July 4, 1939. J. R. MacKAY 2,165,064

SUPERVISION OF RADIO SIGNALING SYSTEMS

Filed June 20, 1936 3 Sheets-Sheet 1

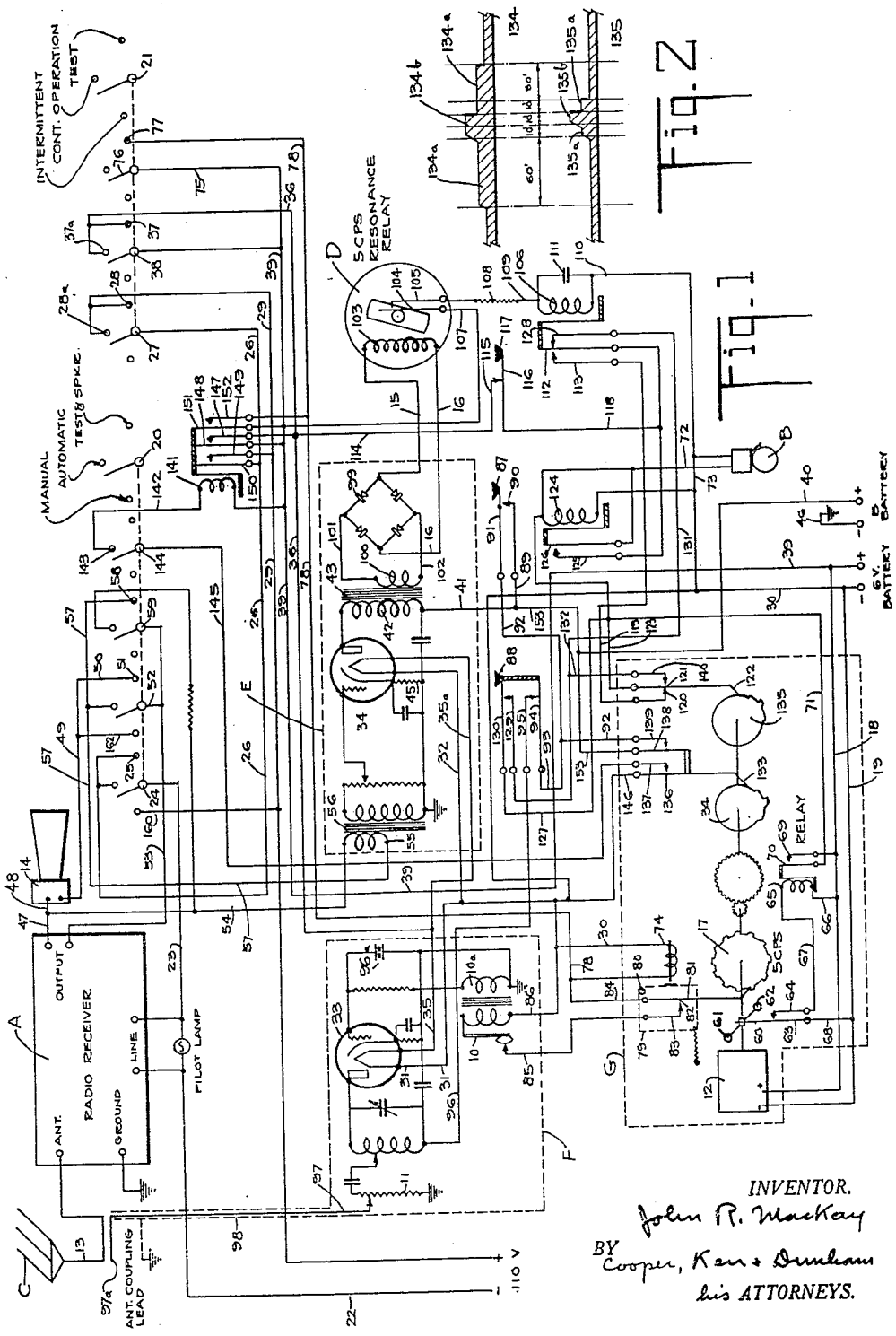


Fig. 2

Fig. 1

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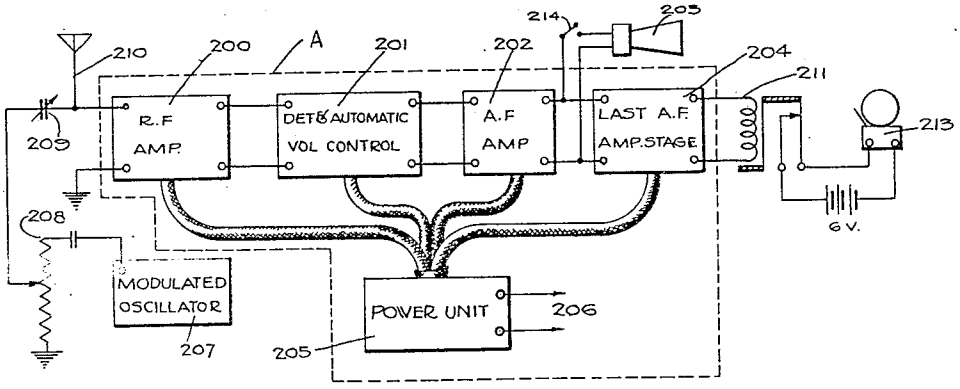
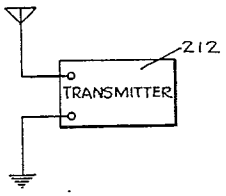


