Jan. 5, 1937. J. W. BEYER ET AL 2,066,514

GAIN CONTROL CIRCUITS

Filed April 23, 1936

FIG. 1

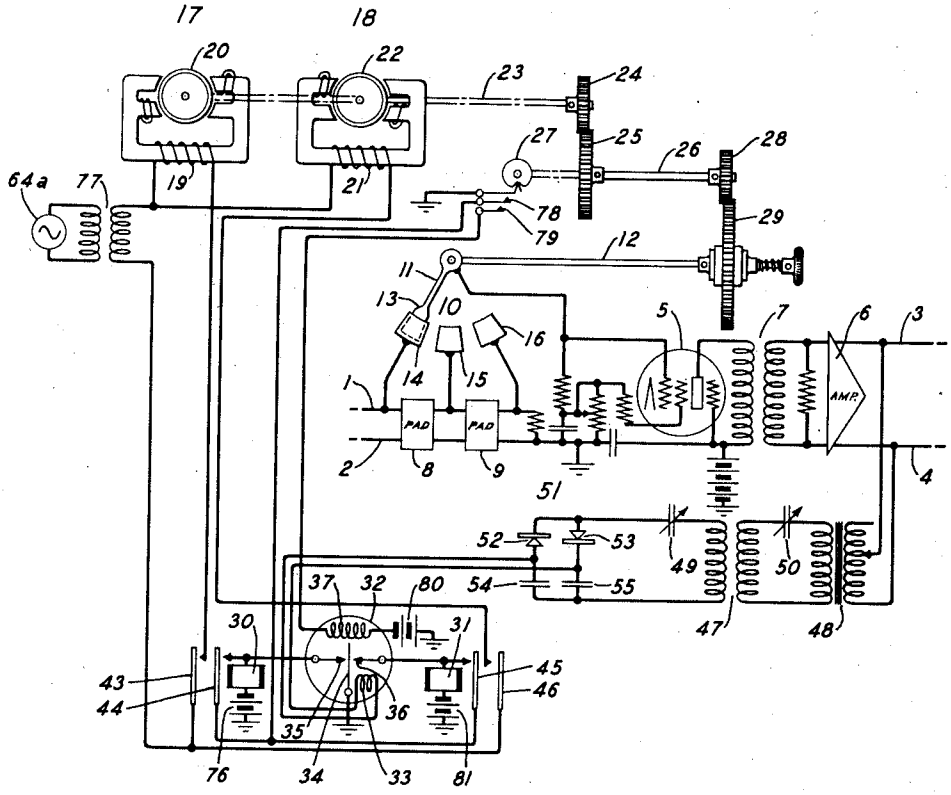


FIG. 2

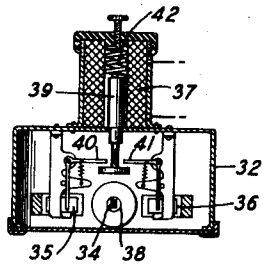
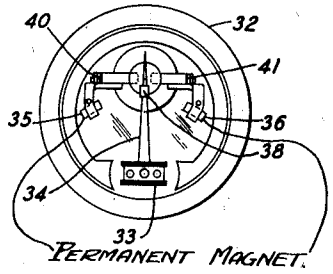


FIG. 3



INVENTORS: J. W. BEYER
D. M. TERRY

BY Wayne B Wells

ATTORNEY

Patented Jan. 5, 1937 2,066,514

UNITED STATES PATENT OFFICE

2,066,514

GAIN CONTROL CIRCUITS

Jesse W. Beyer, Rutherford, N. J., and Donald M. Terry, Brooklyn, N. Y., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application April 23, 1936, Serial No. 76,020

8 Claims. (Cl. 178—44)

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

One object of the invention is to provide a signal transmission system with gain control circuits that shall be operated in a new and improved manner to maintain the energy level of the signals substantially constant.

Another object of the invention is to provide a signal transmission line with a condenser potentiometer for controlling the gain of a line amplifier that shall have a feedback circuit for governing the operation of the potentiometer under control of an improved meter relay operating in a step-by-step manner.

