AUTOMATIC SWITCHOVER SYSTEM FOR RADIO RELAY

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This invention relates generally to a system for sensing failure of radio equipment and more particularly to a failure sensing system for use with microwave relay equipment to automatically switch from a main unit to a standby unit in the event of failure of the main unit. The equipment is being used to provide communication in many applications in which dependable continuous operation is highly essential. One important application of this type is microwave relay systems which may be used to provide a plurality of channels over long distances. In such systems it is desirable to locate the relay points as high an altitude as possible and in many cases the relay stations are placed on mountain tops or other relatively inaccessible places. These systems do not require the continuous attendance of an operator as they are completely automatic, and to provide a dependable continuous operation it has been proposed to provide a standby or spare unit which can be connected when a failure occurs in any part of the main unit.

Because of the complexity of the microwave relay equipment, it must be expected that failures will occur occasionally. Each microwave repeater station may have approximately fifty vacuum tubes of various different types which have relatively limited life. In a microwave relay system covering 1,000 miles, it would be expected that there would be approximately fifty repeater stations making a total of 2,500 vacuum tubes in all. The average life of such tubes will probably be more than 20,000 hours and after the tubes become burned out it would be expected that in such a system a tube would fail every eight hours. It is obvious that some time would be required to find the tube that failed to repair it and that either during this time or immediately thereafter another failure might occur, so that the relay system might be out of operation a large percent of the time. From the above it is apparent that the provision of a standby or spare unit which can be connected in this system is essential for continuous dependable operation.

Since an operator is not always present at the relay stations, automatic switchover equipment at a relay station may be provided for switching in the standby equipment. It is also desirable that the switchover system give some indication to another station, such as a terminal station where an operator may be present, that a particular maintenance man can be sent to the equipment which has failed for repairing the same. After such repair the relay system can then be changed back to the main unit and in the event of another failure the standby unit will be available to be automatically switched in. The sensing equipment must be effective to detect the failure of any component of the main unit at a particular station but must not operate in the event of failure of equipment at another station. For example, if a relay station a signal might not be received due to failure of the transmitter at another station with which the relay station is communicating, and in such case the sensing equipment must not respond. However, the sensing equipment must be highly responsive to failure of equipment at each such relay station.

It is therefore an object of the present invention to provide an improved failure sensing system for use with communication equipment.

It is another object of this invention to provide a system for sensing failure of the components of the receiving portion of the microwave equipment at a relay station which is effective independently of operation of the transmitting portion of the station with which it is in communication.

A further object of this invention is to provide a simple and dependable system for automatically switching from the main unit at a microwave radio relay station to a standby unit in response to failure of any component of the main unit.

A still further object of this invention is to provide a system for sensing failure of the microwave communication equipment for switching in standby equipment which automatically checks to determine that the fault continues for a predetermined time before switching in the standby equipment.

Still another object of this invention is to provide an automatic switchover system for connecting standby equipment in the event of failure of main equipment, which is operative to connect power to the standby equipment for a predetermined time interval to condition the standby equipment for operation and thereafter switch to the operative connections from the main to the standby unit.

A feature of this invention is the provision of a system for automatically sensing defective operation of components of radio equipment in which certain components are checked by the output thereof and certain other components are checked by their efficiency in transmitting a test signal.

Another feature of this invention is the provision of a system for sensing failure of components of a microwave unit in a relay system by applying a low frequency test signal to the local oscillator of the receiving portion of the unit and deriving the test signal from the video amplifier of the transmitting portion, with the operation of the components being indicated by the efficiency with which the test signal is transmitted therethrough.

A feature of this invention is the provision of a system for sensing failure of a microwave receiving portion which transmits noise in the absence of a signal, in which a low frequency signal is applied to the local oscillator of the receiving portion of modulating the same to a small extent and sensing means is connected to the output of the receiving portion which indicates the presence of the low frequency test signal and/or noise whereby the presence of the low frequency signal indicates proper operation of the receiving unit when a signal is being received and the presence of noise indicates proper operation in the absence of a received signal.

Still further feature of this invention is the provision of failure sensing equipment for automatically checking individual components of a microwave relay system, which checks back to determine if a defect which continues over a predetermined time. The equipment automatically switches a standby unit into the system in place of the main unit when the defect continues for the predetermined time.

Still another feature of this invention is the provision of equipment for automatically switching a standby unit into a system in the event of defective operation of a component of the main unit, with the equipment checking to determine that the fault continues for a predetermined time before starting the switchover operations, and then energizing the standby unit for another predetermined period so that it is completely operative before the circuits are connected from the main unit to the standby unit. In this way, the main unit remains in the system and may provide communication, even though somewhat defective, until the standby unit is in full operative condition.