Fig. 3



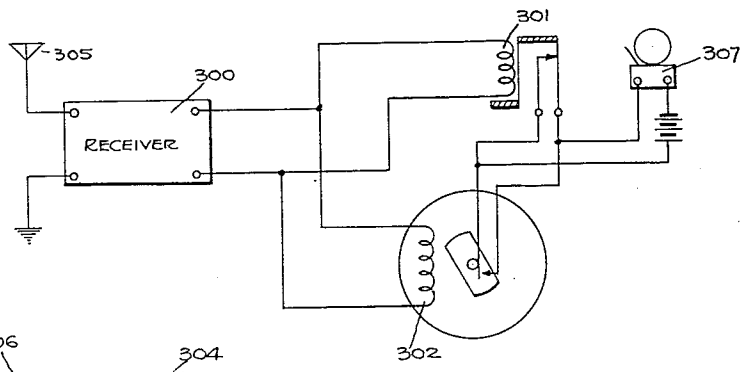
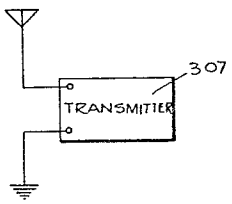


Fig. 4



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Filed June 20, 1936 3 Sheets-Sheet 3

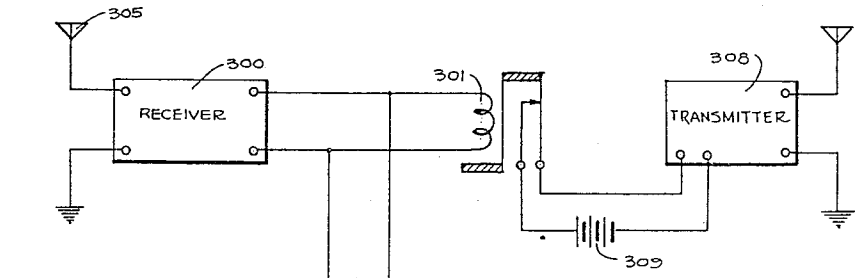
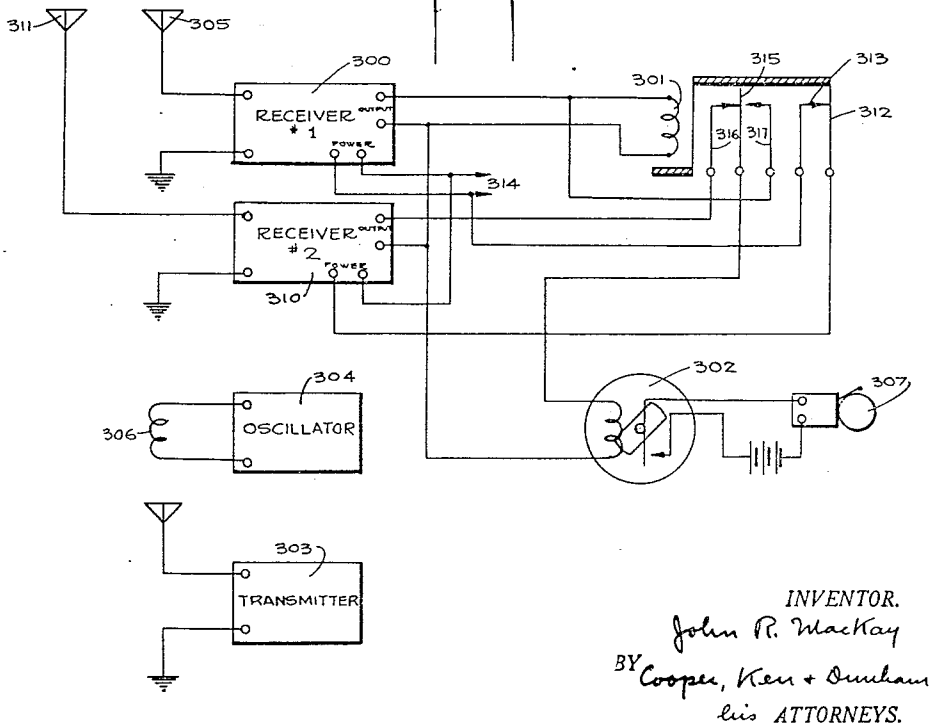


Fig. 5

Fig. 6



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UNITED STATES PATENT OFFICE

2,165,064

SUPERVISION OF RADIO SIGNALING SYSTEMS

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Application June 20, 1936, Serial No. 86,270

29 Claims. (Cl. 250—20)

This invention relates to the supervision of radio signaling systems, and in more specific aspects to receiving stations thereof having provision for automatic response to calling or other signals, and wherein the receiving apparatus is monitored, or otherwise supervised at desired times.

One of the objects of the invention is to provide a radio signaling system in which the receiving apparatus is arranged to listen in continually or intermittently in order to control an alarm bell or other apparatus, automatically, in response to a predetermined signal transmitted by radio waves from a remote transmitter, such as, for example, a distress signal, and wherein means are provided for automatically and intermittently monitoring or checking the entire receiving system, including its capability of automatic response to and control by the predetermined remotely transmitted signal. A further object of the invention is to provide new means and combinations of instrumentalities for supervising the responsive condition of a radio receiver and its associated equipment (and to operate an alarm or other apparatus upon failure thereof), thereby checking the functioning of many or all of the several instrumentalities and power sources of the receiving apparatus, such as the tuning of the receiver to a desired carrier frequency, both the activation and the filament life of the vacuum tubes, and the condition of transformers, condensers, resistors, connecting circuits, and batteries.