A further object of the invention is to provide a motor operated potentiometer for governing the gain of an amplifier in a signal transmission line that shall be governed in an improved manner by a meter relay according to the energy of the signals on the line beyond the amplifier.

In a carrier telephone system, a plurality of signals are simultaneously transmitted over a common conducting medium by means of carrier currents of different frequencies. The attenuation of a system of this type changes with variations in line conditions. One 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.

According to the present invention an amplifier in a signal transmission line is controlled by a motor operated condenser potentiometer to hold the energy value of the signals in the transmission line beyond the amplifier substantially constant. The motors which operate the condenser potentiometer are controlled by a control circuit having a sensitive meter relay therein. The sensitive relay is operated in a step-by-step manner under control of the motor operating the condenser potentiometer.

The system employed to describe the invention is similar to the system shown in the application of R. W. Chesnut, Serial No. 5,696, filed February 9, 1935 which issued as Patent No. 2,049,195, July 28, 1936. This system is a carrier wave 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. In the illustrated circuits the carrier waves transmitted in one direction are governed by an amplifier under control of a condenser potentiometer. The condenser potentiometer is operated by motors which are preferably constant speed synchronous motors of the type employed in operating electric clocks. The motors operating the condenser potentiometer are controlled by a very sensitive meter relay having a contact arm which is held in either of two operative positions by means of small permanent magnets. The meter relay is provided with restoring means for disconnecting the contact arm from either of the small permanent magnets after operation of one of the motors has been effected. The restoring means of the sensitive meter relay is controlled preferably by means of a cam member operated by one of the motors.

The sensitive meter relay is controlled according to the strength of the pilot or control current on the line beyond the amplifier. A control circuit connects the sensitive relay to the transmission line and includes a selective circuit for selecting the pilot current and a rectifier arrangement for effecting full voltage rectification of the pilot current. The sensitive relay is operated whenever the pilot current voltage is raised or lowered a fixed small amount from a predetermined value.

In the accompanying drawing:

Fig. 1 is a diagrammatic view of a gain control circuit constructed in accordance with the invention;

Figs. 2 and 3 are diagrammatic views of the relay employed to control the motor operated condenser potentiometer shown in Fig. 1.

Referring to Fig. 1 of the drawing a transmission line comprising input conductors 1 and 2 and output conductors 3 and 4 is provided with a gain control amplifier 5 which is connected to a second amplifier 6 by means of a transformer 7. The transmission line shown in Fig. 1 of the drawing may represent one channel of the repeater station as shown in the patent to R. W. Chesnut No. 2,049,195, July 28, 1936. Two attenuation networks 8 and 9 which may be of the type disclosed in the patent to R. W. Chesnut et al., No. 1,880,800 dated October 4, 1932 are provided in the transmission line for controlling the operation of the gain control amplifier 5 in accordance with the operation of an adjustable condenser 10. The condenser 10 comprises a rotat-

able arm 11 mounted on a shaft 12. The arm 11 carries a condenser plate 13. The condenser plate 13 is movable adjacent to condenser plates 14, 15 and 16. The condenser plate 14 is connected to the line conductor 1 on one side of the network 8. The condenser plate 15 is connected to the conductor 1 between the networks 8 and 9. The condenser plate 16 is connected to the line conductor 1 beyond the network 9. A condenser arrangement of this type is disclosed and claimed in the application of C. R. Eckberg Serial No. 5,717, filed February 9, 1935.

The variable condenser 10 is operated by a synchronous motor 17 to raise the gain of the amplifier 5 and is operated by a synchronous motor 18 to lower the gain of the amplifier 5. The synchronous motor 17 comprises a winding 19 and a rotor 20. The synchronous motor 18 comprises a stator winding 21 and a rotor 22. The rotors 20 and 22 of the motors 17 and 18 are mounted on a shaft 23 carrying a pinion 24. The pinion 24 meshes with a gear wheel 25 mounted on a shaft 26. The shaft 26 not only carries the gear wheel 25, but a cam member 27 and a pinion 28. The pinion 28 meshes with a gear wheel 29 on shaft 12 carrying the contact arm 11 of the variable condenser 10.

