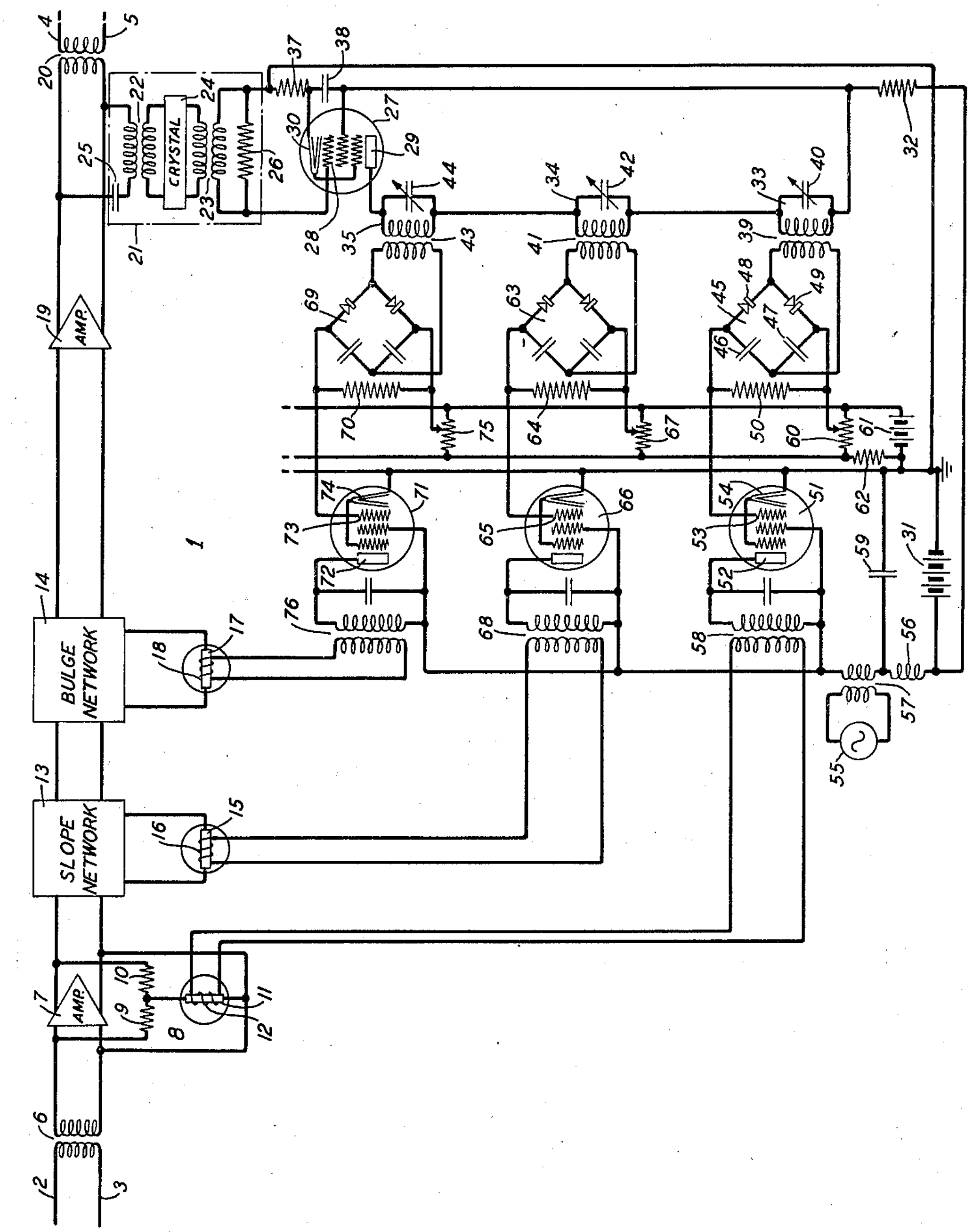
June 17, 1941. H. K. KRIST 2,246,307

SIGNAL TRANSMISSION LINE

Filed April 3, 1940



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Patented June 17, 1941

2,246,307

UNITED STATES PATENT OFFICE

2,246,307

SIGNAL TRANSMISSION LINE

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Application April 3, 1940, Serial No. 327,581

7 Claims. (Cl. 178—44)

This invention relates to signal transmission lines and particularly to signal transmission lines having control circuits for automatically compensating for any change in loss on the transmission lines.

One object of the invention is to provide a signal transmission line having carrier and pilot channels thereon that shall control the flat gain on the line according to the strength of one pilot current on the transmission line and control the line attenuation characteristic according to the strength of another pilot current on the transmission line.