Further objects are: to provide a radio receiving station in which the presence of atmospheric or other disturbances sufficient to prevent reception of desired radio signals will be automatically determined, and will cause operation, for example, of a suitable warning signal; to provide means and combinations of instrumentalities which, for effecting supervision or monitoring, in the foregoing and other respects, can be readily applied to any of the usual or standard types of receiving apparatus, particularly automatic radio calling systems or like systems wherein an alarm or other apparatus is to be automatically controlled by radio waves transmitted from a remote point; and to provide new combinations of instrumentalities and new sub-combinations thereof, for the purposes above stated, which are in themselves relatively simple in operation, and thoroughly reliable, and which obviate or reduce the necessity of frequent personal inspection of a radio receiving station by an attendant or operator.

Other objects and advantages will appear as some of the preferred forms of the invention are hereinafter described.

Referring to the drawings which illustrate what I now consider to be preferred forms of the invention:

Figure 1 is a wiring diagram of the receiving station of an automatic radio calling system;

Figure 2 is a projected plane section of certain switch operating cams, to show their timing;

Figure 3 is a wiring diagram of another form of radio signaling system; and

Figures 4, 5 and 6 are respectively wiring diagrams of somewhat further modified forms of radio signaling systems.

Referring first to Figure 1, the receiving station here shown is of the type in which the radio wave receiving apparatus proper, generally designated A, is adapted to be tuned and set for reception of a desired radio signal, so that in response to that signal the receiver will automatically bring into operation apparatus such as the alarm bell B. In the specific apparatus shown, it is contemplated that upon reception of a carrier having a predetermined radio frequency and modulated at a predetermined audio frequency, the alarm bell will ring to indicate that a call is being received. The radio receiving apparatus itself may be of any suitable type, embodying, for example, the usual vacuum tubes and the usual tuning and other circuits for selecting, amplifying at radio frequency, detecting, and amplifying at audio frequency, the signals picked up by the antenna system C. As shown here, the receiving apparatus is further understood to include suitable power supply elements, of which many types are known in the art, for deriving the necessary filament, plate, and other power from a standard 110-volt line. It is also preferable but not essential that the receiving apparatus include an automatic volume control device or be of a circuit arrangement, such as the super-regenerative type, having automatic volume control inherent in its design.

The alarm bell is operable under control of a suitable resonance relay, generally designated D, which is in turn brought into operation under the control of a relay amplifier E coupled to the output of the receiving apparatus. Preferably the relay amplifier is designed to respond to an audio frequency E. M. F. set up by the receiver, and to deliver to the relay a pulsating direct current, or a succession of direct current impulses, having a frequency corresponding to that impressed upon the relay amplifier, and thus to the audio frequency at which incoming radio frequency oscil-

lations are modulated. The resonance relay, in turn, is tuned for response only to that specific audio frequency, viz., that of the particular call modulation to which the station is intended to respond.

There is further provided a local source of modulated radio frequency oscillations generally designated F, which is preferably inherently stabilized as to frequency and which may include a vacuum tube oscillator, and may have a modulating device such as the microphone hummer 10. The radio frequency oscillator here shown is of the crystal controlled type, although other inherently stable oscillators, for example the Dynatron, can be satisfactorily employed. In general, this oscillator may be similar in physical size and characteristics to the oscillators used for frequency conversion in superheterodyne receivers. The microphone hummer 10 may likewise be replaced by any other modulating device, such as a simple constant frequency generator or buzzer, or a vacuum tube audio oscillator. In fact, in some cases, it is possible to dispense with a separate modulator, and to make the vacuum tube oscillator self-modulating by the inclusion of a secondary circuit tuned to a lower or audio frequency, as is known in the art. The oscillator also includes an adjustable attenuating device 11, through which the modulated oscillations are impressed upon the input of the receiving apparatus.

There is further provided a cycling mechanism, generally designated G, and operated by a continuously driven motor 12, for intermittently bringing into play the supervision of the receiving apparatus and also, if desired, for intermittently placing the receiving apparatus in operative condition—i. e., so that the receiver intermittently and automatically listens in for calls from the remote transmitter, and so that there is effected a saving of energy consumption and of wear and tear on the various receiver elements, in the manner described in my copending applications Serial Nos. 730,127 and 11,783, entitled "Communicating systems" and respectively filed on June 11, 1934 and March 19, 1935.

Assuming that the cycling mechanism controls both the receiving apparatus and the supervising instrumentalities, it is arranged, as is hereinafter particularly explained, so that at periodic intervals it effects energization of the receiver A, the oscillator F, and the other associated elements, brings about a further modulation of the oscillations set up by the oscillator F (to make them simulate the call signal of the remote transmitter), and so disposes the alarm bell under control of the resonance relay D that if the oscillator F has impressed upon the input of receiving apparatus the local signal properly simulating both the radio and audio frequency characteristics of the call signal of the remote transmitter, and if the receiving apparatus is in proper working condition to respond to such a call, the resonance relay will be energized and operate to prevent actuation of the alarm bell, otherwise biased to go into operation. Following this supervising period, wherein any failure of the receiving apparatus, or its vacuum tubes, power supply, tuning or other circuits, will ring the alarm bell and advise the attendant that something is wrong, the cycling mechanism then cuts off operation of the oscillator F, and during a listening period, so connects the alarm bell as to cause the latter to ring if a call is then received from a remote transmitter.