The two synchronous motors 17 and 18 which rotate in opposite directions are selectively operated by two relays 30 and 31 under control of a sensitive meter relay 32. The sensitive relay 32 which is shown in detail in Figs. 2 and 3 of the drawing comprises an operating coil 33, a contact arm 34 which is adapted to be moved into engagement with contact members 35 and 36 and a restoring coil 37. The contact members 35 and 36 are in the form of small permanent magnets which engage and hold a small iron armature 38 on the contact arm 34 whenever the contact arm 34 is moved to near proximity of either of its operated positions. In order to restore the contact arm 34 to initial or neutral position the restoring coil 37 is energized to attract a core armature 39. The core armature 39 effects operation of two bell crank levers 40 and 41. One or the other of the bell crank levers 40 and 41 engages the contact arm 34 and moves it to neutral position. An adjustable stop 42 is provided for limiting the movement of the core armature 39.

The relay 30 is provided with switch members 43 and 44 and relay 31 is provided with switch members 45 and 46. The sensitive meter relay 32 is operated by means of a feedback circuit connected to the conductors 3 and 4 beyond the amplifier 6. The feedback circuit comprises two transformers 47 and 48 which are tuned by means of condensers 49 and 50 to select the pilot or control current on the transmission line and a full voltage rectifier bridge 51. The rectifier bridge 51 comprises rectifiers 52 and 53 forming two arms of the bridge and condensers 54 and 55 forming the other two arms of the bridge. The output vertices of the bridge 51 are connected to the operating coil 33 of the sensitive relay 32 and the input vertices of the bridge are connected by the transformers 47 and 48 to the transmission line. The two rectifiers 52 and 53 which are preferably of the copper-oxide type are oppositely connected so as to effect rectification of each half of the pilot current voltage. The sensitive relay 32 may be adjusted to effect operation of the contact arm 34 by half a decibel change in the strength of the pilot current.

If the strength of the pilot current on the conductors 3 and 4 is lowered over a half decibel from normal, the strength of the rectified current supplied to the winding 33 of the sensitive meter relay 32 is reduced sufficiently to effect engagement between the contact member 35 and the contact arm 34. A circuit is then completed from a battery 76 for operating the relay 30. The switch arm 43 when operated by the relay 30 completes a circuit from the source of alternating current 64a for energizing the stator winding 19 of the synchronous motor 17. The circuit completed by the switch arm 43 may be traced from one terminal of the secondary winding of a transformer 77 through the switch arm 43 of relay 30 and winding 19 of the synchronous motor 17 to the other terminal of the secondary winding. The synchronous motor 17 is operated to effect movement of the condenser arm 11 carrying the condenser plate 13 towards the left as viewed in Fig. 1 of the drawing. This movement of the condenser plate 13 serves to raise the gain of the amplifier 5. At the same time the cam member 27 is operated to place a ground on contact members 78 and 79. Grounding of the contact member 78 by operation of the cam member 27 serves to complete a holding circuit for the relay 30 from the battery 76 through the switch arm 44. Grounding of the contact member 79 serves to complete a circuit for energizing the restoring coil 37 of the relay 32 from a battery 80. The synchronous motor 17 will continue in operation under control of the relay 30 until the cam member 27 has completed one rotation to open the holding circuit for the relay 30.

If the strength of the pilot current on the transmission line has not been raised to normal value by the above operation, the sensitive meter relay 32 is operated again and the above cycle of operations is repeated. If the strength of the pilot current goes more than a half decibel above normal value, the armature 34 of the sensitive relay 32 is moved to effect engagement between the contact arm 34 and the contact member 36. This operation of the sensitive relay 32 completes a circuit from a battery 81 for operating the relay 31. The switch arm 46 of the relay 31 completes a circuit from the alternating current source 64a for energizing the winding 21 of the synchronous motor 18. The synchronous motor 18 when operated effects movement of the condenser arm 11 in a direction towards the right as viewed in Fig. 1 of the drawing to reduce the gain of the amplifier 5. At the same time the cam member 27 places a ground on the contact members 78 and 79. Placing a ground on the contact member 78 completes a holding circuit for the relay 31 from the battery 81 through the switch arm 45. The placing of ground on the contact member 79 completes a circuit from the battery 80 for operating the restoring coil 37 of the relay 32. The restoring coil 37 returns the contact arm to neutral position in the manner above described. The sensitive relay 32 may be operated by very small changes in strength of the pilot current without producing a so-called chattering effect. The permanent magnet contact members 35 and 36 engage and hold the armature 38 of the contact arm 34 whenever the meter relay armature 34 moves to the near proximity of either of its operated positions. The contact arm 34 is returned to normal or neutral position by means of the restoring coil 37 which operates the bell crank levers 40 and 41. One or the other of the bell crank levers 40 and 41 engages and moves the contact arm 34 to neutral position.

