

Aug. 10, 1943.

A. C. DICKIESON

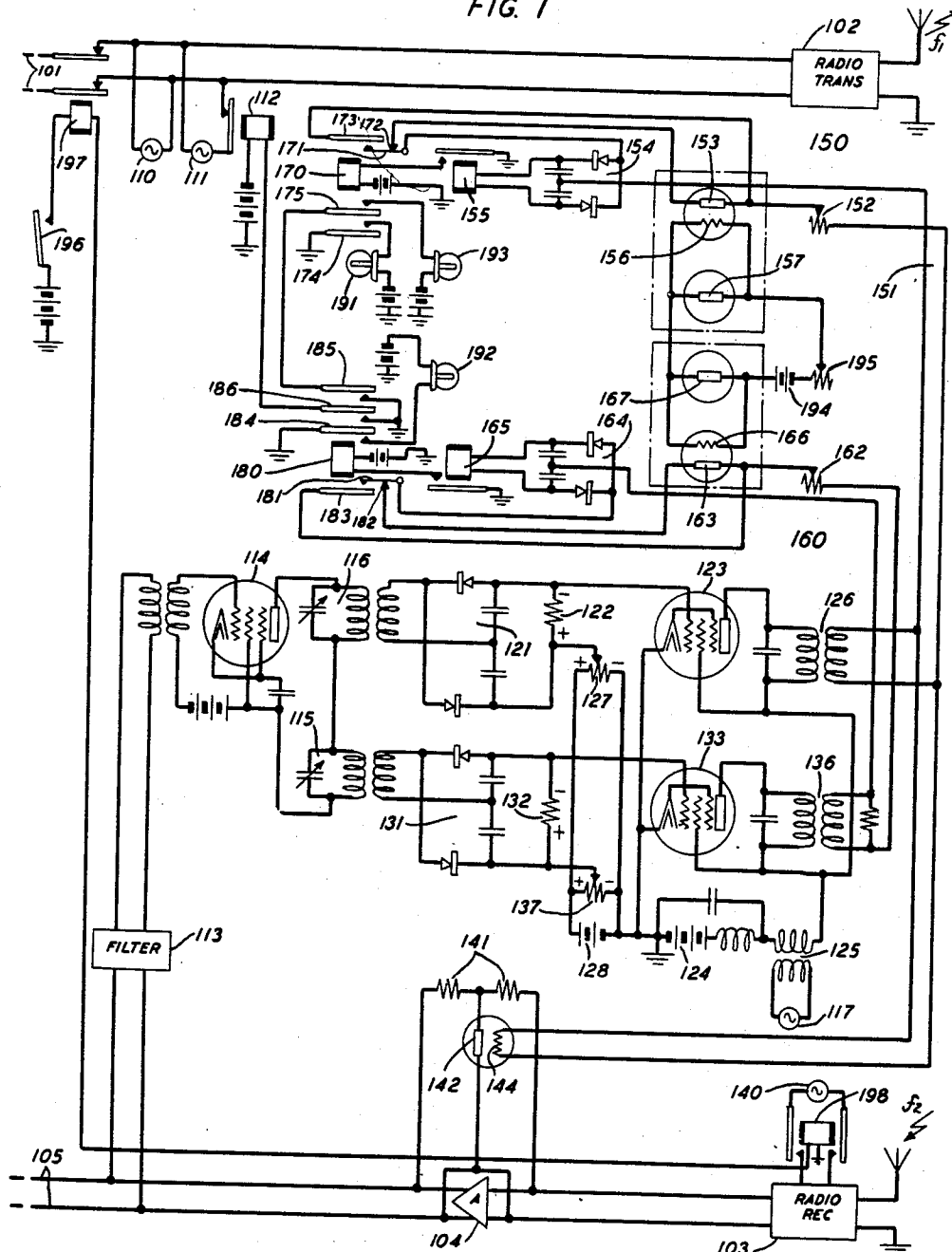
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ALARM AND TESTING CIRCUIT