As will now be appreciated, the cycling mechanism can be arranged to provide these testing and listening-in periods at intervals of any desired duration; here, for instance, it is assumed that a 10-second testing period and a 30-second listening-in period are desired every 15 minutes. Switching means are also provided for operating the receiving apparatus without any supervision at all, and also for placing the receiving apparatus continuously in listening condition, subject only to the provision of intermittent testing periods by the cycling mechanism—an arrangement peculiarly desirable where the apparatus is used to provide an automatic SOS reception alarm on shipboard.

The attenuator 11 is adjusted to permit introduction of the signal locally generated by oscillator F into the receiving apparatus at such a level of intensity as will cause the receiving apparatus and its associated amplifier E and relay D to respond in spite of a predetermined permissible maximum atmospheric or noise level. In this way, the arrangement is such that if static or other outside disturbance is so intense as would prevent normal reception of a calling signal, it will have the same effect on the locally generated signal and thus, during the testing period, cause operation of the alarm bell. The attendant will then be summoned and will learn, upon manual operation of the receiving apparatus, that atmospherics or the like are so heavy as to prevent normal automatic call repection.

Referring more particularly to the specific apparatus shown in Figure 1, it will be appreciated that the radio receiver is coupled to the antenna through a suitable conductor 13, and is equipped with a loudspeaker 14, or like communication translating device, such as a telephone receiver. It may also be preliminarily explained that whereas the selective relay D, coupled by conductors 15 and 16 to the output of the relay amplifier E, is here designed for response to a modulating frequency of, say, five cycles per second imparted by the cam 17 which is driven by the motor 12, any other suitable selective signal response device may be similarly coupled to the conductors 15 and 16, and the cam 17 so designed as to interrupt or modulate the local testing oscillations set up by oscillator F, in simulation of the signal to which the selective signal response device is intended to respond. For example, the relay D may be replaced by a device which will close an alarm-controlling circuit upon reception of a prescribed type of "SOS" signal, and cam 17 would then be arranged, with its associated instrumentalities, to operate as an automatic key for local "transmission" of that prescribed signal by the oscillator F.

The motor 12, for operating the cam 17 and the cycling mechanism, may be of any suitable type which is reasonably constant in speed. I prefer at present to employ a motor of the magnetic type, such as that described and claimed in United States Patent No. 1,985,357, for Electric motor apparatus, granted December 25, 1934, upon the application of Charles F. Wallace. As a motor of that type can be made to run on approximately 75 watt-hours per year, motor 12 is operated continuously, its energizing circuit being as follows: from the positive side of a suitable power source, such for example as a 6-volt battery as indicated, through the conductor 18,

motor 12, and through the conductor 19, back to the negative side of the 6-volt battery.

There are conveniently provided two multiple pole switches 20 and 21 for bringing the receiving apparatus and the various testing instrumentalities selectively into operation in various ways. Switch 20, for example, is of the four-pole, three-position type, and in its right-hand position arranges the receiver A and the loudspeaker 14 for preliminary testing operation which will include a test of the speaker and will enable the operator to adjust the receiver tuning. In its central position, switch 20 connects the receiving apparatus through the relay amplifier E to the selective relay D, for automatic call operation, and with the switch 20 in its left-hand position, the receiver is connected directly to the loudspeaker 14, or like device, for direct "manual" operation—i. e. under the immediate personal attendance of an operator who personally listens for calls, as is the case on shipboard, for example, when the operator is on watch—and the automatic call-response and monitoring features of the system are not brought into play. Switch 21, for controlling the cycling and supervising devices, is adapted, when in its right-hand position, to condition these devices for preliminary tests of the receiving apparatus and other instrumentalities. In its central position, switch 21 connects the receiver for continuous operation, while bringing into play the intermittent monitoring thereof, and when turned to its left-hand position, switch 21 brings the station into full automatic intermittent operation—i. e., so that the cycling mechanism G both tests the receiver and causes it to listen in for calls, only at predetermined periodic intervals.

The construction and connections may now be further explained by describing a characteristic set of operations of the system shown in Figure 1.

Let it be first assumed that the operator or attendant, as on shipboard, is going off watch and desires to leave the apparatus in condition for automatic response to an incoming call. As it is first desired to determine whether the receiver and monitoring system are functioning properly throughout, he rotates the selector switches 20 and 21 to their extreme right-hand or "test" positions. By this operation the receiving apparatus A and various other instrumentalities are energized, as will now be explained.

The following circuit is established to connect the receiving apparatus with the 110-volt line: from the negative side of the 110-volt line through conductor 22 to one side of the receiver power input, and from the other side of the receiver power input through conductor 23, switch arm 24 of switch 20 (now in its right-hand position), switch point 25, conductor 26, switch arm 27 of switch 21 (now in its right-hand position), switch point 28, and through conductor 29 back to the positive side of the 110-volt line. With the 110-volt line thus connected to the power input of the receiver, the power supply elements of the latter, as previously explained, bring it into full operative condition.