Modifications in the circuit and in the arrange-

ment 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, an amplifier on said line, a relay having a contact arm held in operative position upon operation thereof, means comprising a control circuit connected to the line for operating said relay according to the strength of a pilot current on the line, and means controlled by said relay when operated upon change in the strength of the pilot current on the line for controlling the gain of said amplifier and for returning the relay contact arm to initial position.

2. In combination, a signal transmission line, an amplifier on said line, a potentiometer for controlling the gain of said amplifier, a relay having a contact arm held in operative position upon operation thereof, means comprising a control circuit connected to the line beyond said amplifier for operating said relay according to the strength of a pilot current on the line, and means controlled by said relay when operated upon change in strength of the pilot current for operating said potentiometer for a fixed period and for returning the relay contact arm to initial position.

3. In combination, a signal transmission line, an amplifier on said line, a condenser potentiometer for controlling the gain of said amplifier, a relay having a contact arm held in operative position upon operation thereof, means comprising a control circuit connected to the line beyond said amplifier for operating said relay according to the strength of a pilot current on the line, means comprising a motor controlled by said relay for operating said potentiometer, and means operated by said motor for releasing said contact arm and for insuring operation of the motor for a fixed period.

4. In combination, a signal transmission line, an amplifier on said line, a relay having a contact arm held in operative position upon operation thereof, means comprising a control circuit connected to the line beyond said amplifier for operating said relay according to the strength of a pilot current on the line, a motor operated by said relay upon change in strength of the pilot current, and means operated by said motor for releasing the relay contact arm, for insuring the operation of the motor for a fixed period and for controlling the gain of said amplifier.

5. In combination, a signal transmission line, an amplifier on said line, a condenser potentiometer for controlling the gain of said amplifier, a relay having a contact arm held in operative position upon operation thereof, a control circuit for connecting said relay to the line beyond said amplifier, said control circuit comprising means for selecting a pilot current and full voltage rectifier means, a motor operated by said relay upon change in strength of the pilot current for operating said potentiometer, and means comprising a cam member operated by said motor for releasing the relay contact arm and for insuring the operation of the motor for a fixed period.

6. In combination, a signal transmission line, an amplifier on said line, a condenser potentiometer for controlling the gain of said amplifier, a relay having a contact arm held in operative position upon operation thereof, means comprising a control circuit connected to the line beyond said amplifier for operating said relay according to the strength of a pilot current on the line, and means controlled by said relay upon change in the strength of the pilot current on the line for operating said potentiometer to control the gain of said amplifier and for returning the relay contact arm to initial position.

7. In combination, a signal transmission line, an amplifier on said line, a condenser potentiometer for controlling the gain of said amplifier, a motor for operating said potentiometer to raise and lower the gain of said amplifier, a relay, a control circuit for connecting said relay to the line beyond said amplifier, said control circuit comprising means for selecting a pilot current and full voltage rectifier means, means controlled by said relay for operating said motor, and means effective upon starting of said motor for releasing said relay and for insuring operation of the motor for a fixed period.

8. In combination, a signal transmission line, an amplifier on said line, a condenser potentiometer for controlling the gain of said amplifier, a motor for operating said potentiometer to raise and to lower the gain of said amplifier, a relay having a contact arm held in operative position upon operation thereof, a control circuit for connecting said relay to the line beyond said amplifier, said control circuit comprising means for selecting a pilot current and full voltage rectifier means, means controlled by said relay for operating said motor upon change in strength of the pilot current, and means effective upon starting of said motor for releasing the relay contact arm and for insuring the operation of the motor for a fixed period.

JESSE W. BEYER.
DONALD M. TERRY.