Filed July 30, 1941

2 Sheets-Sheet 1

FIG. 1



INVENTOR
A. C. DICKIESON
BY *George C. Ford*
ATTORNEY

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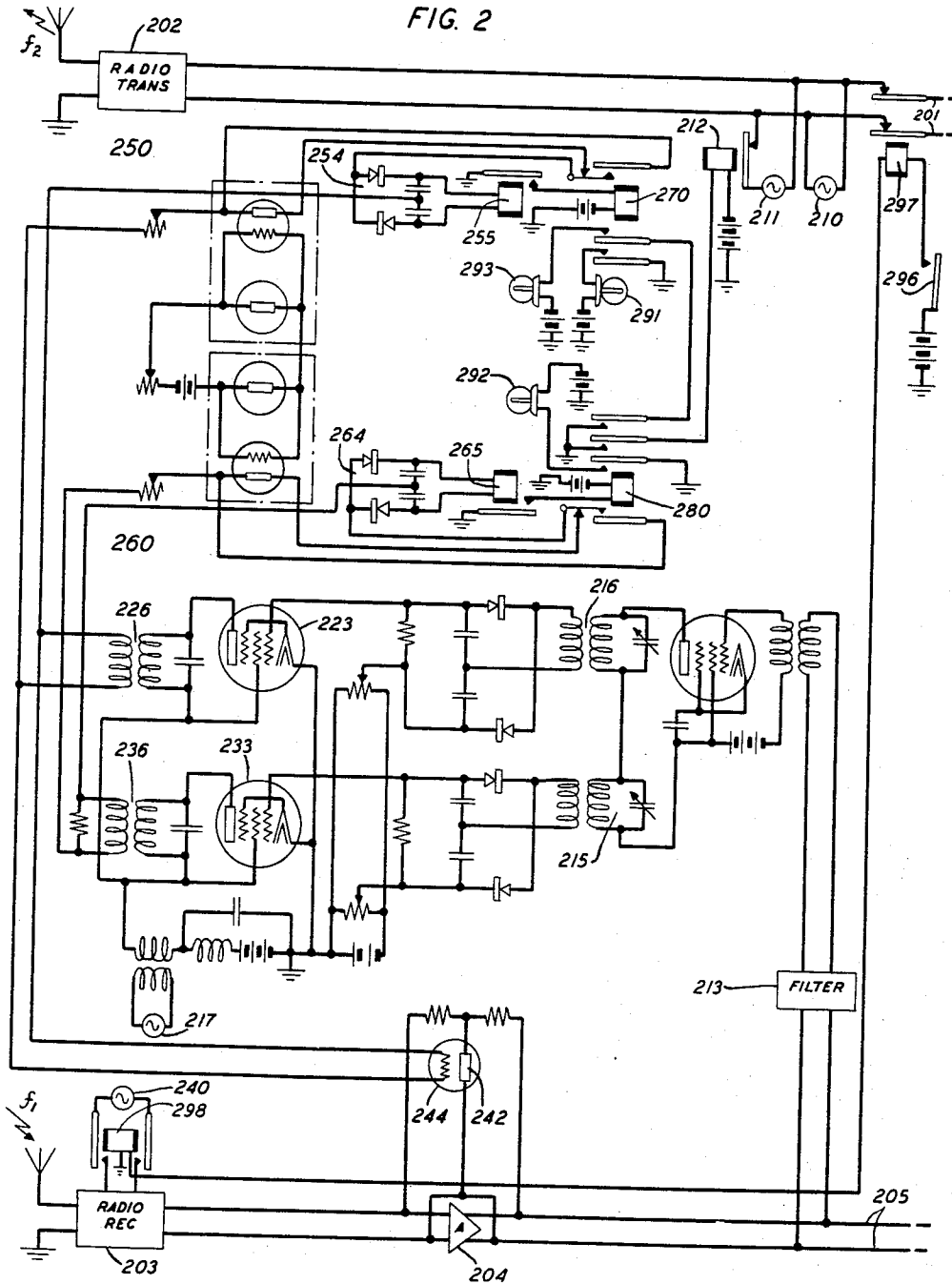
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FIG. 2



INVENTOR
A. C. DICKIESON
BY *George C. Tol*
ATTORNEY

UNITED STATES PATENT OFFICE

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ALARM AND TESTING CIRCUIT

Alton C. Dickieson, Mountain Lakes, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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6 Claims. (Cl. 250—6)

This invention relates to alarm and testing circuits for communication systems and particularly for two-way radio telephone or other communication systems employing separate one-way paths for two-way communication.

In the use of radio links in commercial telephone systems, it is often desirable that the operation be conducted without the continual attendance of technically trained personnel. Accordingly it is desirable to provide alarm systems which will not only operate on failure of any of the apparatus but will also give an indication as to that portion of the apparatus to which the difficulty has occurred so that a technician can be immediately notified and the system restored to an operative condition with a minimum loss of time. Even where technically trained personnel are in constant attendance the length of service interruption can be reduced by the use of a system which gives an automatic indication of the point of failure.