Another object of the invention is to provide a signal transmission line having carrier and pilot channels, a flat gain amplifier, a bulge network and a slope network thereon that shall govern the amplifier, the bulge network and the slope network separately according to the strengths of three pilot currents on the transmission line.

Another object of the invention is to provide a signal transmission line having carrier and pilot channels thereon that shall control the flat gain on the line according to the strength of one pilot current, that shall control the slope of the line attenuation characteristic according to the strength of another pilot current on the line and that shall control the bulge of the line attenuation characteristic according to the strength of a third pilot current on the line.

A further object of the invention is to provide a signal transmission line having carrier and pilot channels thereon that shall govern three low frequency control circuits respectively according to the strengths of three pilot currents on the line and that shall control the flat gain on the line, the slope of the line attenuation characteristic and the bulge of the line attenuation characteristic by said low frequency circuits.

Long transmission systems such, for example, as carrier cable systems are generally provided with flat gain and twist pilot wire regulators which are located at intervals along the cable. These pilot wire regulators may be of the type disclosed in the F. A. Brooks Patent 2,075,975, April 6, 1937. However, it is found that certain over-all losses occur on the pairs of conductors making up a cable for which compensation is not effected.

According to the present invention, terminal or deviation regulators, which are controlled by pilot currents, are provided to compensate for over-all losses that are not corrected for by the flat gain and twist regulators. The deviation regulators not only adjust the flat gain but also the slope and bulge of the line attenuation characteristic.

In the carrier cable system employed to describe the invention, a gain control amplifier, a slope network and a bulge network are placed on each pair of conductors in the cable at the terminal station. Each pair of conductors in the cable is not only provided with carrier channels but also with three pilot channels. The pilot currents on a pair of conductors respectively control the amplifier, the slope network and the bulge network on the associated pair of conductors.

A filter which selects the three pilot currents is connected to the transmission line at a point beyond the flat gain amplifier and the slope and bulge networks. The transmission line may be a pair of conductors in a carrier cable system. The three pilot currents selected by the filter are amplified and supplied to three auxiliary filters which respectively select the three pilot currents. The auxiliary filter which selects the pilot current controlling the flat gain amplifier is connected to a voltage doubler rectifier. The output from the voltage doubler rectifier is opposed by a constant potential for impressing a negative bias on the control grid of a control amplifier. The output from the voltage doubler rectifier is opposed by a constant potential in order to effect a more proportional change for any variation in the strength in the pilot current.

The plate of the control amplifier is supplied not only with direct potential but also with a low frequency alternating current preferably a 60-cycle power current. The output from the control amplifier governs a thermistor connected across the negative feedback circuit of the flat gain amplifier. An increase in the strength of the pilot current on the transmission line which governs the flat gain amplifier increases the negative bias on the control amplifier. An increase in the strength of the negative bias on the control amplifier lowers the heating current supplied to the thermistor in the negative feedback circuit of the flat gain amplifier to increase the feedback and accordingly lower the gain of the amplifier. An opposite effect takes place in case the strength of the pilot current on the transmission line is lowered.

The bulge network on the transmission line is controlled in a similar manner to that of the flat gain amplifier by another pilot current on the transmission line. The auxiliary filter which selects the pilot current governing the bulge network is connected to a voltage doubler rectifier which controls the negative bias on a control amplifier. The control amplifier governs the heating of a thermistor having a negative coefficient of resistance which is included in the bulge network. An increase in the strength of the pilot current on the transmission line which controls the bulge network increases the negative bias on the control grid of the control amplifier. A reduction in the output from the control amplifier lowers the heating of the thermistor in the bulge network to increase the resistance thereon. An increase in the resistance of the thermistor in the slope network increases the loss effected by the bulge network. An opposite effect is produced in the operation of the bulge network in case the strength of the pilot current of the transmission line is lowered.

The auxiliary filter which selects the pilot current for controlling the slope network is connected to a voltage doubler rectifier which impresses a negative bias on the grid of a control amplifier. The control amplifier governs a thermistor having a negative coefficient of resistance in the slope network to control the operation of the network. The control amplifiers employed for governing the slope and the bulge networks are each supplied with low frequency alternating current the same as the control amplifier employed to govern the flat gain amplifier so that the thermistors governing the slope and bulge networks are each controlled by circuits having low frequency currents impressed thereon. The thermistors associated with the flat gain amplifier and the bulge and slope networks may be located at any desired distances away from the control amplifiers. The thermistor included in the slope network is governed in the same manner as the thermistor included in the bulge network. The thermistors may be of the type disclosed in the E. F. Dearborn application Serial No. 280,692, filed June 23, 1939.

