July 16, 1940. J. J. GILBERT 2,208,417

TRANSMISSION SYSTEM

Filed April 7, 1939 2 Sheets-Sheet 1

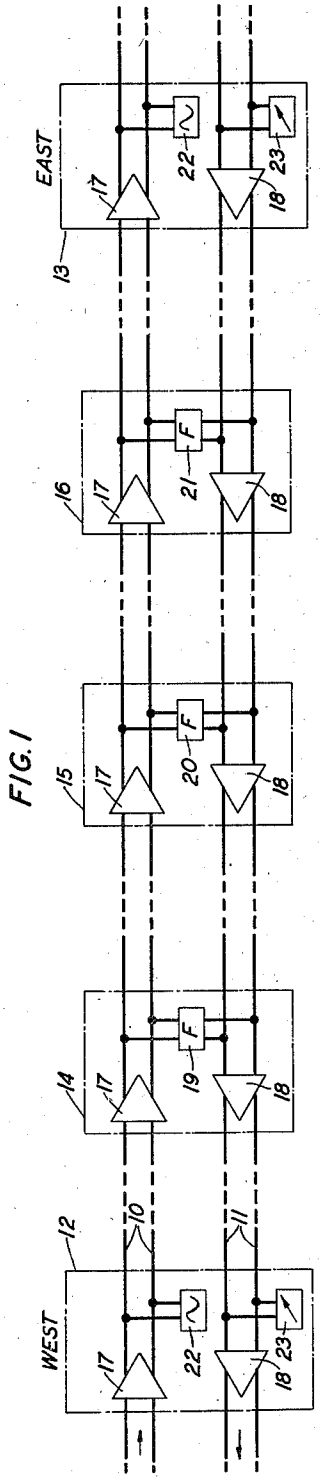

FIG. 1

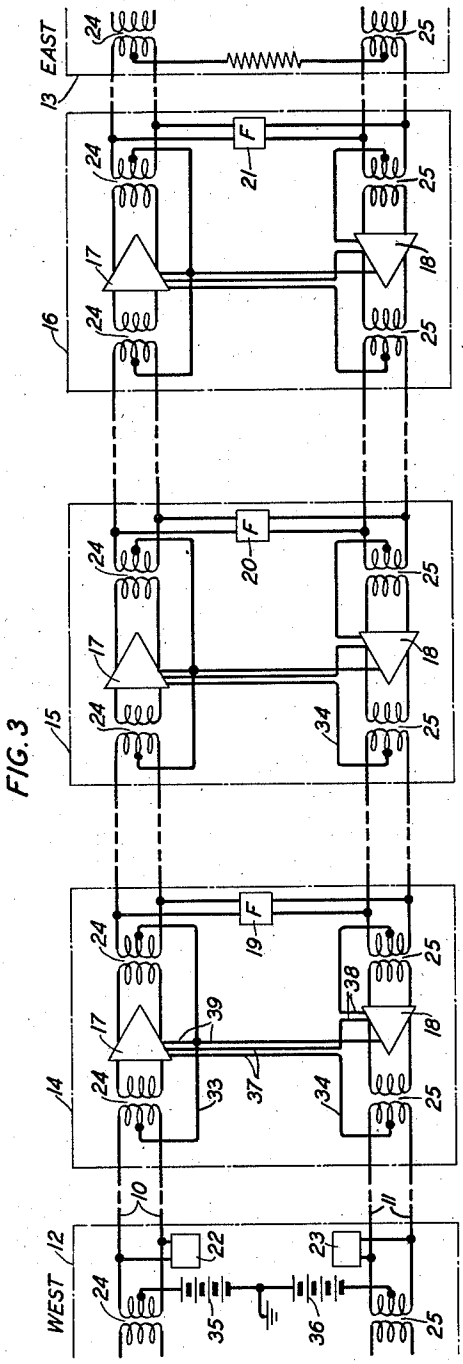

FIG. 3

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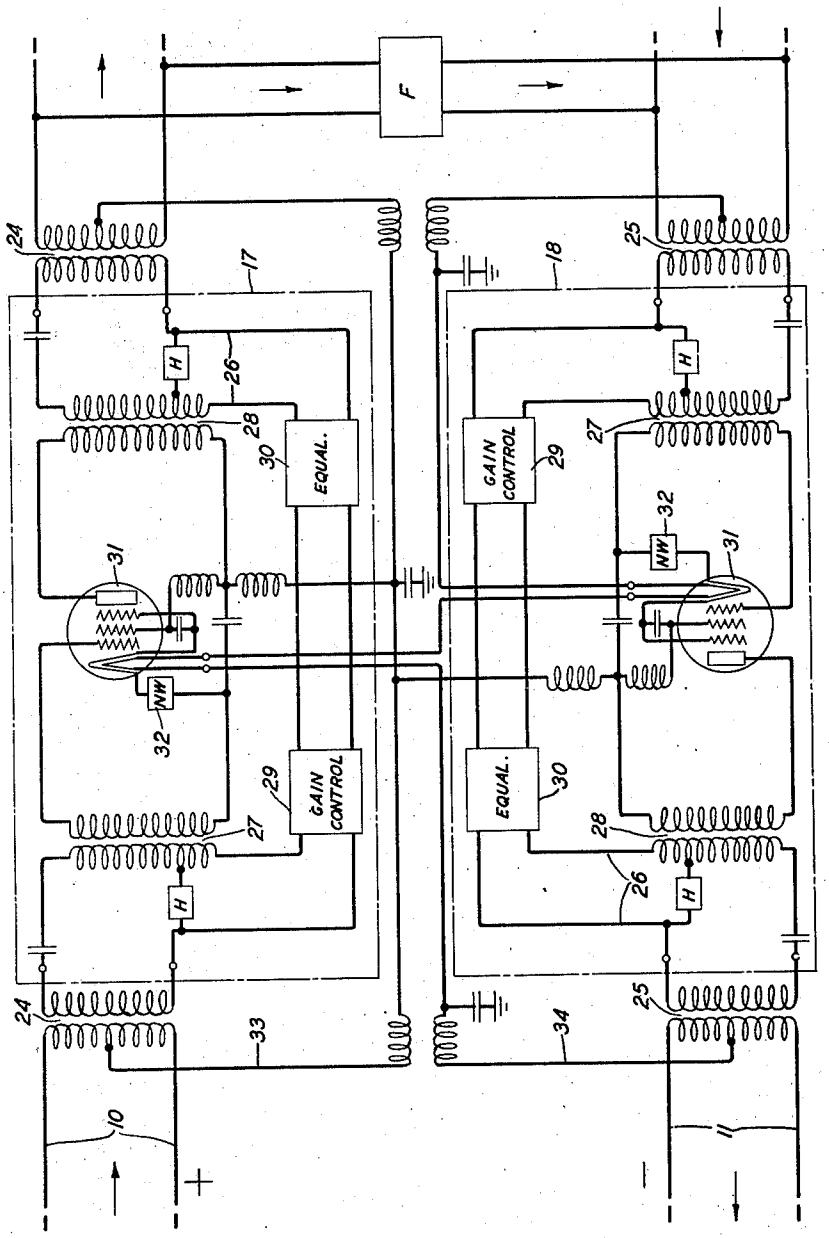

FIG. 2

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TRANSMISSION SYSTEM

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7 Claims. (Cl. 179—175.31)

This invention relates to transmission systems, and, more particularly, to a transmission system including one or more unattended repeater stations between attended stations or between the terminals of the system, and means and a method for testing for faulty repeaters at unattended stations.

Transmission systems are known in which a plurality of repeater stations are located at geographically separated points along a transmission line between attended repeater stations or between the terminals of the line. If a repeater or amplifier at such an unattended station should fail, it would be desirable to be able quickly to determine which one of them it was, or to be able to determine prior to such a failure which of the repeaters at a plurality of unattended stations was faulty, for example, in its amplifying tube, before transmission became affected.