Further objects and features of the invention will be apparent from a consideration of the following description when taken in connection with the accompanying drawings in which:

Fig. 1 is a block diagram illustrating the application of the failure sensing and automatic switchover system to a microwave relay installation;

Fig. 2 is a block diagram illustrating the equipment required for providing automatic switchover at a terminal station;

Fig. 3 is a block diagram illustrating the equipment for providing automatic switching at a relay station;

Figs. 4 and 5 are circuit diagrams of the sensing ap-
paratus for indicating the presence of the test signal and noise; and

In practice the invention the failure sensing and switchover system is applied to a microwave relay station installation including two terminal stations and one or more relay stations. At each station there are provided main and standby units for transmitting and receiving microwave signals which may be of substantial intensity and of different frequencies. The units are entirely separate and independent, including the power supplies therefor, and are selectively connected to a common antenna through a wave guide switch. The sensing system includes three circuits which together check all the components of the main unit. The transmitting portion of the main unit is checked by means on the antenna which responds to the output of the trans

mission portion. The local oscillator and mixer of the receiving portion are checked by means at the output of the mixer which is responsive to the amplitude of the output. The intermediate frequency amplifier, detector, and the video amplifier of the main unit are checked by the use of a test signal. This test signal is used to modulate the local oscillator to a small extent and is thereby applied through the mixer when a signal is being received by the intermediate frequency amplifier and detector. In the absence of a received signal, noise is present which appears at the output of the detector. Therefore, either the test signal is applied in the same way as the system is operating properly. A selective amplifier which responds to the test signal and to noise is connected to the output of the detector and is used to indicate defective operation of the intermediate frequency amplifier. The test signal may also be applied through the video amplifier to check this component. Each of the video amplifiers is provided with a detector in the terminal stations, being applied from the detector directly to the video amplifier through the existing connection in the relay station.

The various indications of defective operation are applied to a switchover panel and any one of the indications starts the operation of a timer mechanism. The timer mechanism continues to check and determine if the defective operation continues for a predetermined time, and if the defective operation continues for the predetermined time, starts the switchover operation for connecting in the standby unit. The switchover panel causes unloading of the main unit and the standby unit to warm up switches the circuits and antenna from the main unit to the standby unit. The main unit remains in service until the complete operating condition so that the main unit, although defective, may provide partially effective operation.

In Fig. 1 there is illustrated a microwave relay installation including terminal stations A and B and relay station C. The terminal station A includes a microwave unit 10 and a standby microwave unit 11. These units are connected to a waveguide switch 12 which selectively couples one of the units to the antenna 13. For controlling the waveguide switch there is provided an automatic switchover system 14 which includes equipment for sensing defective operation of the main transmitter-receiver unit 10 and operates to disconnect the main unit 10 from the antenna 13 and connect the standby unit 11 thereto. A power indicator 16 is provided along the waveguide between switch 12 and the antenna 13. Signalling equipment 15 which may be of the type providing multiple operation is connected to the power indicator for applying signals thereto and deriving signals therefrom. This signalling equipment may be connected to the units through the automatic switchover system 14 so that the signalling equipment is connected only to the unit which is operative at any time if this is desired.

The terminal station B includes main microwave unit 20 and a standby microwave unit 21 which are connected through the waveguide switch 22 to the antenna 23. A power indicator 26 is provided as at station A. An automatic switchover system 24 and signalling equipment 25 is provided as at the terminal station C. The components at the terminal station B may be identical with those at terminal station A and operate in exactly the same manner.

At the relay station C, two sets of equipment are pro-

vided for communicating with stations A and B respectively, with each set of equipment being similar to that at each terminal station. For communicating with terminal station A, a main microwave unit 30 is provided which is connected through waveguide switch 32 to antenna 33. This unit will be either the main unit 30 or the standby unit 31 to the antenna 33. For simplicity the portion of the relay station communicating with the terminal station A will be called west unit A, the transmission communicating with terminal station B will be called the east unit and includes main microwave unit 34, standby microwave unit 35, waveguide switch 36 and antenna 37. The connection of the standby units 31 and 35, an automatic switchover system 38 is provided which is similar in operation to the automatic switchover systems 14 and 24 at the terminal stations. This system operates to detect failure of the main units 30 and 34 and in such event to connect the standby units 31 and 35 to the antennas. The relay station may be what is called a "straight through" repeater station in which all of the signals are retransmitted and the individual signals are not derived at the relay point. Alternatively, it may be desired to receive or transmit signals at the relay sta-
tion C over one or more of the channels of the relay. The transmitter-receiver unit 40 may be any suitable microwave tube such as a klystron or a magnetron, and applies a modulated microwave signal to the antenna for transmission thereby. The signal received by the antenna is applied to the receiving portion of the unit 10 which includes mixer 42, local oscillator 43 and intermediate frequency amplifier and detector unit 44. The construction of these components of a microwave unit may be standard.