The single figure in the accompanying drawing is a diagrammatic view of a transmission system constructed in accordance with the invention.

Referring to the drawing, a terminal or deviation gain control station 1 is shown connected to a transmission line having input conductors 2 and 3 and output conductors 4 and 5. The input conductors 2 and 3 are connected by a transformer 6 to a flat gain amplifier 7 having a negative feedback circuit 8. The negative feedback circuit 8 includes series resistance elements 9 and 10 and a shunt connected resistance element 11. The resistance element 11 has negative temperature coefficient of resistance and is controlled by a heater coil 12. The amplifier 7 is connected to a slope network or equalizer 13 which in turn is connected to a bulge network or equalizer 14. A resistance element 15 having a negative temperature coefficient of resistance is included in the network 13 for control purposes. The resistance element 15 is controlled by a heater coil 16. The bulge network 14 is provided with a resistance element 17 having a negative temperature coefficient of resistance which is controlled by a heater coil 18. The resistance elements 11, 15 and 17 may be of the type disclosed in application of E. F. Dearborn, Serial No. 280,692. The bulge network is connected to an amplifier 19 which in turn is connected by a transformer 20 to the output conductors 4 and 5.

The transmission line is not only provided with a number of carrier channels but also with three pilot channels. The three pilot currents on the transmission line are selected by a main filter 21 which is connected to the transmission line beyond the amplifier 19. The filter 21 which selects the three pilot currents comprises two transformers 22 and 23, a crystal 24, a condenser 25 and a resistance 26 shunted across the secondary winding of the transformer 23. The main filter 21 is connected to the input circuit of an amplifier tube 27 which is preferably of the pentode type. The amplifier 27 is provided with a control grid 28, an anode 29 and a cathode 30. The anode 29 is connected to a battery 31 by a circuit including a resistance element 32 and three auxiliary filters 33, 34 and 35. Negative bias for the control grid 28 of the tube 27 is supplied by the potential drop across a resistance element 37.

The three auxiliary filters 33, 34 and 35 in the output circuit of the amplifier tube 27 select the pilot currents respectively controlling the flat gain amplifier 7, the slope network 13 and the bulge network 14. The slope network 13 in the transmission line may be of the type disclosed in the patent to H. W. Bode 2,096,027, October 19, 1937, or the patent to E. L. Norton, 2,019,624, November 5, 1935. The bulge network 14 may be of the type disclosed in the S. Darlington Patent 2,153,743, April 11, 1939. The circuit from the battery 31 to the tube 27 may be completed to ground through the resistance element 37. The alternating current circuit for the tube 27 may be completed through the condenser 38.

The auxiliary filter 33 which selects the pilot current governing the flat gain amplifier 7 comprises a transformer 39 and an adjustable condenser 40. Preferably in the circuit under consideration, this filter selects a frequency of 12 kilocycles. The auxiliary filter 34 which selects the pilot current for controlling the slope network 13 comprises a transformer 41 and an adjustable condenser 42. The filter 34 preferably in the circuit under consideration selects a frequency of 56 kilocycles. The auxiliary filter 35 which selects the pilot current for governing the bulge network 14 comprises a transformer 43 and an adjustable condenser 44. The filter 35 in the circuit under consideration selects a frequency of 28 kilocycles. The frequencies of the three pilot currents for governing the flat gain amplifier 7, the slope network 13 and the bulge network 14 are selected in a manner to prevent interference between the control of the various pieces of apparatus. Interference between the controls effected by the various pilot currents is prevented by the construction of the networks and the spacing of the pilot currents.

The secondary winding of the transformer 39 is connected to two opposite vertices of a bridge 45 in the form of a voltage doubler rectifier. Voltage doubler rectifiers of this type are disclosed in the patent to D. M. Terry 2,084,115, June 15, 1937. The bridge 45 comprises two condensers 46 and 47 and two rectifiers 48 and 49 which are preferably in the form of copper oxide elements. The output vertices of the bridge 45 are connected across a resistance element 50 which supplies a negative bias for governing a control space discharge device 51. The control space discharge device 51 is preferably in the form of a pentode tube. The two copper oxide elements 48 and 49 in the bridge 45 are oppositely connected so as to effect rectification of each half wave of a current supplied thereto.

