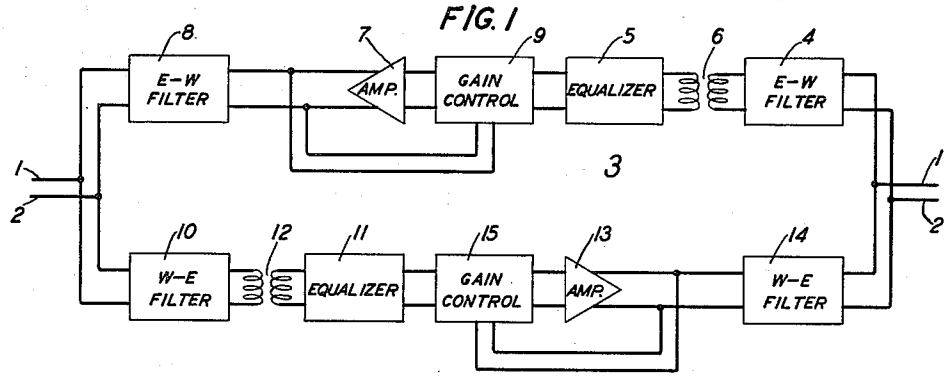
July 28, 1936. R. W. CHESNUT 2,049,195

GAIN CONTROL CIRCUIT

Filed Feb. 9, 1935

FIG. 1



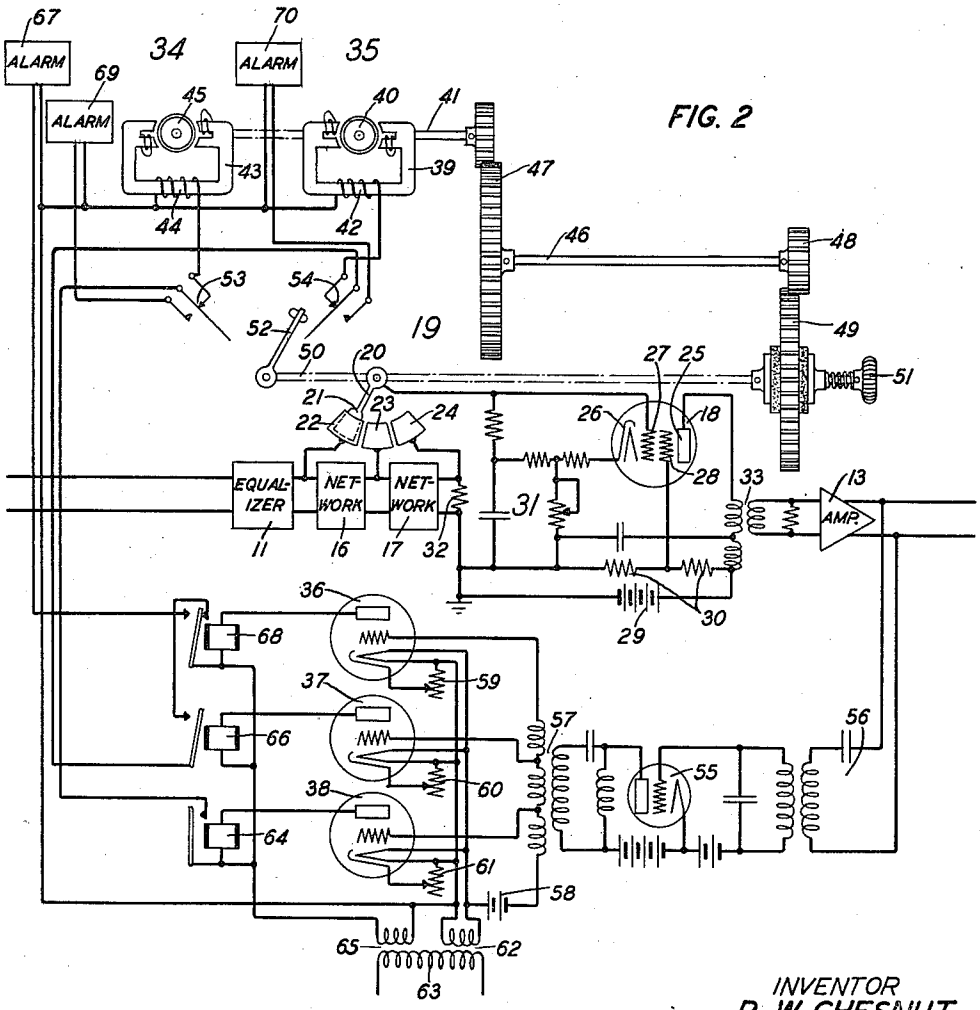


FIG. 2

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GAIN CONTROL CIRCUIT

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Application February 9, 1935, Serial No. 5,696

11 Claims. (Cl. 178—44)

This invention relates to gain control circuits and particularly to gain control circuits for carrier telephone systems.