For sensing failure of the components of the main microwave unit, an automatic switchover system is provided. The switchover-receiver unit is connected in the control cabinet 48 together with certain components shown connected directly to components of the transmitter-receiver unit to make up the automatic switchover system 41 of Fig. 1. For checking with the operation of the transmitting portion, a power indicator device 16 for detecting the power output of the transmitter, such as a crystal detector, may be provided. In Fig. 2 this power indicator is illustrated as being included above the waveguide switch 12 in the line feeding antenna 13. This device is connected through conductor 50 to the power meter 51 and to the transmitter sensing unit 52 in the control cabinet 18. Similarly, a detecting device responsive to the output of the receiver mixer 42 may be incorporated in the mixer and connected through conductor 53 to meter 54 and to the sensing unit 55 for the local oscillator and mixer.

For checking the operation of the video amplifier 41 and the intermediate frequency amplifier 44, a test signal is applied through these components. This may be a signal of any convenient frequency which does not interfere with the communications passing through the system. A 60 cycle signal may be provided by a source 56 to the video amplifier and be passed therethrough simultaneously with the normal communication signals. Connected to the output of the video amplifier 41 is an intermediate frequency amplifier 57 which is selective to the 60 cycle signal and causes operation of the relay when the 60 cycle signal is not received thereby at a certain level. The amplifier-relay unit 57 is connected to terminal station A. A passive filter 59 is provided for preventing application of the 60 cycle test signal to the transmitter 40.

The intermediate frequency amplifier 44 may also be checked by applying the test signal therethrough. The
60 cycle signal from the source 56 may be applied to the local oscillator 43 to modulate the oscillator to a slight extent. When a signal is being received from the antenna 30 and is applied to mixer 42, the 60 cycle modulation which is applied to the mixer will not appear in the output of the mixer and is applied through the intermediate frequency amplifier 44 to the detector portion thereof wherein it is detected. Connected to the output of the intermediate frequency amplifier and detector 44 is a selective amplifier 45 of 60 which is responsive to the 60 cycle test signal and to noise signals. When a signal is not being received and applied to the mixer 42, the output of the local oscillator 43 will not appear at the output of the mixer.

However, under these conditions the receiver will provide noise which will be amplified in the intermediate frequency amplifier and will be applied to the selective amplifier 45. The unit 69 is arranged so that when either the noise signal or the 60 cycle signal is applied thereto at or above a certain level no operation will take place but when the signal applied thereto is of an amplitude which exceeds the noise level the main relay units 67 and to the main and standby units 65 of the unit 30, and the filter 82 interposed between the video amplifier 41 and the transmitter 40 of the unit 30 to reject the 60 cycle test signal. The relay and filter 82 is connected to the switchover panel 83 in the control cabinet 17. The test signal sources 75 and 80 of the two units 30 and 34 may be combined if desired.

As shown in Fig. 3, the switchover panel 77 is connected to the sensing units of the west unit microwave unit 30 and responds to failure of any component thereof to energize the standby unit 31 and connected transmitter 40 through the waveguide section 82. Similarly, the switch over panel 83 responds to the various sensing units of the east microwave unit 34 and in response thereof energizes standby unit 35 and connected transmitter 40 through the waveguide switch 36. It is to be noted that a single switchover panel might be used for both east and west units with various sensing units being coupled thereby in the event of failure of any component of either unit, both standby units 31 and 35 would be simultaneously connected in operation.

In Fig. 4 there is illustrated the detail circuit of the amplifier-relay unit for detecting the presence of the 60 cycle test signal and noise. The circuit of Fig. 4 is particularly adaptable to be used as the unit indicated in Fig. 2 which is connected directly to the output of the intermediate frequency amplifier and detector 44. The circuit includes an input terminal 90 adapted to be connected to the output of the detector and any of the wide band amplifier stages 91 and 92 connected in amplifying the 60 cycle test signal, and noise signals in the range from a few cycles per second to several thousand cycles per second. The output of the amplifier stages are applied to rectifier 93 which produces a negative direct current output. The negative direct current voltage is applied to tube 94 having a relay 95 connected in the output circuit thereof. This relay is normally held open by the 60 cycle signal and the noise signal and when components operate defectively so that the 60 cycle test signal and the noise signal both fall below a predetermined level, the relay operates through the contact 96 which closes the line 97 will be connected to a source of potential. The line 97 is connected to the circuit of the switchover panel as will be more fully explained.

Fig. 5 illustrates a similar amplifier-relay circuit to be used at the output of the video amplifier. This circuit can be used for the unit designated 57 in Fig. 2 and the units designated 76 and 81 in Fig. 5 and that of Fig. 4 is that less amplification is provided in Fig. 5 since the signals applied to this unit have been passed through a video amplifier and are already at a level which is an adequate voltage to the input terminal 100 and amplified in the stage 101. Rectifier 102 provides a negative direct current voltage from the signal and this negative direct current voltage is applied to the grid of the tube 103. Relay 104 is connected in the plate circuit of the tube 103 and holds the contact 105 thereof open when 60 cycle or noise signals of a predetermined level are applied to the unit. When the level of the signals fall below a predetermined value, the relay drops out and the line 106 connected to the switchover panel is connected by the contact 105 of the relay 104 to a source of potential.