An object of the invention is to provide a simple and effective system for giving an alarm in the case of failure of a communication system and for indicating the source of the failure.

A further object of the invention is to provide an alarm system that will give an indication at both terminals of a two-way transmission system in case of a failure of transmission in either direction or apparatus failure at either terminal.

In accordance with a feature of the present invention, two pilot currents are transmitted from each terminal of a two-way radio communication system. At one terminal the transmission of one of these pilots is placed under the control of the reception of the corresponding pilot from the other terminal and is only transmitted when that pilot is received. Transmission of the other pilot is similarly controlled at the other terminal. Accordingly lights or other alarms made responsive to the pilots received at each terminal will give an indication at both terminals in the case of failure of transmission in either direction. When such a pilot controlled alarm system is combined with the so-called near end loop test, in which the receiver at a terminal is made responsive to waves from the transmitter at the same terminal, the system can be used to give an indication of the source of any transmission failure. It is also possible to use one or both of the pilot currents for transmission regulation as well as the alarm function.

The operation of the invention with respect to these and other features can be more readily understood from the following detailed descrip-

tion of one embodiment of the system in a two-way radio telephone system as shown in schematic circuit form in the drawings in which Fig. 1 shows one terminal of the system and Fig. 2 the other terminal.

The system shown in the drawings comprises a two-way radio telephone system of the multiplex type in which twelve carrier channels in the range of 12 to 60 kilocycles on the carrier telephone line 101 are supplied to a radio transmitter 102 wherein they are caused to modulate a radio carrier of frequency f_1 for radiant transmission. At the other terminal the radio transmitter 202 handles a similar group of multiplex channels from the line 201 for transmission as modulations of a radio carrier of frequency f_2 . At this terminal a radio receiver 203 receives the modulated radio wave of frequency f_1 from the first terminal, the resultant demodulated waves in the output of the receiver 203 comprising the group of channel carriers are amplified in the amplifier 204 and supplied to the carrier line 205.

At the first terminal a similar radio receiver 103 receives the modulated radio frequency carrier f_2 from the transmitter 202 of Fig. 2 and supplies the resultant demodulated signal comprising the carrier channels through the carrier amplifier 104 to the carrier line 105.

At each terminal the pair of one-way carrier lines 101—105 and 201—205, respectively, will terminate in carrier terminal apparatus which is not shown as it bears no direct relation to the present invention.

While the system of the present invention is shown in the drawings as applied to a multiplex radio system in which a group of carrier telephone channels are handled by the radio equipment, it relates to an alarm or indicating system operating as an adjunct to the communication system and is equally applicable to other types of systems; for example a radio system for the transmission of a single voice frequency channel or to four-wire line systems for either voice or carrier communications.

For the purposes of this invention there are transmitted from the terminal of Fig. 1 two pilot currents of different frequencies produced by the generators 110 and 111. These currents are supplied to the input of the radio transmitter 102 and are radiated, along with the carrier channels, as modulations of the radio frequency carrier. In the present embodiment in which carrier channels in the frequency ranges referred to above are transmitted, the current from the generator 110 is preferably of a frequency of 28 kilo-

cycles and that from the generator 111 of a frequency of 12 kilocycles. Current from generator 110 is transmitted at all times and that from the generator 111 is under control of reception of a similar pilot current from the terminal of Fig. 2. For this purpose, the connection of the generator 111 to the input of the radio transmitter 102 is under control of the relay 112.

At the terminal of Fig. 2 similar pilot current generators 210 and 211 are applied to the input of the radio transmitter 202. The connection of the generator 211 to the transmitter is under control of the relay 212. This arrangement is identical to that of the arrangement of the terminal of Fig. 1 except in this case the frequency of the generator 210 for the continuously transmitted pilot is 12 kilocycles and that of the generator 211 for the controlled pilot is 28 kilocycles. In other respects as well the terminal of Fig. 2 is identical with that of the terminal of Fig. 1, the only difference between the two terminals being with respect to the frequency of the pilots and consequently of the frequency characteristics of the apparatus for handling them and responsive thereto.