One object of the invention is to provide a carrier telephone system with gain control circuits that shall maintain the transmission efficiency of the system for the various carrier currents substantially constant in a new and improved manner.

Another object of the invention is to provide a carrier telephone system with gain control circuits that shall control the strengths of the carrier currents according to the strength of a pilot frequency current under the control of marginal space discharge devices.

Another object of the invention is to provide a carrier telephone system with gain control circuits that shall employ gas-filled space discharge devices governed according to the strength of a control current for controlling the connection of an amplifier to impedance networks to hold the strengths of the various carrier currents between predetermined limits.

A further object of the invention is to provide a carrier telephone system with gain control circuits that shall employ gas-filled space discharge devices governed according to the strength of a control current for operating a condenser potentiometer to connect an amplifier to various impedance networks in the system and maintain the strengths of the various carrier currents between predetermined limits.

In carrier telephone systems, a plurality of signals are simultaneously transmitted over a common conducting system through the agency of carrier currents of different frequencies. The attenuation of the system changes in accordance with the variations in line conditions. Variations in the line conditions are due to a number of different causes. The principal cause of variations in line conditions is the change in leakage conditions of the conductors. The attenuation of open wire conductors is much greater during wet weather than during dry weather.

It has been customary to hold the strengths of the carrier currents within predetermined limits by means of attenuation networks operated by relays and switches and governed by a complicated measuring instrument according to the strength of a pilot frequency current. Gain control circuits of this type are expensive to install and to maintain.

According to the present invention, the arrangement of relays and switches under control of a measuring instrument is replaced by gain control circuits employing apparatus having few moving parts. The measuring of the strength of the control or pilot current is effected by gas-filled space discharge devices and a simplified circuit under control of gas-filled devices is provided for controlling an amplifier in the line circuit.

The system employed to describe the invention is a carrier current telephone system employing multi-carrier waves for transmitting signals. Carrier waves within one frequency range are employed for transmitting signals in one direction and carrier waves located within another frequency range are employed for transmitting signals in an opposite direction. A pilot frequency current or control current is transmitted with each range of carrier waves for controlling gain control apparatus to maintain the strengths of the carrier waves between predetermined limits. At a repeater station the east to west line would be controlled by one pilot frequency current and the west to east line would be controlled by the other pilot frequency current.

In the illustrated circuits, attenuation networks are inserted in one side of the line at a repeater station or a terminal station and a gain control amplifier located in the line beyond the attenuation networks has the input circuit thereof selectively connected to the attenuation networks by means of a condenser potentiometer. A line amplifier is preferably inserted in the line beyond the gain control amplifier and beyond the line amplifier is connected a feed-back circuit for controlling the operation of the condenser potentiometer which connects the input circuit of the gain control amplifier to the attenuation networks.

The condenser potentiometer is operated by two hysteresis motors to include more or less of the attenuation networks in the input circuit of the gain control amplifier according to the strength of the pilot frequency current on the line beyond the line amplifier. The two hysteresis motors are directly controlled by three gas-filled space discharge devices. The three gas-filled devices are marginal in their operation and are controlled according to the strength of the pilot frequency current. One of the gas-filled devices is broken down and operated when the strength of the pilot frequency current is raised above a predetermined upper limit. Normally, the other two gas-filled space discharge devices are broken down and in operation. When the high level gas-filled device is broken down, a circuit is completed to energize one of the hysteresis motors for so operating the

condenser potentiometer as to include more of the attenuation networks in the input circuit of the gain control amplifier.

If the high level gas-filled device is released and the low level gas-filled device is released, a circuit is completed for operating the other hysteresis motor. Operation of the second hysteresis motor drives the movable element of the condenser potentiometer in a direction to reduce or decrease the amount of the attenuation networks included in the input circuit of the gain control amplifier. If the high level gas-filled device and the low level gas-filled device are in released position, and the third gas-filled device is released, then an alarm is sounded giving the operator at the station warning that the strengths of the carrier waves at the station have been reduced to very low values.

The three gas-filled space discharge devices which control the operation of the two hysteresis motors and the low level alarm are connected to the line beyond the line amplifier by means of an amplifier and a circuit which is tuned to the frequency of the control current. Alarms are also provided to indicate when the condenser potentiometer has been operated to either of its extreme positions. The attenuation networks which are selectively connected to the input circuit of the gain control amplifier may be attenuation networks of the type disclosed in the patent to R. W. Chesnut et al., No. 1,880,800 dated October 4, 1932.