An object of this invention is so to arrange a transmission system including a plurality of spaced attended and unattended repeater stations, that the presence of a faulty repeater at an unattended station may be quickly and simply determined from an attended or a test station.

In accordance with the invention, a transmission system comprising a pair of transmission paths or lines for transmitting electric wave energy in opposite directions and having a plurality of attended and unattended repeater stations at spaced intervals along the transmission line, is provided with means interconnecting the transmission lines or paths of opposite direction at each unattended station so that a preassigned different test signal for each unattended station may be sent from and received at a test or attended station over the system and through each unattended repeater station to give information as to the operating condition of the repeater station. The interconnecting means may comprise a filter at each unattended station connecting one line on the output side of the repeater or amplifier therein to the other line on the input side of the repeater or amplifier therein.

A more complete understanding of the invention will be obtained from the detailed description which follows read with reference to the appended drawings, wherein:

Fig. 1 shows a transmission system embodying the invention;

Fig. 2 shows the repeaters or amplifiers at an attended or at an unattended station; and

Fig. 3 illustrates how power may be supplied from an attended repeater station in the system of Fig. 1 to one or more unattended repeater stations.

Fig. 1 shows a transmission system extending between geographically separated points or regions comprising a transmission path or line 10 for transmitting electric wave energy in one direction, for example, from west to east, and another transmission path or line 11 for transmitting electric wave energy in the opposite direction, i. e., from east to west. Such electric wave energy might be communications or other signal energy superimposed on a wave of carrier frequency, and the transmission paths could be adapted for the transmission of a single carrier wave in each direction, or for the transmission of a plurality of carrier wave frequencies distributed over a preassigned frequency band, for example, the system could be one adapted for twelve-channel carrier operation utilizing a 12 kilocycles to 60 kilocycles frequency band. The transmission lines may comprise pairs of insulated wires buried in the ground; or, two pairs of conductors in a buried or a suspended lead-covered cable; or, pairs of wires especially insulated for pole line construction; or a pair of submarine cables.

A plurality of attended repeater stations 12, 13 are provided at geographically separated points along the transmission lines, and a plurality of unattended repeater stations 14, 15, 16 at smaller separations are provided intermediate the attended stations. If the transmission system is not a long one, the attended stations could be the terminal stations of the system and only one unattended station might be required between them. At each repeater station there is an amplifier 17 for amplifying electric wave energy incoming thereto and being transmitted in one direction, for example, from west to east, and an amplifier 18 for amplifying electric wave energy incoming thereto and being transmitted in the opposite direction, i e., from east to west.

At each unattended repeater station, the transmission paths of opposite direction are interconnected by a filter or other signal discriminating network 19, 20, 21, connecting the line 10 on the output side of an amplifier 17 with the line 11 on the input side of the amplifier 18. Each network 19, 20, 21 passes a different, preassigned, single frequency or a narrow band of frequencies outside of the useful band of the amplifiers, i. e., in a system for transmission in the band of 12 kilocycles to 60 kilocycles, outside of that frequency band and preferably above 60 kilocycles. Sufficient transmission loss is provided in the

pass-band of the filter to prevent singing or overloading of the repeaters. These various single frequencies or narrow frequency bands are furnished by a suitable source 22, for example an oscillator, connected across the line 10 at an attended station, and adapted to provide, under control of the attendant at the attended station, each of the unattended stations between it and the next attended station with its appropriate preassigned frequency or narrow frequency band. Recording, indicating or measuring means 23 is connected across the line 11 at each attended station, whereby, as explained more fully hereinafter, the frequency or frequency bands originating in the source 22, transmitted to each unattended repeater station, passed by the lines-interconnecting network thereat, and returned along line 11, afford evidence of the condition of the amplifiers at the unattended stations. In Fig. 1, attended station 12 would be a test station in this respect for the unattended stations 14, 15, 16, and attended station 13, a test station in this respect for unattended stations (not shown) at points farther to the east along the transmission paths.