Reference is now made to Fig. 6 in which the circuit of the switchover panel and certain of the sensing units is illustrated. The circuit will be described in connection with a terminal station illustrated in Fig. 2 although it is also applicable for use at a relay station. The circuit includes an input terminal 110 to which the voltage from the power indicated 116 is applied. This voltage is a measure of the output of the transformer 40 at the desired transmitting frequency. Input terminal 111 is provided to which the voltage from the detector of the mixer 42 is applied with this video amplifier 41 connected to the input terminals 110 and 111 and are applied to sensitive relays 112 and 113 respectively which may be of the type commonly known as reed switches. These relays 112 and 113 may be adjusted so that when the voltage applied to the relay is decreased through the use of a potentiometer the armatures will be drawn to the magnets 115 closing a circuit therethrough. The armatures are
connected through conductors 118 and 119 to one terminal of a source of potential which is designated as the A. C. common bus. The relays 112 and 113 are effective to complete the connection from the A. C. common bus to the conductor 120.

Switchover panel also includes input terminals 121 and 122 which are connected to the conductor 120. The terminals 121 and 122 may be connected to the amplifier and relay units 57 and 60 of Fig. 2 which are shown in Figs. 5 and 6 respectively. The conductors 123 and 124 connect to terminals 97 and 106 of the amplifier-relay units are connected to the terminals 121 and 122 so that when the relays of these units drop out due to defective operation of components in relays are intermittently interrupted. The terminals 121 and/or 122 will be connected to the A. C. common bus 10.

It is seen from the above that failure of any component of the main unit of the terminal station will operate through one of the sensing units to cause the lead 120 to be connected to the A. C. common bus. The lead 120 is connected to timer 125 to cause operation thereof. The other terminal of the timer is connected through conductor 126 and contact 127 of relay 128 to the other side of the A. C. line. The relay 128 is the main energizing relay for the main microwave unit 10 and is normally closed. This relay energizes the filament supply of the main unit 10 and operates through delay unit 129 to energize the plate supply. The plate supply is connected after the filament supply to protect components in it in a manner that is well known. The timer 125 is adapted to operate for a predetermined time and then close the contacts 130 thereof. A schematic diagram 161 may schematically represents the closing arm for the contacts.

Connected in parallel with the timer 125 is a motor 132 which drives toothed wheels 133 and 134. Barring against the toothed wheel 133 is a switch contact 135 which is allowed to close when the timer 125 engages the reconnection 136 in the wheel. The contact 136 causes energization of the reset solenoids 117 of the relays 112 and 113 so that the energizing circuit are intermittently interrupted. The intermitting provisions are necessary as the relays are locked after they are once actuated and it is necessary to re-energize the secondary if the voltage applied to the windings thereof indicates a failure continues.

Contact 138 bears against toothed wheel 134 and is allowed to close when it engages the recesses 139 therein. The recesses 139 are arranged so that the contact 138 closes before the contact 135 and stays closed until after the contact 135 is opened. The contacts 138 connects the conductor 120 to the conductor 118 so that the energizing circuit is applied to the timer 125 while the relays 112 and 113 are reset. It is, therefore, seen that the timer 125 will start operating when a fault occurs and it will not be energized if the fault is removed before the time terminal of the time interval for which it is set.

In a relay system as disclosed, the timer 125 may be set for a 90 second interval and if the fault continues for thirty seconds the timer will operate to close the switch contacts 130.

The contacts 130 when closed are effective to connect relay 140 to the alternating current source. Relay 140 is the main energizing relay for the standby unit 11. The relay 140 includes movable contact 141 which closes when the relay is operated and contact 142 which opens when the relay is operated. The contact 141 connects the filament supply of the standby unit 11 to the primary power source and also energizes the timer 143 to the same source. The timer 143 then runs for a predetermined time after which it operates to close the contacts 144 thereof. The timer 143 is like timer 125 is shown schematic as including a project 145 which operates the contact.

Contacts 144 of the timer 143 connect relay 150 to a direct current voltage source, with the relay being held closed through operation of contact 151 thereof which connects the relay in series with resistance 152 to the direct current voltage source. The relay 150 also includes contacts 153 and 154, with the contact 153 moving away from contact 155 to deenergize the timer 143 and energizing contact 156 to energize the plate supply of the standby unit 11. The contact 154 of the relay 150 is bridged across contact 152 of the relay 140. These contacts control energization of the relay 128 for energizing the main unit 10. Therefore, after the relay 140 is energized in response to action of the timer 125 and the relay 150 is energized in response to the action of the timer 143 the energizing circuit to the winding of the relay 128 will be broken and this relay will drop out. This will cause the contact 127 to open so that the main unit 10 is deenergized.