The following circuit is also established upon rotation of switch 21 to its right-hand position: from the negative side of the 6-volt battery, through the conductor 30, respectively through the condutors 31 and 32, to one side of each of the vacuum tubes 33 and 34, and from the other side of the filaments of said tubes, through conductors 35 and 35a respectively (the filaments of these tubes being connected in parallel, as will be understood), through conductor 36, switch point 37 and switch arm 38 (of switch 21) and through conductor 39 back to the positive side of the 6-volt battery. By the circuit just traced, the filaments of the oscillator tube 33 and the relay amplifier tube 34 are energized, and the relay amplifier E is brought into operative condition, since plate current therefor is supplied in the following circuit: From the positive side of a suitable source of plate current, such as the "B" battery indicated, through conductors 40 and 41, through the primary winding 42 of the audio frequency output transformer 43, to the plate of tube 34, and from the cathode of the tube 34 through the biasing resistor 45 to ground, and thereby back to the negative side of the "B" battery, connected to ground through the conductor 46.

The following circuit is also established at this time: from one side of the output of the receiving apparatus, through conductors 47 and 48, loudspeaker 14, conductors 49 and 50, switch point 51, switch arm 52 of selector switch 20 (now in its right-hand position), and through conductor 53, back to the other side of the receiver output. At the same time a circuit is likewise established from one side of the receiver output through conductors 47 and 54, through the primary winding 55 of the input audio frequency transformer 56 of the relay amplifier E, conductor 57, switch point 58, switch arm 59 of switch 20 (now in its right-hand position) and through conductor 53 back to the other side of the receiver output. In this manner, with switch 20 in its right-hand position, both the loudspeaker 14 and the input of the relay amplifier E are connected in parallel to the output of the receiving apparatus A.

It may here be explained that means are provided for supervising the circuit of the motor mechanism 12, so as to afford operation of an alarm upon any failure of this mechanism to maintain its required operation. To this end, a centrifugal switch 60 is mounted on the shaft of the motor 12, and although this switch may be of any suitable type, I prefer to employ one which consists of an eccentric bushing, normally rendered concentric with the motor shaft by means of the governor weights 61 and 62 when the motor is driving the shaft at the proper speed of rotation. Under such circumstances, i. e., when the bushing is concentric with the shaft, contacts 63 and 64 are maintained open, but when the motor slows down or stops these contacts will intermittently or permanently close and thereby energize relay 65 in the following circuit: from the positive side of the 6-volt battery through conductors 18 and 66, through the relay 65, conductor 67, contacts 64 and 63 (now closed) and through conductors 68 and 19, back to the negative side of the 6-volt battery. Energization of relay 65 will cause its contacts 69 and 70 to close, establishing the following circuit: from the positive side of the 6-volt battery, through conductor 18, contacts 69 and 75 (now closed) of relay 65, through conductors 71 and 72, alarm bell B, and through conductors 73 and 30, back to the negative side of the 6-volt battery. Thus if the motor mechanism stops or fails to drive its shaft at the predetermined speed, such failure will be announced by the alarm bell B, brought into operation by the instrumentalities just described.

Referring again to the setting of the selector switches for preliminary testing: rotation of

switch 21 to its right-hand position also causes energization of the modulator relay 74 in the following circuit: from the positive side of the 6-volt battery, through conductors 39 and 75, switch arm 76, and switch point 77 (of switch 21), conductor 78, relay 74, and through conductor 30 back to the negative side of the 6-volt battery. The armature of relay 74, attracted upon energization of the latter, is affixed to a switch plate 79, which is pivoted on the pin 80 and is moved counterclockwise with the armature, so that the switch operating spring or arm 81 is brought into engagement with the surface of cam 17, and continuing rotation of the latter thereafter causes the switch arm 81 to close contacts 82 and 83 each time the switch arm rides over a high spot on the cam. With this arrangement, the switch arm 81 is only brought into engagement with the rapidly rotating cam 17 at times when it is desired to effect modulation of the oscillator F; although in some cases this arrangement may be dispensed with, it provides an effective means for reducing wear and tear on these parts.

Assuming that the periphery of cam 17 is so designed that its teeth are caused to operate the cam switch 81 five times per second, it will be seen that the cam and cam switch, together with the circuit controlled thereby, provide means for setting up a modulating frequency of 5 cycles per second. Each time the contacts 82 and 83 of the cam switch are closed, there is brought into play a modulating device such as the microphone hummer 10, in the following circuit: from the positive side of the 6-volt battery, through conductors 39 and 75, through switch arm 76 of selector switch 21, switch point 77, conductors 78 and 84, contacts 82 and 83, conductor 85, the microphone hummer 10 (including its primary), and through conductors 86 and 30, back to the negative side of the 6-volt battery. It will be seen that an alternating current of characteristics dictated by the cam 17 (e. g., in this instance 5 cycles per second) will now be induced in the secondary 10*a* of the microphone hummer, and since the latter is connected with the grid of the oscillator tube 33, as in the manner shown, corresponding modulation will be effected upon the radio frequency oscillations produced by tube 33 when and if plate current is applied to the oscillator tank circuit.

It will be understood that all of the operations just described as taking place upon the positioning of switches 20 and 21 in their right-hand positions will occur at once. After waiting a reasonable time for the filaments or cathodes in the receiver, oscillator and amplifier tubes to heat up, the operator now tests his equipment for response to a calling signal by depressing in succession the test switches 87 and 88.