Fig. 2 shows the circuit arrangement for an unattended repeater station. So far as concerns the amplifiers 17 and 18, however, the attended stations are the same. The amplifiers 17, 18 are substantially identical, and specific description of one is equally applicable to the other, like elements bearing corresponding identifying numerals. The input and output terminals of amplifier 17 are coupled to the line 10 through repeating coils 24, and the corresponding terminals of amplifier 18 are coupled to line 11 through repeating coils 25. The amplifier 17 is a single-stage feedback amplifier incorporating stabilized negative feedback as disclosed in H. S. Black Patent 2,102,671, issued December 21, 1937, the amplifying or μ-path of the amplifier being connected to the feedback path 26 through hybrid coils 27, 28, including the networks H, as taught in the aforesaid Black patent and in the pending H. S. Black application, Serial No. 114,390, filed December 5, 1936. The feedback path may include gain control means 29 and an equalizer network 30. The amplifying device or tube 31 may be a pentode having a cathode of the indirectly heated type. A network 32 may be connected in the cathode lead in accordance with D. D. Robertson Patent 1,994,486, issued March 19, 1935, to minimize any tendency for the amplifier to sing at some frequency outside of the transmission range. Heating current for the heater elements of the amplifying devices and anode and screen grid potentials are obtained over the transmission lines, either from the terminals of the system or from an attended station, through the connections 33 and 34 coupling the mid-points of the line windings of the repeating coils 24, 25 in the lines 10, 11, respectively. The impedances in the connections 33, 34 are of high impedance to signal frequencies.

Fig. 3 shows how anode and screen potential and cathode heater or filament heating current may be supplied to the unattended repeater stations from an attended station. The power supply may comprise the batteries 35, 36, the former having its positive terminal connected to the mid-point of the line winding of the repeating coil 24 at station 12, and its negative terminal together with the positive terminal of battery 36 connected to ground, the battery 36 having its negative terminal connected to the mid-point of the line winding of repeating coil 25 at station 12. As already noted with reference to Fig. 2, the mid-points of the line windings of the repeating coils in each line are interconnected by connections 33, 34, connections to the cathode heater being made through conductors 37, 38 and to the screen grids and anodes through conductors 39.

The arrangement described hereinabove provides a quick and simple means and method for locating faulty repeaters or line sections intermediate repeaters or for periodic testing of the condition of repeaters, by operations conducted entirely at an attended station. In the disclosed embodiment of the invention, station 12 constitutes the test station with respect to the unattended stations 14, 15, 16. In case of an interruption which affects transmission without affecting the power supply, the repeater station at fault may be readily determined by using source 22 to apply to the line 10 test tone of appropriate frequency or frequencies corresponding to the pass-band of network 19, and detecting through the measuring device 23 the extent to which the test tone is returned over transmission line 11 to the test station. If the tone is received properly and satisfies preassigned requirements indicative of satisfactory transmission and amplification condition of the amplifiers at the unattended station, another test tone corresponding to the pass-band of network 20 is applied to the line 10 and picked off line 11; and likewise for the succeeding unattended repeater station, the deviation in the detected test tone from its proper character if the particular unattended repeater station's amplifiers were not faulty, indicating which unattended station is responsible for the interruption in transmission over the system. The test tones should be chosen, of course, in a frequency region where the net loss of the system is not so high as to prevent reception of the test tone through noise.

It is desirable not only to be able to determine at which unattended station trouble exists that impairs or interrupts transmission, but it is of importance to ascertain the condition of the amplifying devices or tubes so as to have forewarning of the necessity of replacing them before transmission is affected. The amplifier being of the stabilized negative feedback type would be equalized over a much broader band than the transmission band. If the transmission band is 12 kilocycles—60 kilocycles, the equalization provided might cover the range of 8 kilocycles—100 kilocycles. Periodic tests using test tones in the frequency region at the upper limit of the range for which the amplifier is equalized provide an index to the condition of the tubes before the effect of impairment becomes appreciable in the transmission band. This follows because there will be very little feedback at the highest frequencies transmitted, and thus the gains of the amplifiers will vary according to the condition of the tubes.

