charging said condenser and controlling the oscillator operation, means for opening the circuit supplying direct current to the oscillator input circuit in case of failure of the direct current, and means including said charged condenser for holding the oscillator output fixed in case of failure of the direct current impressed on the oscillator input circuit.

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