In the accompanying drawing:

Fig. 1 is a diagrammatic view of a repeater station in a carrier telephone system provided with gain control circuits; and

Fig. 2 is a diagrammatic view of gain control circuits constructed in accordance with the invention.

Referring to Fig. 1 of the drawing, a carrier telephone transmission line comprising conductors 1 and 2 is provided with a repeater station 3. The east to west line of the repeater station 3 comprises a directional filter 4 which selects the carrier waves and the pilot frequency current within the range employed for transmission from the east to the west. The directional filter 4 is connected to an equalizer 5 by means of a transformer 6. The equalizer 5 is connected to a line amplifier 7 and a second directional filter 8. Between the amplifier 7 and the equalizer 5 is provided gain control apparatus 9 for adjusting the strength of the carrier waves according to the strength of the pilot frequency current on the line beyond the line amplifier 7.

The west to east line at the repeater station 3 comprises a west to east directional filter 10 which selects the carrier currents and the pilot frequency current located within the range employed for transmission from the west to the east. The directional filter 10 is connected to an equalizer 11 by means of a transformer 12. The equalizer 11 is connected to a line amplifier 13 and the line amplifier 13 is connected to a second west to east directional filter 14. Between the equalizer 11 and the line amplifier 13 is provided gain control apparatus 15 which is similar to the gain control apparatus 9 employed in the east to west line of the repeater. The gain control apparatus 15 is controlled in accordance with the strength of the pilot frequency current on the line beyond the amplifier 13.

Referring to Fig. 2 of the drawing, the gain control apparatus 15 employed in the west to east line of the repeater is disclosed in detail. Inasmuch as the gain control apparatus 9 employed in the east to west line of the repeater is similar in construction and operation to the gain control apparatus 15, it is deemed unnecessary to describe the apparatus 9 in detail. Two attenuation networks 16 and 17 which may be of the type disclosed in the above mentioned patent to R. W. Chesnut et al. are provided in the line for controlling the operation of a gain control space discharge device 18 in accordance with the operation of a condenser potentiometer 19. The condenser potentiometer comprises a movable arm 20 carrying a condenser plate 21. The condenser plate 21 is movable adjacent to condenser plates 22, 23, and 24. The condenser plate 24 is connected to the line on one side of the network 17. The condenser plate 23 is connected between the networks 16 and 17 and the condenser plate 22 is connected to the line between the equalizer 11 and the network 16. A somewhat similar potentiometer condenser is disclosed and claimed in the application of C. R. Eckberg, Serial No. 5,717, filed February 9, 1935.

The gain control amplifier 18 comprises an anode 25, a cathode 26, a grid element 27 and a screen grid element 28. The grid element 27 of the amplifier 18 is directly connected to the condenser plate 21 of the condenser potentiometer 19. The cathode 26 of the amplifier 18 which is heated in any suitable manner, is connected to the side of the line opposite to that connected to the plates 22, 23, and 24 of the condenser potentiometer. When the input circuit of the amplifier 18 is so connected, it is apparent that movement of the arm 20 and the plate 21 of the condenser potentiometer selectively connects the attenuation networks 16 and 17 in the amplifier input circuit to control the level of the signals in the amplifier output circuit. Plate potential for the amplifier 18 is supplied by a suitable source of direct current 29. Potential for the screen grid 28 is provided by a tap extending from a resistance 30 which is connected across the source 29. Resistance elements 31 are provided for biasing the grid 27 of the amplifier 18. The line beyond the attenuation network 17 is terminated by means of a relatively large resistance 32 which matches the impedance of network 17. The output circuit of the gain control amplifier 18 is connected to the line amplifier 13 by means of a transformer 33.

The arm 20 of the condenser potentiometer 19 is rotated in a forward and in a reverse direction under the control of two hysteresis motors 34 and 35. The hysteresis motors 34 and 35 are controlled by three gas-filled space discharge devices 36, 37 and 38 according to the strength of the pilot frequency current on the line beyond the amplifier 13. The hysteresis motor 35 comprises a horseshoe shaped field structure 39 and an iron or steel rotor 40 which is fixedly mounted on a shaft 41. A coil 42 is mounted on the field structure 39 and shading coils are provided on the pole faces adjacent to the rotor 40. The hysteresis motor 34 is similar in construction and operation to the hysteresis motor 35 and is provided with a field structure 43, an energizing winding 44 and a rotor 45. The rotor 45 is fixedly mounted on the shaft 41. The two hysteresis motors 34 and 35 are so adjusted that energization of the winding 42 of the motor 35 rotates the shaft 41 in one direction and energization of the winding 44 of the hysteresis motor 34 rotates the shaft 41 in an opposite direction. The shaft 41 is connected to a shaft 46 by suitable reducing gears 47. A pinion 48 on the shaft 46 meshes with a gear

wheel 49 which is frictionally mounted on a shaft 50. The shaft 50 carries the arm 20 of the condenser potentiometer 19.