The relay 128 includes a contact 160 which is bridged across the contacts 136 of the timer 125. This contact closes when the relay 128 drops out, and serves to hold the relay 140 operated if the fault is removed, and the timer 125 is thereby released after the main unit has been deenergized. It will be noted in this connection that if the fault is removed before the timer 143 has completed the time interval, the relay 140 will be energized and the changeover cycle will be stopped. This causes contacts 150 will be opened when the fault is removed and the main unit is deenergized. Under these conditions the main unit will remain in operation and the equipment will be in condition for sensing another fault.

In addition to energizing the standby unit and deenergizing the main unit, the switchover equipment is used to disconnect the main unit from the antenna and to connect the standby unit thereto. This is accomplished through the contact 161 on the relay 128 which connects the waveguide switch to the power supply when the proper contacts are made. The contact 161 energizes the terminal equipment from the main unit 10 and to connect the same to the standby unit 11. This may be accomplished by relay 162 which, in the normal position connects the terminal equipment to the main unit 10, and when the relay 162 is energized connects the terminal equipment to the standby unit 11. As has been pointed out, the relay 162 is not necessary as it may be satisfactory to connect this terminal equipment to both the main unit and the standby unit without interfering with the operation of either unit. The terminal equipment may in such case be continuously connected to both units and no switching will be required for the changeover operation.

Considering now the switchover equipment required at a relay station, in the event that the standby units 31 and 35 are individually controlled in response to failure of the main units 30 and 34 respectively, it will merely be necessary to duplicate the arrangement shown in Fig. 6 for the east and the west systems. Since a single amplifier relay unit checks the intermediate frequency amplifier, the detector of the video amplifier, this unit may be connected to either input terminal of the switchover panel and the other terminal will not be used.

The detecting means attached to power indicator 63 and mixer 42 will be connected to the terminals 110 and 111 as in the terminal equipment. If it is desired to provide a single switchover panel for connecting the standby units of both the east and west system in the event of failure of components of either main unit, it will be necessary to add two more selective relays similar to the relays 112 and 113. These relays can be connected in parallel to the relays 112 and 113. The four selective relays will therefore respond to the detecting means in the two power indicators 63 and 66 and in the two mixers 42 of the units 30 and 34. The amplifier relay units 76 and 81 can be connected to the terminals 121 and 122. In such a system failure of any component of one main unit will cause the timer 125 to start operation and the changeover cycle will take place. The main units 30 and 34 can both be energized by the same main relay and the standby units 31 and 35 can both be energized by a single standby relay. The switchover panel will be connected to both waveguide switches 32 and 36 so that in the response to failure of any component of either main unit, the standby units will be energized, will be connected to the antennas, and the main units will be deenergized.

It is seen from the above that there is provided a system for detecting failure of any component of the main unit at either a relay or a terminal equipment automatically switching the standby unit when such failure occurs. The system is particularly adapted for use at stations where an operator is not present so that communication may continue even though a failure occurs in the regular operating equipment. The system is ar-
ranged so that sensing indications for various components are brought together and combined, and the indication of failure from any one of the sensing units causes the switch-over operation to be initiated. Before the switch-over operation is initiated, the equipment continues to check to determine whether the fault is merely a temporary interruption which is soon removed or is a serious failure of one or more components. The equipment also makes provision for disconnection of components before standby equipment is switched in to insure proper operation thereof. In the event that the main equipment operates satisfactorily before the warm-up period is over, the switch-over cycle can be stopped and the main unit will then continue in the system.

Although certain embodiments of the invention have been described which are illustrative thereof, it is obvious that various changes and modifications can be made therein without departing from the intended scope of the invention as defined in the appended claims.

1. Failure sensing apparatus for a relay system which includes a portion for receiving signals having a local oscillator, a mixer, an intermediate frequency amplifier and a detector connected in a superheterodyne circuit, a portion for transmitting signals having a video amplifier, and a transmitter connected in tandem in the order named, with the output of the detector being connected to the input of the video amplifier, and in which noise is produced in the output of the detector in the absence of a signal, said apparatus including in combination, first frequency selective means coupled to the output of said mixer and operable when the amplitude of the output thereof falls below a predetermined value to indicate defective operation of said mixer and said local oscillator, second frequency selective means coupled to the output of said mixer and operable when the amplitude of the output thereof falls below a predetermined value to indicate defective operation thereof, and means for indicating defective operation of said intermediate frequency amplifier, said detector and said video amplifier including a source of test signals coupled to said local oscillator for modulating the same and third frequency selective means coupled to the output of said video amplifier and operable when the amplitude of said test signals and said noise signals falls below a predetermined value to indicate failure of at least one of said intermediate frequency amplifier, said detector and said video amplifier.