The control space discharge device 51 comprises anode 52, a control grid 53 and a cathode 54. Current is not only supplied to the anode 52 from the battery 31 but also alternating current from a low frequency source 55. The source 55 may, if so desired, be a local 60-cycle source of power current. The circuit from the battery 31 through the device 51 may be traced from one terminal of the battery 31 through a choke coil 56, secondary winding of a transformer 57, primary winding of a transformer 58, anode 52 and cathode 54 to the other terminal of the battery 31. The low frequency source 55 is connected to the device 51 by means of the transformer 57. A condenser 59 is provided for completing the alternating current circuit through the device 51.

The potential across the resistance element 50 supplied by the voltage doubler 45 for impressing a negative bias on the grid 53 of the device 51 is opposed by the potential drop across a portion of the resistance element 60. The potential drop across the resistance element 60 is provided by a battery 61 which is connected to the resistance 60 in series with the resistance element 62. The potential drop across the resistance element 50 is opposed by the potential drop across the portion of the resistance element 60 in order to obtain a more than proportional change for any change in strength of the pilot current selected by the auxiliary filter 33.

The space discharge device 51 is governed by the potential variations across the resistance element 50 for supplying low frequency heating current to the heater coil 12 through the transformer 58. The heater coil 12 governs the temperature of the resistance element 11 to control the feedback effected by the amplifier 7. If the pilot current on the transmission line which controls the flat gain amplifier 7 increases in strength, the potential drops across the resistance element 50 increases to increase the negative bias on the grid 53 of the control space discharge device 51. This lowers the output from the device 51 to lower the heating current supplied to the coil 12. The temperature of the resistance element 11 is lowered to reduce the shunt effect thereof in the feedback circuit of the amplifier 7. Accordingly, the feedback of the amplifier 7 is increased to lower the gain effected by the amplifier and therefore to obtain the gain desired. In case the strength of the pilot current on the transmission line decreases, an opposite effect is produced to raise the gain effected by the flat gain amplifier 7.

The secondary winding of the transformer 41 in the auxiliary filter 34 is connected to two opposite vertices of a voltage doubler rectifier 63 which is similar in construction and operation to the voltage doubler 45 above mentioned. The auxiliary filter 34 selects the pilot current employed for governing the operation of the slope network 13. The output vertices of the voltage doubler rectifier 63 are connected across a resistance element 64 which serves to impress negative bias on the control grid 65 of a control space discharge device 66. The control space discharge device 66 is similar in construction and operation to the control space discharge device 51 and is supplied with direct current from the battery 31 and alternating current from the source 55. The potential drop across the resistance element 64 which is impressed on the grid 65 is opposed by the potential drop across the portion of the resistance element 67. The resistance element 67 is energized by the battery 61. The output circuit of the control space discharge device 66 is connected by a transformer 68 to the coil 16 for heating the resistance element 15. The resistance element 15 which has negative temperature coefficient resistance is included in the circuit of the network 13.

If the pilot current on the transmission line which controls the slope network 13 increases in strength the potential drop across the resistance element 64 is increased to reduce the output from the control space discharge device 66. This reduces the low frequency current in the heating coil 16 to reduce the temperature of the resistance element 15. A reduction in the temperature of the resistance element 15 increases the resistance thereof and increases the loss on the line effected by the slope network 13. In case the pilot current governing the operation of the slope network 13 is reduced in strength below normal value then an opposite operation to that described above takes place.

The auxiliary filter 35 which selects the pilot current for governing the operation of the bulge network 14 is connected to a voltage doubler rectifier circuit 69 by means of the secondary winding of the transformer 43. The voltage doubler rectifier circuit 69 is similar in construction and operation to the voltage doubler rectifier circuit 45. The output vertices of the bridge in the voltage doubler rectifier 69 are connected to the terminals of the resistance element 70. The potential drop across the resistance element 70 controls the operation of a control space discharge device 71 which is similar in construction and operation to the control space discharge device 51. The device 71 comprises an anode 72, a control grid 73 and a cathode 74. The negative bias impressed on the control grid 73 by the drop across the resistance element 70 is opposed by a portion of the potential drop across the resistance element 75. The potential drop across the resistance element 75 is effected by a circuit connected to the battery 61. The anode 72 of the device 71 is supplied with alternating current from the source 55 and direct current from the battery 31 in a manner similar to that described with respect to the control device 51. Low frequency control current from the control space discharge device 71 is connected to the heating coil 18 by means of a transformer 76. The heating coil 18 governs the temperature of the resistance element 17 for governing the operation of the bulge network 14.