A knob 51 is provided on the end of the shaft 50 for making a manual adjustment of the condenser potentiometer 19. An arm 52 on the opposite end of the shaft 50 controls limiting switches 53 and 54.

An amplifier 55 has the input circuit thereof connected to the line beyond the amplifier 13 by means of a tuned circuit 56. The circuit 56 is tuned to the frequency of the pilot current included in the range of signals employed for transmission from the west to the east. The output circuit of the amplifier 55 is connected by a transformer 57 to the input circuits of the gas-filled devices 36, 37, and 38. A battery 58 provides a normal bias for the grids of the three devices 36, 37, and 38. Adjustable bias for the grids of the devices 36, 37, and 38 is respectively provided by the resistance elements 59, 60, and 61. A transformer 62 which is connected to a source of alternating current 63 provides heating current for the cathodes and potential for the anodes.

The device 38, which may be called the high level device, is normally inoperative and is only broken down to transmit current therethrough when the strength of the pilot frequency current rises above a predetermined upper limit. Upon operation of the device 38, a relay 64 is energized for completing a circuit to operate the hysteresis motor 34. The circuit completed by the operation of relay 64 may be traced from one terminal of the secondary winding 65 of the transformer 62, coil 44 of the motor 34, limit switch 53 and contact members of relay 64 to the other terminal of the secondary winding 65. Upon operation of the motor 34, the arm 20 of the condenser potentiometer 19 is moved towards the right, as viewed in Fig. 2 of the drawing, to increase the attenuation networks included in the input circuit of the gain control amplifier 18.

The gas-filled device 37, which may be called the low level device, is normally broken down and in operation to complete a circuit for energizing a relay 66. If the strength of the pilot frequency current on the line falls below a low level, the device 37 releases and effects release of the relay 66. Upon release of relay 66, a circuit is completed for operating the hysteresis motor 35. The circuit through the hysteresis motor 35 may be traced from one terminal of the secondary winding 65 of the transformer 62, through winding 42 of motor 35, limit switch 54, contact members of relay 66, and contact members of relay 68 to the other terminal of the secondary winding 65. The hysteresis motor 35 operates the arm 20 of the condenser potentiometer 19 towards the left, as viewed in Fig. 2 of the drawing, to decrease the attentuation networks included in the input circuit of the gain control amplifier 18.

The gas-filled device 36 is normally in operation to complete a circuit for energizing the relay 68. The device 36 is only released to break the circuit of the relay 68 when the strength of the pilot frequency current on the line is reduced to a very low level. Upon release of the relay 68 a circuit is completed from the secondary winding 65 for operating an alarm 67.

In case the arm 20 of the condenser potentiometer 19 is moved to its extreme position towards the right, as viewed in Fig. 2 of the drawing, to increase the attenuation in the line and reaches an extreme position, the arm 52 operates the limit switch 53 to effect operation of an alarm 69 and to stop motor 34 by removing power from winding 44. The arm 52 on the shaft 50 operates the limit switch 54 for effecting operation of the alarm 70 and for stopping motor 35 in case the arm 20 of the condenser potentiometer is moved to its other extreme position.

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 line transmitting signal currents and a control current, impedance means on said line for controlling the strength of the currents on the line, measuring means comprising two gas-filled space discharge devices respectively operated by a single backward acting control circuit at upper and lower limits in strength of the control current, and motor means operated in a forward and in a reverse direction by said measuring means to govern said impedance means and hold the strength of the line currents between predetermined upper and lower limits.

2. In combination, a line transmitting signal currents and a control current, attenuation networks on said line, a space discharge amplifier on the line beyond said networks, a condenser potentiometer for connecting the input circuit of said amplifier selectively to said networks to control the strength of the currents on the line beyond said amplifier, measuring means comprising gas-filled space discharge devices operated according to the strength of the control current, and motor means controlled by said measuring means for governing said condenser potentiometer to hold the strength of the line currents beyond said amplifier between predetermined limits.