Although this invention has been disclosed with reference to a specific embodiment thereof, it will be understood that it is to be considered as limited only by the scope of the appended claims.

What is claimed is:

1. A transmission system comprising a test station; a transmission line outgoing from said test station; a transmission line incoming to said test station; a plurality of unattended repeater stations at spaced intervals along each of said

lines between geographically separate points; a repeater for outgoing transmission and a repeater for incoming transmission being located at each unattended station; filter means at each repeater station bridging said lines, each filter means passing a preassigned frequency band outside of the transmission frequency band; and means at said test station for sending test frequency bands over said outgoing line to each repeater station to determine the operating condition of the repeaters thereat.

2. A transmission system comprising a test station; a transmission line outgoing from said test station; a transmission line incoming to said test station; a plurality of unattended repeater stations at spaced intervals along each of said lines; a repeater for outgoing and a repeater for incoming transmission being located at each unattended station; filter means connected between the outgoing and the incoming transmission lines at each unattended station on the output side of the outgoing repeater and the input side of the incoming repeater, each of said filter means having a different pass-band outside of the transmission band; and means at said attended station for sending a test frequency band over said outgoing line, through the filter adapted to pass said band and said incoming line to measuring equipment at said attended station for determining the condition of the repeaters at each unattended station.

3. A transmission system comprising a test station; one or more unattended repeater stations at spaced intervals between said test station and a remote point; a transmission line for conducting signal waves from station-to-station in one direction through said system, a transmission line for conducting signal waves from station-to-station in the reverse direction through said system; a repeater at each of said unattended stations for repeating the signal waves in one direction, and a repeater for repeating the signal waves in the reverse direction; and means interconnecting the transmission lines at each unattended repeater station for frequencies outside of the band of the signal waves the system is designed to transmit.

4. In a transmission system, a transmission line for transmitting signal waves of a preassigned frequency band in one direction; a transmission line for transmitting said frequency band in the opposite direction; a repeater in each transmission line, said repeaters being located at the same station; and means at said repeater station interconnecting said transmission lines for a signal wave of frequency content outside of said preassigned frequency band, whereby said latter wave transmitted from one end of the system to said repeater station is utilized to test the condition of the repeaters thereat.

5. In a transmission system comprising a test station; and one or more unattended repeater stations between the test station and a geographically remote point; a transmission line for conducting signal waves from station-to-station in one direction through said system; a transmission line for conducting signal waves from station-to-station in the opposite direction through said system; a repeater at each of said unattended stations for repeating the signal waves in one direction, and another repeater for repeating signal waves in the opposite direction; and means operatively interconnecting the transmission lines at each unattended repeater station for frequencies outside of the band of the signal waves the system is intended to transmit; the method of testing the condition of the repeaters at each unattended station which comprises transmitting over one transmission line to each repeater station a different preassigned signal wave outside of the transmission band and measuring the character of the signal received at said test station over the other transmission line for each of said unattended repeater stations.

6. In a transmission system comprising a transmission path for signal waves to pass in opposite directions, and a repeater station intermediate the ends of said path, said station including repeater means for signal waves passing in each direction; the method of testing the condition of said repeater means which comprises impressing at one end of the path a test signal wave of a frequency outside the band of frequencies that the system is designed to transmit, causing said test signal wave to pass through and around said repeater means to return to its originating point, and measuring the strength of the signal wave received at its originating point.

7. In a transmission system having one or more unattended repeater stations and an attended repeater or test station, means interconnecting the transmission paths of opposite direction at each unattended station so that a preassigned different test signal for each repeater station may be sent from and received at the test station over the system and through each repeater station to give information as to the operating condition of the repeater station.

JOHN J. GILBERT.