2. Failure sensing apparatus for a communication system which includes a portion for receiving signals having a local oscillator, a mixer, an intermediate frequency amplifier and a detector connected in a superheterodyne circuit, and a portion for transmitting signals having a video amplifier and a transmitter connected in tandem in the order named, in which noise is produced in the output of the detector in the absence of a signal, said apparatus comprising in combination, first frequency selective means coupled to the output of said mixer and operable when the amplitude of the output thereof falls below a predetermined value to indicate defective operation of said mixer and said local oscillator, second frequency selective means coupled to the output of said mixer and operable when the amplitude of said test signal and said noise signals falls below a predetermined value to indicate defective operation of said intermediate frequency amplifier and said detector, and means for indicating defective operation of the video amplifier including means for producing a signal to said local oscillator for modulating the same and third frequency selective means coupled to the output of said detector and operable when the amplitude of said test signal and said noise signals falls below a predetermined value to indicate failure of at least one of said intermediate frequency amplifier and said detector, and means for indicating defective operation of said video amplifier including means for producing a signal to said local oscillator for modulating the same and fourth frequency selective means coupled to the output of said video amplifier and operable when the amplitude of said test signal falls below a predetermined value to indicate failure of said video amplifier.

3. A radio relay station comprising in combination an antenna means, a main unit, a standby unit, receiving means normally connecting said main unit to said antenna means and operable to connect said standby unit to said antenna means, each of said units including a receiving portion, a transmitting portion and means coupling the output of said receiving portion to the input of said transmitting portion, said receiving portion having a local oscillator, a mixer, an intermediate frequency frequency amplifier and a detector connected in a superheterodyne circuit and being effective to produce noise at the output of said detector in the absence of a signal, said transmitting portion having a video amplifier and being operable to connect said standby unit to said antenna means, each of said units including a source of test signals coupled to said local oscillator of said main unit and frequency selective means coupled to the output of said video amplifier for producing a predetermined output in response to said test signals and said noise signals, rectifier means, and relay means connected through said rectifier means to said frequency selective amplifier means and operable in response to said predetermined voltage, said relay means being coupled to said switching means for operating said switching means to connect said standby unit when the output of said video amplifier falls below said predetermined value.

4. A radio relay station comprising in combination antenna means, a main unit, a standby unit, switching means normally connecting said main unit to said antenna means and operable to connect said standby unit to said antenna means, each of said units including a receiving portion, a transmitting portion and means coupling the output of said receiving portion to the input of said transmitting portion, said receiving portion having a local oscillator of said main unit and frequency selective means coupled to the output of said video amplifier for producing a predetermined output in response to said test signals and said noise signals, rectifier means, and relay means connected through said rectifier means to said frequency selective amplifier means and operable in response to said predetermined voltage, said relay means being coupled to said switching means for operating said switching means to connect said standby unit when the output of said video amplifier falls below said predetermined value.

5. A radio relay station comprising in combination antenna means, a main unit, a standby unit, receiving means normally connecting said main unit to said antenna means and operable to connect said standby unit to said antenna means, each of said units including a receiving portion, a transmitting portion and means coupling the output of said receiving portion to the input of said transmitting portion, said receiving portion having a local oscillator of said main unit and frequency selective means coupled to the output of said video amplifier for producing a predetermined output in response to said test signals and said noise signals, rectifier means, and relay means connected through said rectifier means to said frequency selective amplifier means and operable in response to said predetermined voltage, said relay means being coupled to said switching means for operating said switching means to connect said standby unit when the output of said video amplifier falls below said predetermined value.
to produce noise at the output of said detector in the absence of a signal of the predetermined frequency, said transmitting portion including a video amplifier and a transmitting oscillator connected in tandem in the order named, and means for operating said switching means to connect said standby unit to said antenna means in response to failure of components of said main unit including a source of test signals coupled to said local oscillator of said main unit for modulating the same, and a sensing unit coupled to the output of said video amplifier of said main unit, said sensing unit including frequency selective means responsive to said test signals and said noise signals, and relay means connected to said switching means for operating said switching means to connect said standby unit when said test signals and said signals are not present, each of said output of said video amplifier, said switching means including timer means for delaying operation thereof of until said failure has continued for a predetermined time interval.

9. Communication apparatus comprising in combination antenna means, a main unit, a standby unit, terminal equipment, switching means normally connecting said main unit to said terminal equipment, and to said antenna means and operable to connect said standby unit to said terminal equipment and to said antenna means, each of said units including a receiving portion, and a transmitting portion operating at a predetermined frequency and having a local oscillator, a mixer, an intermediate frequency amplifier and a detector connected in a superheterodyne circuit, and being effective to produce noise at the output of said detector in the absence of a signal of the predetermined frequency, said transmitting portion including a video amplifier and a transmitter oscillator connected in tandem in the order named, and means for operating said switching means to connect said standby unit to said terminal equipment and to said antenna means in response to failure of components of said main unit including, a source of test signals coupled to said local oscillator of said main unit for modulating the same, and a sensing unit coupled to the output of said video amplifier of said main unit, said sensing unit including frequency selective means responsive to said test signals and said noise signals, and relay means connected to said frequency selective means and to said switching means for operating said switching means to connect said standby unit when said test signals and said signals are not present, each of said output of said video amplifier, said switching means including timer means for delaying operation thereof of until said failure has continued for a predetermined time interval.