Returning to the circuit of the terminal of Fig. 1, the pilot currents in the output of the radio receiver 103 are separated from the signal waves (channel carriers) by the filter 113 which may be, for example, of the piezoelectric crystal type to provide sharp selectivity between the pilot currents and the signal currents. The output of this filter is supplied to a pentode amplifier 114.

Connected in the output circuit of the amplifier 114 are two filters 115 and 116 of the tuned circuit type for separating the two pilot currents from each other. The filter 115 is responsive to 12 kilocycles which is the frequency of the pilot tone continuously transmitted from the terminal of Fig. 2. The filter 116 is selective to 28 kilocycles which is the frequency of the control pilot tone transmitted from the terminal of Fig. 2.

The output of the filters 115 and 116 are supplied to individual circuits for controlling the transmission of 60-cycle current from the source 117. The two control circuits are identical. That for the output of filter 116 will be described in detail.

The output of filter 116 is supplied to a voltage doubler rectifier 121 of the conventional type which develops a voltage across the load resistor 122 proportional to the amplitude of the 28 kilocycle current applied to the rectifier. This voltage is utilized for operating the control vacuum tube 123.

Space current for the control tube 123 is obtained from a battery 124 in series with the secondary winding of the transformer 125, the primary of which is connected to the 60-cycle source 117. Also included in the plate circuit is the primary of a tuned transformer 126 from which the 60-cycle output to the alarm control circuit is taken.

The 60-cycle output from the tube 123 through the transformer 126 is controlled by the voltage variation across the resistor 122, connected in the control grid circuit of the tube 123. This resistor is connected in series with the potentiometer 127 across which there is developed a fixed biased voltage due to the current from the battery 128. The voltages across the potentiometer 127 and the resistor 122 oppose each other in their action on the tube 123. Thus the voltage from the potentiometer 127 is such as to maintain a positive voltage on the grid and that from the re-

sistor 122 to make the grid negative. In the absence of any 28 kilocycle input to the rectifier 121, the voltage across the resistor 122 is zero and the control grid of tube 123 is at maximum positive value determined by the adjustment of the potentiometer 127. This provides a maximum value of 60-cycle current in the output transformer 126. In the presence of the 28 kilocycle pilot current input to the rectifier 121, there will be developed across the resistor 122 a voltage which opposes the voltage from the potentiometer 127 causing a marked decrease in the 60-cycle output current of the transformer 126. As this 28 kilocycle current varies in amplitude, the 60-cycle output from the transformer 126 will also vary, being decreased for increases in the pilot current and vice versa. This action occurs under normal operating conditions and the varying 60-cycle current is used for regulating the gain of the line amplifier 104 as will be described immediately below. Upon the interruption of the 28 kilocycle input to the rectifier 121 for any reason, there will result a marked increase in the amplitude of the 60-cycle output of the transformer 126. This is utilized for operating the alarm circuit of the present invention as will be later described.

For the purpose of regulating the gain thereof, the line amplifier 104 is provided with a negative feedback path including the series connected resistors 141 and the shunt connected thermistor 142. (The term thermistor is used in this application as meaning a resistor having a high temperature coefficient of resistance.) For the purpose of regulating its resistance the thermistor 142 is provided with a heating winding 144.

The 60-cycle output current from the transformer 126 is supplied to the heating winding 144 so that the temperature and consequently the resistance of the thermistor 142 is controlled to regulate the gain of the amplifier 104. Thus, if the amplitude of the received 28 kilocycle pilot current increases in strength the voltage drop across the resistor 122 also increases to increase the negative bias on the grid of the tube 123. This lowers the 60-cycle output from the tube 123 to lower the heating current supplied to the winding 144. As a result the temperature of the thermistor 143 is lowered and its resistance is increased to reduce the shunting effect thereof in the feedback path. Accordingly the feedback of the amplifier 104 is increased to lower the gain of the amplifier 104 and therefore to bring about a compensating decrease in the amplitude of the 28 kilocycle pilot supplied to the rectifier 121. In case the amplitude of the pilot current decreases an opposite effect is produced to raise the gain of the amplifier 104.

The secondary winding of the tuned circuit 115 which selects the 12 kilocycle pilot is supplied to a circuit identical with that to which the output of the filter 116 is supplied. This includes a voltage doubler rectifier 131 with its load resistor 132 which is connected in series with the potentiometer 137 to the control grid of the tube 133. By means of this circuit the 60-cycle output from the transformer 136 is controlled in response to the 12 kilocycle input from the filter 115 in the same way that the 60-cycle output from the transformer 126 is controlled.