If the strength of the pilot current on the transmission line which governs the operation of the bulge network 14 increases in strength the potential drop across the resistance element 70 is increased. An increase in the potential drop across the resistance element 70 decreases the low frequency current output from the control space discharge device 71. A decrease in the output from the control space discharge device 71 lowers the current flow through the heating coil 18 to reduce the temperature of the resistance element 17. A reduction in the temperature of the resistance element 17 increases the resistance thereof to increase the loss effected by the network 14.

The slope network 13 governs the slope of the attenuation characteristic of the transmission line and the bulge network 14 governs the bulge of the attenuation characteristic of the transmission line. The two networks 13 and 14 are so operated as to correct for any change in the slope or bulge of the attenuation characteristics.

Modifications in the circuits 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. In combination a signal transmission line having signal and pilot currents thereon, a control station, an amplifier and slope and bulge networks on said line at said station, and means for simultaneously and separately controlling said amplifier, said slope network and said bulge network by different pilot currents on the transmission line to govern the flat gain on the line, the slope of the line attenuation characteristic and the bulge of the line attenuation characteristic.

2. In combination a signal transmission line having carrier and pilot currents thereon, an amplifier and slope and bulge networks on said line, means comprising circuits having low frequency current thereon for separately governing said amplifier, said slope networks and said bulge network, and means comprising said pilot currents for separately controlling said low frequency circuits to govern the flat gain on the line, the slope of line attenuation characteristic and the bulge of the line attenuation characteristic.

3. In combination a signal transmission line having carrier and pilot currents thereon, a control station, a bulge network on said line at said station for controlling the bulge of the line attenuation characteristic, a slope network on said line at said station for controlling the slope of the line attenuation characteristic, means comprising low frequency circuits for separately governing said networks, and means for governing one of said low frequency circuits to control the bulge of the line attenuation characteristic according to the strength of one pilot current on the line and for simultaneously governing another one of said low frequency circuits to control the slope of the line attenuation characteristic according to the strength of another pilot current on said line.

4. In combination a signal transmission line having carrier currents and relatively high frequency pilot currents thereon, a control station, an amplifier on said line at said station for controlling the flat gain, a slope network on said line at said station for controlling the slope of the line attenuation characteristic, a bulge network on said line at said station for controlling the bulge of the line attenuation characteristic, and means simultaneously for controlling said amplifier by one pilot current to govern the flat gain on the line, for controlling the slope network by a second pilot current to govern the slope of the transmission line attenuation characteristic and for controlling the bulge network by a third pilot current to govern the bulge of the transmission line attenuation characteristic.

5. In combination a signal transmission line having carrier currents and three relatively high frequency pilot currents thereon, an amplifier and slope and bulge networks on said line, means comprising low frequency circuits for separately governing said amplifier to control the flat gain on the line, for governing said slope network to control the slope of the line attenuation characteristic and for governing said bulge network to control the bulge of the line attenuation characteristic, and means controlled by said pilot currents for respectively governing the strengths of the low frequency currents on said low frequency circuits for controlling the amplifier gain, the slope network loss and the bulge network loss to maintain the energy of the different frequency currents on said line the same at any desired levels.

6. In combination a signal transmission line having carrier and pilot currents thereon, a control station, an amplifier on said line at said station, a slope network on said line at said station for governing the slope of the line attenuation characteristic, a bulge network on said line at said station for governing the bulge of the line attenuation characteristic, means for separating three pilot currents from the currents on the transmission line and for separating the three pilot currents, means controlled by one of said pilot currents for governing said amplifier to control the flat gain on said line, means controlled by another one of said pilot currents for governing said slope network to adjust the slope of the transmission line attenuation characteristic, and means controlled by the third one of said pilot currents for governing the bulge network to adjust the bulge of the transmission line attenuation characteristic, said last three-mentioned means operating simultaneously.

7. In combination a signal transmission line having carrier and pilot currents thereon, a control station, an amplifier on said line at said station having a feedback circuit, a first network on said line at said station for governing the slope of the line attenuation characteristic, a second network on said line at said station for governing the bulge of the line attenuation characteristic, means for separating said pilot currents from the carrier currents at a point beyond said amplifier and said networks, means for separating three of said pilot currents, means controlled by one of said pilot currents for governing the feedback circuit of said amplifier to control the flat gain of the currents on said line, means controlled by a second one of said separated pilot currents for governing said first network to adjust the slope of the line attenuation characteristic and means controlled by the third separated pilot current for governing the second network to adjust the bulge of the line attenuation characteristic, said last three-mentioned means operating simultaneously.

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