10. Communication apparatus comprising in combination antenna means, a main unit, a standby unit, terminal equipment, switching means normally connecting said main unit to said terminal equipment and to said antenna means, each of said units including a receiving portion, and a transmitting portion operating at a predetermined frequency and having a local oscillator, a mixer, an intermediate frequency amplifier and a detector connected in a superheterodyne circuit, and being effective to produce noise at the output of said detector in the absence of a signal of the predetermined frequency, said transmitting portion including a video amplifier and a transmitter oscillator connected in tandem in the order named, and means for operating said switching means to connect said standby unit to said terminal equipment and to said antenna means in response to failure of components of said main unit including, a source of test signals coupled to said local oscillator of said main unit for modulating the same, and a sensing unit coupled to the output of said video amplifier of said main unit, said sensing unit including frequency selective means responsive to said test signals and said noise signals, and relay means connected to said frequency selective means and to said switching means for operating said switching means to connect said standby unit when said test signals and said signals are not present, each of said output of said video amplifier, said switching means including timer means for delaying operation thereof of until said failure has continued for a predetermined time interval.

11. Radio communication apparatus comprising in combination antenna means, a main unit, a standby unit, a transmitting portion including a video amplifier and a transmitting oscillator connected in tandem in the order named, and means for operating said switching means to connect said standby unit to said antenna means in response to failure of components of said main unit including a source of test signals coupled to said local oscillator of said main unit for modulating the same, and a sensing unit coupled to the output of said video amplifier and to said switching means for initiating operation of said switching means when said test signals and said noise signals fall below a predetermined level, said switching means including timer means initiated by said frequency selective means, interruptor means operating with said timer means for intermittently releasing said switching means during a particular time interval, contact means for connecting said standby unit to said source of potential after said defective operation continues for said particular time interval, and means for connecting said standby unit to said source of potential and for disconnecting said main unit from said source of potential after said standby unit has been energized for said predetermined time.
including a receiving portion, a transmitting portion and means interconnecting said portions, said receiving portion providing receiving signals at a local oscillator, a mixer, an intermediate frequency amplifier and a detector connected in a superheterodyne circuit and being effective to produce noise at the output of said detector in the absence of a signal of the predetermined frequency, said transmitting portion including a video amplifier and a transmitter oscillator connected in tandem in the order named, and means for operating said switching means to connect said standby unit to said source of potential and to said test signals and to said noise signals coupled to the output of said video amplifier and to said switching means for initiating operation of said switching means when said test signals indicate a certain amplitude thereby indicating defective operation, said switching means including timer means initiated by said frequency selective means, interrupting means operating with said timer means for temporarily releasing said switching means during a particular time interval, and means for connecting said standby unit to said source of potential and for causing operation of said switching means when said predetermined voltage is produced and for causing operation of said switching means to connect said portion of said standby unit to said source of potential and to said antenna means, and means for operating said switching means to connect said standby unit to said source of potential in response to failure of components of said main unit including a source of test signals coupled to said local oscillator of said main unit, and frequency selective means for initiating operation of said switching means after said failure has continued for a particular time interval.

13. A radio relay system comprising in combination antenna means, main unit means, a standby unit, a receiving portion, a transmitting portion, and means interconnecting said portions, said receiving portion providing receiving signals at the output of said detector in the absence of a desired signal, said transmitting portion including a video amplifier and a modulator connected in tandem in the order named, and means for operating said switching means to connect said standby unit to said source of potential and to said test signals, and said noise signals coupled to the output of said video amplifier of said main unit, said sensing unit including frequency selective means responsive to said test signals and said noise signals, and relay means connected to said frequency selective means and to said switching means for operating said switching means to connect said standby unit to said source of potential and to said antenna means, and connect said standby unit to said main unit means for causing operation of said switching means when said predetermined voltage is produced and for causing operation of said switching means to connect said portion of said main unit to said source of potential and to said antenna means, and means for operating said switching means to connect said standby unit to said source of potential in response to failure of components of said main unit including a source of test signals connected to the input of said signal channel of said main unit and a sensing unit connected to said source of test signals for causing operation of said switching means after said failure has continued for said predetermined time after said second timer operation.

14. Radio communication apparatus including in combination, antenna means, a main unit including portions forming a signal channel having an input and an output, a standby unit which includes an energization for a predetermined time before it is operative, a source of potential and said antenna means and means operable to connect said source of potential and to said antenna means, and means for operating said switching means to connect said standby unit to said source of potential in response to failure of components of said main unit including a source of test signals connected to the input of said signal channel in said main unit and a sensing unit coupled to the output of said signal channel of said main unit, said source of test signals having a period of time for operation of said switching means when said test signals continue for said predetermined time after said failure has continued for said predetermined time after said second timer operation.