As has just been described, there is obtained from the transformers 126 and 136 a supply of 60-cycle current under respective control of the 28 kilocycle and 12 kilocycle pilot currents ob-

tained from the output of the radio receiver 103. The 60-cycle currents are supplied through the leads 151 and 161 to the alarm and control circuits. Rheostats 152 and 162 are included in the respective circuits for providing a means for controlling the operating sensitivity of such alarm and control circuits.

The leads 151 and 161 are connected to similar circuits 150 and 160 respectively to supply the 60-cycle currents thereto for operating the control and alarm functions.

The circuit 150 will first be described in detail. The 60-cycle current in the leads 151 is supplied through a thermistor 153 and the contacts 171, 172 of a relay 170 to a voltage doubling rectifier 154. The output of the rectifier 154 is connected to the operating winding of a relay 155. The constants of the circuit are so chosen that under normal conditions, there will be insufficient voltage applied to the rectifier 154 to operate the relay 155. Upon a failure of the 28 kilocycle pilot frequency, there will be a sharp increase in the 60-cycle current applied to the circuit. Since the resistance of the thermistor 153 is very high compared to the rest of the circuit most of this applied voltage will appear across the terminals of the thermistor 153 causing it to absorb power. As the thermistor heats up, its resistance will be reduced and after a period, for example of about 10 seconds practically the full input voltage will be impressed across the input of the rectifier 154. This will cause a direct current voltage to build up across the winding of the relay 155 causing that relay to operate. The operation of relay 155 causes the operation of relay 170 by closing the circuit through its winding.

The operation of relay 170 will open or close various circuits as follows:

The closing of the circuit between the armature 173 and the contact arm 171 before the opening of the circuit between arm 171 and contact 172 will by-pass the input current around the thermistor 153 before removing the thermistor from the circuit. This arrangement allows the thermistor to begin cooling off once the alarm condition has registered and insures a full, slow operate period for conditions of intermittent operation;

The operation of the armature 174 will close the circuit causing the alarm lamp 191 to light; and

The operation of the armature 175 will close half of the operating circuit for the lamp 193.

The circuit 160 is similar to the circuit 150 including a thermistor 163, a voltage doubling rectifier 164, a first relay 165 and a control relay 180.

The control relay 180 includes an armature 183 with an associated contact arm 181 and contact 182 which operates in the same manner as the corresponding elements of the relay 170 for controlling the connection of the thermistor 163 to the circuit. The armature 184 controls the operation of the signal lamp 192. The armature 185 is connected in the control circuit for the lamp 193 so that when both of the relays 170 and 180 are operated, the lamp 193 will be lighted. The armature 186 controls one of the outgoing pilots and thus when the relay 180 is operated, a circuit is completed from ground through armature 186 and its associated contact, winding of relay 112 and battery to ground. The operation of the relay 112 disconnects the pilot frequency source 111 from the input to the radio

transmitter 102 so that when no 12 kilocycle pilot frequency is received by the radio receiver 103, no 12 kilocycle pilot frequency is transmitted by the radio transmitter 102.

Since the characteristics of the thermistors 153 and 163 are quite variable with changes in temperature, an ambient temperature control circuit is provided to insure a fairly constant slow operate time over the normal range of operating temperatures. For this purpose each thermistor 153 and 163 has built therein a heater winding (156 and 166) which keeps the internal temperature of the respective thermistor at a fixed temperature. For this purpose current is obtained from a battery 194 which flows through a regulating rheostat 195 to the heater windings 156 and 166 in series. Each of the heater windings 156 and 166 has connected in parallel therewith a compensating thermistor 157 and 167, respectively. These compensating thermistors are exposed to the ambient temperature and will change their resistance to control the amount of current flowing through the heaters and maintain the control thermistors 153 and 163 at a fixed temperature.

There is also provided a circuit for a so-called near end loop test. This circuit is operated by closing the switch 196 which causes current to flow from battery through switch 196, winding of relay 197, winding of relay 198 to ground. The operation of relay 197 opens the connection from the input of the transformer 102 to the carrier line 101. The operation of relay 198 connects a source of beating oscillations 140 to the first detector of the radio receiver 103 which is of the superheterodyne type. The frequency of the oscillations produced by source 140 is the difference between the transmitted frequency (f_1) and the received frequency (f_2). As a result when such oscillations are applied to the receiver 103, it will be responsive to the radio frequency f_1 from the transmitter 102 as well as to the frequency f_2 from the radio transmitter 202 at the other terminal.