If the receiver is properly tuned to the desired calling signal, and the monitoring equipment is in proper condition, depressing test switch 87 will cause operation of the alarm bell B, in the manner now to be described.

When switch 87 is depressed, plate circuit supply is established to the oscillator F, through the following circuit: from the positive side of the "B" battery, through conductors 40 and 89, contacts 90 and 91 of switch 87 (now closed), conductors 92 and 93, contacts 94 and 95 (now closed) of test switch 88, through conductor 96, to the plate circuit of the oscillator tube 33, and thence through the tube to ground, and through conductor 46 back to the negative side of the "B" battery. Thus energized, the oscillator F, frequency-stabilized by the piezo-electric crystal 96*a*, generates a radio frequency carrier modulated by the microphone hummer 10 in accordance with the audio frequency note of the latter and in accordance with the signal characteristics (here, 5 cycles per second) imparted by the cam 17. Through the attenuator 11, which preferably comprises a coupling condenser and an adjustable non-inductive resistor connected as shown, the modulated radio frequency output of the oscillator is carried by conductor 97 and impressed upon the radio receiving apparatus A, through a coupling device 97*a*, connected, for example, to the antenna lead 13. The coupling device 97*a* may be any suitable type, such as an inductive coupling, or such as the condenser arrangement shown, having one plate connected to the conductor 13 and the other to conductor 97—such a condenser being preferably variable. In some cases, a loose coupling device or a preselector (which may include a radio frequency amplifier stage) or the like may be interposed between the antenna and the point where the oscillator is coupled to the receiver; such an arrangement serving to block off such radiation of locally generated test signals as might otherwise occur from the antenna and might, for example under extreme circumstances, cause a false operation of another and nearby call-receiving station.

The conductor 97 is preferably shielded, as indicated at 98, and the attenuator 11, with which the shielding 98 cooperates, is preferably so adjusted that the intensity of the modulated oscillations received by the receiving apparatus A from the oscillator F is reduced to a value equal to the lowest signal intensity which will satisfactorily operate the receiving apparatus and the parts controlled therefrom, under a predetermined maximum severity of atmospheric conditions.

In other words, the local signal thus impressed upon the receiver (from the oscillator F) is no stronger than is necessary to operate the receiver until such time as static or other disturbances become so severe that automatic listening-in equipment would not function properly; when static or the like reaches such an intensity as would prevent response to a signal from a distant station, it will also prevent response to the "local" signal, with the consequences which are hereinafter explained as resulting from a failure of response to the local signal in accordance with the manner in which it is used for testing.

It will now be seen that when test switch 87 is depressed, a modulated local signal is generated by the oscillator F, received and amplified by the receiving apparatus A, and impressed upon the loudspeaker 14 and also upon the input of the relay amplifier E. In response to the modulated signal, the relay amplifier thereupon delivers an alternating current (alternating at the frequency of microphone hummer 10 and broken or modulated at the frequency imparted by cam 17) to the input of the rectifier 99, which is connected to the secondary 100 of the relay output transformer 43, through conductors 101 and 102. Preferably the rectifier 99 is of the full wave type, comprising four groups of copper oxide rectifier elements in the usual bridge connection, although other suitable rectifiers may be used, or a vacuum tube, with its grid normally biased to cut-off, can be employed.

By the rectifier 99 the alternating current 5-cycle pulsations are converted to direct current

impulses which have a corresponding frequency or rate of five per second and which are delivered to the winding 103 of the selective relay D, through conductors 15 and 16. This selective relay is preferably of the torsional pendulum type mechanically tuned to respond to a predetermined modulation frequency which is the same as the modulation frequency produced by the cam 17 and the modulation frequency of the calling carrier which is to be received from a remote station. Other types of relays may be employed, although it is of advantage, in an automatic call receiver, to have the local signal simulate the predetermined call signal, and to have the relay thus responsive to both local and remotely transmitted signals, so as to afford supervision of the relay as well as the receiver. Preferred forms of the relay here shown are described in my aforesaid copending application, Serial No. 730,127, and in the pending application of Charles F. Wallace, Serial No. 82,724, for "Selective relay".

Inasmuch as the periodicity or rate of the impulses traversing the winding 103 of the relay D corresponds to the frequency to which the relay is tuned, the latter is periodically energized and periodically closes its contacts 104 and 105, to energize relay 106 in the following circuit: from the positive side of the 6-volt battery, through conductors 39 and 107, contacts 104, 105, through the limiting resistance 108, conductor 109, relay 106, and through conductors 110, 73 and 30, back to the negative side of the 6-volt battery. A condenser 111 is preferably connected across the winding of relay 106, so that its armature is continuously attracted during the periodic openings and closures of the contacts 104 and 105, even though the current impulses supplied by such periodic closures are of relatively short duration. It will also be understood that the limiting resistor 108 limits the inrush of current to the condenser 111, and thereby prevents damage to the contacts 104 and 105, as by excessive arcing.

Energization of the relay 106 causes its contacts 112 and 113 to close and operate the alarm bell B in the following circuit: from the positive side of the 6-volt battery, through the conductor 39, the switch point 37 and arm 38 (now closed) of the selector switch 21, through the conductors 36 and 114, through the normally closed contacts 115 and 116 of the alarm switch 117, through the conductor 118 and now closed contacts 112 and 113 of the relay 106, through the conductor 110 and the normally closed contacts 120 and 121 of the cam switch 122, through the conductors 123 and 72 to one side of the alarm bell B, and thence via the conductors 73 and 30 back to the negative side of the 6-volt battery.