15. A microwave relay station adapted to operate continuously without an operator in attendance including in combination, antenna means, main unit means, a receiving portion, a transmitting portion, a relay system comprising in combination, antenna means, main unit, a standby unit, a receiving portion, a transmitting portion, and means interconnecting said portions, said receiving portion having a local oscillator, a mixer, an intermediate frequency amplifier and a detector connected in a superheterodyne circuit, said receiving portion providing receiving signals at the output of said detector, said transmitting portion including a modulator connected in tandem in the order named, and means for connecting said standby unit to said source of potential and to said antenna means, each of said units including a receiving portion, a transmitting portion, and means interconnecting said portions, said receiving portion having a local oscillator, a mixer, an intermediate frequency amplifier and a detector connected in a superheterodyne circuit, said receiving portion providing receiving signals at the output of said detector, said transmitting portion including a modulator connected in tandem in the order named, and means for connecting said standby unit to said source of potential and to said antenna means, and a timer means responsive to said test signals and said noise signals coupled to the output of said video amplifier of said main unit, said sensing unit including frequency selective means responsive to said test signals and said noise signals, and relay means connected to said frequency selective means and to said switching means for operating said switching means after said failure has continued for a predetermined time interval.

16. A radio relay system comprising in combination antenna means, main unit means, a receiving portion, a transmitting portion, and means interconnecting said portions, said receiving portion providing receiving signals at the output of said detector, said transmitting portion including a modulator connected in tandem in the order named, and means for connecting said standby unit to said source of potential and to said antenna means, each of said units including a receiving portion, a transmitting portion, and means interconnecting said portions, said receiving portion having a local oscillator, a mixer, an intermediate frequency amplifier and a detector connected in a superheterodyne circuit, said receiving portion providing receiving signals at the output of said detector, said transmitting portion including a modulator connected in tandem in the order named, and means for connecting said standby unit to said source of potential and to said antenna means, and means for operating said switching means to connect said standby unit to said source of potential in response to failure of components of said main unit including a source of test signals coupled to said local oscillator of said main unit, and frequency selective means for initiating operation of said switching means after said failure has continued for a particular time interval, and means for operating said switching means to connect said standby unit to said source of potential in response to failure of components of said main unit including a source of test signals connected to the input of said signal channel in said main unit and a sensing unit connected to said source of test signals for causing operation of said switching means after said failure has continued for said predetermined time after said second timer operation.

17. A radio relay system comprising in combination antenna means, main unit means, a receiving portion, a transmitting portion, and means interconnecting said portions, said receiving portion providing receiving signals at the output of said detector, said transmitting portion including a modulator connected in tandem in the order named, and means for connecting said standby unit to said source of potential and to said antenna means, each of said units including a receiving portion, a transmitting portion, and means interconnecting said portions, said receiving portion having a local oscillator, a mixer, an intermediate frequency amplifier and a detector connected in a superheterodyne circuit, said receiving portion providing receiving signals at the output of said detector, said transmitting portion including a modulator connected in tandem in the order named, and means for connecting said standby unit to said source of potential and to said antenna means, and means for operating said switching means to connect said standby unit to said source of potential in response to failure of components of said main unit including a source of test signals coupled to said local oscillator of said main unit, and frequency selective means for initiating operation of said switching means after said failure has continued for a particular time interval, and means for operating said switching means to connect said standby unit to said source of potential in response to failure of components of said main unit including a source of test signals connected to the input of said signal channel in said main unit and a sensing unit connected to said source of test signals for causing operation of said switching means after said failure has continued for said predetermined time after said second timer operation.
standby unit to said antenna means when said smaller voltage is produced.

16. Radio receiving equipment adapted to operate continuously without an operator in attendance including in combination, antenna means, a main receiver unit, a standby receiver unit, switching means normally connecting said main unit to said antenna means and operable to connect said standby unit to said antenna means, said main receiver unit including a local oscillator, a mixer, an intermediate frequency amplifier, and a detector connected in a superheterodyne circuit, said receiver unit providing noise at the output of said detector at a substantially fixed level in the absence of a signal of said first frequency and at a much lower level in the presence of a signal of said first frequency, a source of test signals coupled to said local oscillator for modulating the same, said receiving portion providing said test signals at the output of said detector at a given level in the presence of a signal of said first frequency and at a much lower level in the absence of a signal of said first frequency, whereby said test signals and noise are alternately present in said detector output in accordance with the presence and absence of a received signal of said first frequency, and a sensing unit coupled to the output of said detector including a selective amplifier and voltage responsive means, said selective amplifier having an input circuit coupled to said detector and producing a voltage in response to said test signals and noise, said voltage reaching a substantially constant predetermined value substantially independent of the level of received signals when the components of the equipment including said intermediate frequency amplifier, and said detector operate effectively, and said voltage falling to a smaller value when any one of said components operates defectively, said voltage responsive means being coupled to said selective amplifier and operatively connected to said switching means for holding said switching means in a normal position connecting said main receiver unit to said antenna means when said predetermined voltage is produced, and for causing operation of said switching means to connect said standby unit to said antenna means when said smaller voltage is produced.

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