As stated above the circuit of the terminal of Fig. 2 is identical with that of Fig. 1 except for a symmetrical rather than identical arrangement with respect to the frequencies of the pilot currents transmitted and received. Accordingly, similar circuit elements of Fig. 2 have been given the same numbers as those of Fig. 1 except in the 200 series rather than the 100 series.

Referring briefly to Fig. 2, the 12 kilocycle pilot current from the source 210 is continuously transmitted while the transmission of the 28 kilocycle pilot from the source 211 is under control of the receipt of the 28 kilocycle pilot from the transmitter 102. This control as well as the control of the alarm lamps is effected in the same way as at the terminal of Fig. 1. Thus, the pilot currents transmitted from the terminal of Fig. 1 after detection in the receiver 203 are separated from the carrier channels by the filter 213. The two pilot currents are then separated from each other by the tuned circuit filters 216 and 215, the filter 216 being selective to the 12 kilocycle pilot and the filter 215 to the 28 kilocycle pilot. The 12 kilocycle pilot then operates through the control tube 223 to regulate the 60-cycle output from transformer 226 and the 28 kilocycle pilot operates through the control tube 233 to regulate the 60-cycle output from transformer 236.

These 60-cycle currents operate through the circuits 250 and 260 respectively to control the relays 270 and 280 so that upon the failure of the

receipt of a 12 kilocycle, control relay 270 will be operated and upon the failure of the receipt of the 28 kilocycle control relay 280 will be operated. The operation of relay 270 lights the alarm light 291. The operation of relay 280 operates the alarm lamp 292 and the operation of both relays 270 and 280 lights alarm lamp 293. In addition to the action of lighting the alarm lamps the operation of relay 280 will also operate relay 212 to interrupt the connection of the 28 kilocycle source 211 to the transmitter 202 and prevent the transmission thereby of the 28 kilocycle pilot.

In addition to the alarm functions the 60-cycle output from transformer 226 under control the 12 kilocycle pilot also operates to regulate the gain of the amplifier 204. For this purpose, it is supplied to the heater winding 244 for the thermistor 242 which is connected in the feedback path of the amplifier 204.

The terminal of Fig. 2 like that of Fig. 1 is arranged to permit the near end loop test. For this purpose, the switch 296 is closed to operate the relays 297 and 298. Relay 297 opens the connection of line 201 to the transmitter 202. Relay 298 connects the heterodyne source 240 to the receiver 203 so that it will receive waves from the local transmitter 202.

Under normal operating conditions, both the 12 kilocycle and the 28 kilocycle pilots will be transmitted from both terminals and received at both terminals and all the alarm lamps at both terminals will be extinguished. Upon a failure anywhere in the system an indication will be given by the lighting of one or more of the alarm lamps at both terminals giving an indication to both operators that a failure has occurred. Then by operating the near end loop test switches 196 and 296 a more definite indication of the source of the failure will be given.

The tabulation below will show just which pilot currents will be received and which alarm lights will be lighted for the various types of failure. First, by way of example, there will be considered the particular conditions for one type of failure, namely, a failure of the transmitter 102.

In case of the failure of the transmitter 102 neither pilot current will be received by the receiver 203. Accordingly both relays 270 and 280 will operate and all three lamps 291, 292 and 293 will light at the terminal of Fig. 2. The operation of relay 280 will also interrupt the transmission of the 28 kilocycle pilot by the transmitter 202.

Accordingly, at the terminal of Fig. 1, 12 kilocycle but no 28 kilocycle pilots will be received. This causes relay 170 to operate and light lamp 191 at that terminal. Both operators having received an indication of a failure by the lighting of the lamps, they may close the near end loop test keys 196 and 296 and the following conditions will be set up:

At the terminal of Fig. 1, no pilot currents will be received from the local transmitter 102 as that has failed. The 12 kilocycle pilot will continue to be received from transmitter 202 but no 28 kilocycle pilot will be received so that the lamp 191 will remain lighted.

At the terminal of Fig. 2, the condition of no pilots being received from transmitter 102 will continue. However, 12 kilocycle pilot current will not be received from the local transmitter 202. Accordingly, relay 270 will release and lamps 291 and 293 will be extinguished. Lamp 292 will remain lighted.