As the winding of the relay 124 is in parallel with the alarm bell B, relay 124 is also energized upon establishment of the foregoing circuit, being established, and by the closure of its contacts 125 and 126, continues its own energization and the energization of the alarm bell until the alarm reset switch 17 is depressed, and even though the selective relay D subsequently becomes de-energized. The circuit so established is as follows: from the positive side of the 6-volt battery, through conductor 39, switch arm 38 of selector switch 21, switch point 37, conductors 36 and 114, normally closed contacts 115 and 116 of the alarm reset switch 117, conductor 118, contacts 125 and 126 (now closed) of relay 124, thence through the alarm bell B and relay 124 in parallel, and through conductors 73 and 30 back to the negative side of the 6-volt battery.

The alarm bell thus continues to ring, indicating that the receiving apparatus is in full operative condition and is properly tuned to the radio frequency of the local signal (and thus to the equivalent radio frequency of the anticipated remotely transmitted signal), and that the relay amplifier and selective relay are properly responsive to the modulating characteristics of the local signal (and thus, again, to the equivalent modulating characteristics of the remotely transmitted signal). It will also be understood that during the time that key 87 is depressed, a further check on the receiver is afforded by the conversion of the local signal to sound in the loudspeaker 14; in fact, the operator can then accurately set the receiver on frequency by listening to the local signal through the loudspeaker and tuning the receiver for maximum loudspeaker volume.

The operator now depresses the alarm reset switch 117, which opens the energizing circuit for alarm bell B and relay 124, thus turning off the bell.

The operator next depresses the test key 88 in order to check for receiver failure response, i. e., to check the circuit which would energize the alarm upon receiver failure in a later test. Contacts 94 and 95 are thereby opened, interrupting the supply of plate current to the oscillator even if certain normally open contacts of the cycling mechanism (hereinafter described) should at that moment happen to be closed. Oscillator F then fails to transmit the local signal, and response of selective relay D is thus prevented, so that contacts 112 and 128 of relay 106 remain closed.

Depressing key 88 also closes its normally open contacts 129 and 130, establishing the following circuit through the alarm bell B: from the positive side of the 6-volt battery, through conductor 39, switch arm 38 of selector switch 21, switch point 37, conductors 36 and 114, normally closed contacts 115 and 116 of the reset switch 117, conductor 118, contacts 112 and 128 (now closed) of the now de-energized relay 106, conductors 131 and 132, contacts 129 and 130 (now closed) of the test key 88, conductors 127 and 72, alarm bell B, and through conductors 73 and 30, back to the negative side of the 6-volt battery. The alarm bell B is thus caused to ring, indicating proper functioning of the circuit through contacts 112 and 128 (of relay 106) which, in subsequent supervision or monitoring, would be employed to energize the bell upon failure of the receiving apparatus; operation of the bell at this time also indicates, among other things, that contacts 104 and 105 of relay D are properly open when no signal is delivered to the relay by the receiver.

Thereupon, key 88 is permitted, as was key 87 after the previous test, to be restored, by its inherent resilience, to normal, non-testing position, and alarm reset switch 117 is again depressed to open the alarm lock-in circuit established by relay 124, and thus to turn off the bell.

Assuming that the above test have demonstrated that the receiver and monitoring apparatus are functioning properly, the operator may then turn the selector switch 20 to its central or "automatic" position, and the selector switch 21 to its extreme left-hand or "intermittent" position, so that thereafter and automatically, the receiver is intermittently monitored for response to the local signal, and intermittently conditioned to listen-in for calling signals from the remote transmitter. To provide this intermittent operation, a cam switch 133 is actuated by cam

134, and the cam switch 122 is similarly actuated by cam 135, cams 134 and 135 being driven in synchronism by the motor mechanism 12, and at a rate corresponding to that at which it is desired to repeat the testing and listening-in periods. It is here assumed, for example, that each cam makes one revolution in 15 minutes, so that a testing period and a listening period are provided every 15 minutes.

Referring to Figure 2, in addition to Figure 1, it will be seen that the timing of these cams and of the contacts operated by their switches 133 and 122, is as follows: At the beginning of the testing and listening interval, the operating spring of cam switch 133 rides up on an intermediate elevation 134a of cam 134 (see Figure 2, a plane projection of the cam surfaces in which it is assumed that the cams are traveling from right to left); during this stage, which lasts 60 seconds, contacts 136 and 137 of cam switch 133 are closed but contacts 138 and 139 remain open until the end of the 60 second interval and the operating arm of the switch rides up on the highest elevation 134b of the cam. When the last mentioned operation takes place contacts 138 and 139 close and remain closed for a period of 20 seconds, following which the operating member drops back to the intermediate level, thus opening contacts 138 and 139, for the next 40 seconds; contacts 136 and 137 remaining closed during the total two-minute period that the switch arm is displaced by elevations 134a and 134b. Cam 135 does not operate its switch 122 until the preliminary 60 second operating period of cam switch 133 is over, whereupon the operating member of cam switch 122 is shifted first by an intermediate elevation 135a of cam 135, for a period of 10 seconds, then to a top position 135b for a further period of 10 seconds (as will be apparent from Figure 2, these two successive 10 second periods correspond to the 20 second period during which contacts 138 and 139 of cam switch 122 are closed); and thereafter the operating member of cam switch 122 drops back to the intermediate stage 135a for a further 10 second period, and then to its normal position.