3. In combination, a line transmitting signal waves and a control current, attenuation networks on said line, a space discharge amplifier on the line beyond said networks, a condenser potentiometer for connecting the input circuit of the amplifier to the line and to selectively connect said networks in circuit with said amplifier, and means for operating said condenser potentiometer according to the strength of the control current to control the strength of the signal waves beyond said amplifier.

4. In combination, a line transmitting modulated carrier waves and a pilot frequency current, attenuation networks on said line, a space discharge amplifier having an output circuit on the line beyond said networks, a condenser potentiometer for connecting the input circuit of said amplifier to the line at various points with respect to said networks, and means for controlling said condenser potentiometer according to the strength of the pilot current to govern the strength of the modulated carrier waves beyond said amplifier.

5. In combination, a line transmitting modulated carrier waves and a pilot frequency current, attenuation networks on said line, a condenser potentiometer connected to the line adjacent to said networks, a space discharge amplifier having an output circuit in the line beyond said networks and having an input circuit connected to the line by said condenser, means comprising marginal space discharge devices for controlling said condenser potentiometer to govern the operation of said amplifier, and means for controlling said marginal devices according to the strength of the pilot current on the line beyond said amplifier.

6. In combination, a line transmitting signal waves and a control current, impedance means comprising a space discharge amplifier for controlling the strength of the currents on the line, motor means operated in a forward and in a reverse direction to control said impedance means, means comprising two marginal space discharge devices for operating said motor means to control the strength of the currents on the line beyond said amplifier, said devices respectively breaking down at upper and lower limits in the strength of said control current, and means operated upon breakdown of one of said devices for controlling said motor means to lower the strength of the currents on the line and operated upon release of the other device for controlling said motor means to increase the strength of the currents on the line.

7. In combination, a line transmitting signal waves and a control current, impedance means for controlling the strength of the currents on said line, motor means operated in a forward and in a reverse direction for controlling said impedance means, means comprising two gas-filled space discharge devices for controlling said motor means to govern the strength of the currents on said line, said devices respectively breaking down at upper and lower limits in the strength of said control current, and means operated upon breakdown of the device breaking down at the upper limit in the strength of the control current for operating said motor means in one direction to control said impedance means and lower the strength of the currents on the line and operated upon release of the device released at the lower limit in the strength of the control current for operating said motor means in a reverse direction to control said impedance means and increase the strength of the currents on the line.

8. In combination, a line transmitting signal waves and a control current, impedance means for controlling the strength of the currents on said line, motor means operated in a forward and in a reverse direction for controlling said impedance means to govern the strength of the currents on the line, means comprising two gas-filled space discharge devices for operating said motor means in a forward and in a reverse direction, one of said devices operating to effect operation of the motor means in one direction and the other of said devices ceasing to operate to effect operation of the motor means in a reverse direction, and means for controlling said space discharge devices according to the strength of the control current.

9. In combination, a line transmitting signal current and a control current, attenuation networks on said line, a space discharge amplifier on the line beyond said networks, control means for connecting the input circuit of said amplifier selectively to said networks to control the strength of the currents on the line beyond said amplifier, means comprising two gas-filled space discharge devices selectively operated according to the strength of the control current on the line beyond said amplifier, said devices respectively breaking down at upper and lower limits in the strength of said control current, motor means for operating said control means and means for operating said motor means upon release of one of said devices and upon operation of the other device for governing said control means to hold the strength of the line currents beyond said amplifier between predetermined limits.

10. In combination, a line transmitting modulated carrier waves and a control current, attenuation networks on said line, a space discharge amplifier on the line beyond said networks, a condenser potentiometer for connecting the input circuit of said amplifier to said networks to control the strength of the line currents beyond said amplifier, motor means for controlling said potentiometer, means comprising gas-filled space discharge devices for controlling said motor means, and means for selecting the control current from the output of said amplifier to control the gas-filled space discharge devices and to hold the strength of the line current beyond the amplifier between predetermined limits.

11. In combination, a line transmitting signal waves and a control current, impedance means on said line for controlling the strength of the currents on the line, three gas-filled space discharge devices operating as marginal devices, means for operaating said devices according to the strength of the control current on the line, one of said devices operating when the strength of the control current rises above a predetermined upper limit and the other two devices ceasing respectively to operate at two lower limiting values in strength of the control current, an alarm, and means controlled by said devices for operating said impedance means to lower the strength of the currents on the line when the strength of the control current is raised above the predetermined upper limit, for operating said impedance means to increase the strength of the currents on the line when the strength of the control currents falls below the first lower limit, and for operating said alarm when the strength of the control current falls below the second lower limit.

ROY W. CHESNUT.