The method by which each source of failure may be located from the condition of the lamps may be determined from the following table:

Terminal—Fig. 1

	Pilots received by rec. 102	Relays operated	Lamps		
			191	192	193
Condition:					
Normal.....	12-28	None	Out	Out	Out
Failure—trans. from term. 1 to term. 2.....	12	170	On	Out	Out
Failure—trans. from term. 2 to term. 1.....	None	170 and 180	On	On	On
Loop test:					
Trans. 102 failure.....	12	170	On	Out	Out
Rec. 103 failure.....	None	170 and 180	On	On	On
Trans. 202 failure.....	28	180	Out	Out	On
Rec. 203 failure.....	12-28	None	Out	Out	Out

Terminal—Fig. 2

	Pilots received by rec. 202	Relays operated	Lamps		
			291	292	293
Condition:					
Normal.....	12-28	None	Out	Out	Out
Failure—trans. from term. 1 to term. 2.....	None	270 and 280	On	On	On
Failure—trans. from term. 2 to term. 1.....	28	270	On	Out	Out
Loop test:					
Trans. 102 failure.....	12	280	Out	Out	On
Rec. 103 failure.....	12-28	None	Out	Out	Out
Trans. 202.....	28	270	On	Out	Out
Rec. 203 failure.....	None	279 and 280	On	On	On

Thus it can be seen that the lights will not only give an indication of a failure, but for a working condition will give an indication of the direction of transmission in which the failure has occurred and for the loop test will further indicate just which portion of the equipment has failed.

Various modifications may be made in the system to suit particular conditions of operation or supervision. For example, if it is not required to indicate by the loop test the particular portion of the equipment which has failed but merely the terminal at which the failure has occurred the loop test switch 196 may be arranged so that under conditions of loop test both pilots will be applied to the near end transmitter 102. With such an arrangement the fact that the alarm lamps are extinguished by the application of the loop test will show that the failure has occurred at the other terminal, while the fact that the alarm lamp remains lighted will indicate a failure at the local terminal.

What is claimed is:

1. A two-way communication system comprising two terminal stations, two oppositely directed one-way transmission paths interconnecting said stations, means at each station for transmitting a first pilot signal, and means at each station under continuous control of the reception of said first pilot signal from the other station for transmitting a second pilot signal of characteristics distinguishable from said first pilot signal.

2. A two-way communication system comprising two terminal stations, two oppositely directed one-way transmission paths interconnecting said stations, means at each station for transmitting a first pilot signal, means at each station under control of the reception of said first pilot signal from the other station, for controlling the transmission of a second pilot signal, and signal means

at each of said stations responsive to the reception of both said first and said second pilot signals from the other station.

3. In a two-way communication system, a terminal station comprising a signal transmitter for transmitting over a one-way transmission path, a signal receiver for receiving signals over a second one-way transmission path, means for supplying a first pilot signal to said transmitter, and means under continuous control of the reception of a pilot signal by said receiver for supplying to said transmitter a second pilot signal of characteristics distinguishable from said first pilot signal.

4. A communication system comprising two terminal stations, two oppositely directed one-way paths interconnecting said stations, a first source of characteristic current at each of said stations, a second source of characteristic current at each of said stations, means at one of said stations responsive to the reception of current from said first source at the other of said stations for controlling the transmission of current from said first source at said one station so that current therefrom is transmitted to said other station only when current from said first source at said other station is received at said first station, similar means for controlling the transmission of current from said second source at said other station, and means at both of said stations for indicating

the reception or absence of reception of current from either of said sources at the other station.

5. In a two-way radio communication system, a terminal station comprising a radio transmitter for transmitting to another terminal station, a radio receiver for receiving signals from the other terminal station, means for supplying a first pilot signal to said transmitter for transmission thereby, and means responsive to and under continuous control of the reception by said receiver of a pilot signal from the other terminal station for supplying a second pilot signal of frequency different from the frequency of said first pilot signal to said transmitter for transmission thereby.

6. In a two-way radio communication system, two terminal stations, a radio transmitter and a radio receiver at each station, each of said receivers being normally responsive to radio waves from the transmitter at the other station to the exclusion of waves from the transmitter at the same station, a source of pilot currents for modulating the waves transmitted by each transmitter, a second source of pilot currents at each station, and means at each station responsive to the reception of pilot currents from the first source transmitted from the other station for causing the modulation of the waves transmitted by currents from the second source.

ALTON C. DICKIESON.