In the normal position of cam switch 122, its contacts 120 and 121 are closed, but during the entire 30 second period during which the operating member of this switch is elevated by the intermediate and highest projections on the surface of cam 135, these contacts are open. On the other hand, contacts 121 and 140 of cam switch 122 are normally open, and are only closed when the operating member of the switch is engaged by the highest elevation 135b of the cam 135—i. e., so that contacts 121 and 140 are only closed during a 10 second interval.

Appreciating that these cam switch operations take place only once, in the described sequence during a two-minute interval every 15 minutes, it may be explained that during such interval the following operations take place: for the first 60 seconds, the receiving apparatus, relay amplifier, and oscillator, having their filament supply circuits energized, are permitted to heat up and reach operating condition, and thereafter for a period of 20 seconds, plate voltage is applied to the oscillator, so as to generate a test signal, and during the second half of that 20 second period, the alarm bell is conditioned to respond upon a failure of the test signal to energize the selective relay D. The plate voltage is subsequently removed from the local oscillator F, and for the final 30 seconds of the 2 minute period, the receiving apparatus A is maintained in condition to listen for calls from a remote transmitter, the alarm bell being at the same time connected to indicate reception of such a call.

The operation of the various instrumentalities during this 2 minute period will now be described in detail. During the first 60 seconds, contacts 136 and 137 of cam switch 133 are closed, establishing the following circuit to energize relay 141, which is preferably a quick-acting type of relay: from the positive side of the 6-volt battery, through conductor 39, relay 141, conductor 142, switch point 143, switch arm 144 of selector switch 20 (now in its central position), conductor 145, contacts 137 and 136 (now closed) and through conductors 146 and 30, back to the negative side of the 6-volt battery. Energization of relay 141 causes closure of its three sets of contacts. Closure of its contacts 147 and 148, causes the filaments of vacuum tubes 33 and 34 to be energized in parallel from the 6-volt battery; these contacts are in parallel with switch point 37 and switch arm 38 of selector swtch 21 (now open), and the energizing circuit for the vacuum tube filaments is otherwise the same as previously traced upon the closure of the switch point 37 and switch arm 38 when selector switch 21 was in its right-hand position. Contacts 149 and 150 of relay 141 are similarly in parallel with switch point 28 and switch arm 27 (now open) of selector switch 21, and close the same circuit (previously described) to connect the power input of the radio receiver A with the 110-volt line, as was closed when selector switch 21 was in its right-hand position. Similarly, closure of contacts 151 and 152 of the relay 141 effect energization of the modulator magnet 74 and the microphone hummer 10 (in parallel), since contacts 151 and 152 are in parallel with switch arm 76 and switch point 77 (now open) of selector switch 21—the circuit being the same as that previously traced for energization of the elements just identified, when the selector switch 21 was in its right-hand position.

Following the period of 60 seconds, during which the filaments or cathodes of the vacuum tubes 33 and 34 and of the vacuum tubes in the receiving apparatus have reached their proper operating temperatures, the operating member of cam switch 133 rides up on the major projection 134b of the periphery of cam 134, for a period of 20 seconds. Closure of contacts 138 and 139 is thereby effected, establishing the following circuit: from the positive side of the "B" battery, through conductors 40 and 153, contacts 138 and 139 (now closed), conductors 92 and 93, contacts 94 and 95 (now closed), and through conductor 96 to the plate circuit of the oscillator tube 33, and from the cathode of the tube to ground and thence via conductor 46 to the negative side of the "B" battery. Plate voltage is thus applied to the oscillator, and the latter accordingly sets up, and through the attenuator 11 and coupling device 97a impresses upon the receiving aparatus A, the characteristic local signal. That is, since cam 17 is continuously driven by the motor 12, since the microphone hummer 10 has been energized, and since relay 74 has been energized to bring the modulating switch 81 into operative engagement with the cam 17, the radio frequency oscillations generated by oscillator F are modulated in accordance wth the characteristics to which selective relay D is adapted to respond—in the manner previously described with reference to the preliminary testing operation.

If the receiving apparatus, the relay amplifier, the selective relay and their associated parts are functioning properly, they will respond to this local test signal, and relay D will be energized. Inasmuch as contacts 120 and 121 of the cam switch 122 are now open (see Fig. 2 and the previous description of the operation of cam 135), the alarm bell B will not now ring upon energization of relay D. During the second half, however, of this 20 second testing period, contacts 121 and 140 of the cam swtch 142 close, and if for any reason the selective relay D has not become energized by the test signal, the alarm bell will then be caused to ring, and will continue ringing until manually turned off by operation of the reset switch 117. That is, if the selective relay D is energized, the resulting closure of its contacts 104 and 105 energizes relay 106, thereupon opening contacts 112 and 128 and closing contacts 112 and 113, but failing to operate the bell since contacts 120 and 121 are opened. On the other hand, if contacts 104 and 105 of the relay D are not closed, relay 106 will remain de-energized, and closure of cam switch contacts 121 and 140 will establish the following circuit: from the positive side of the 6-volt battery, through conductor 39, contacts 148 and 147 (now closed) of relay 141, conductor 114, contacts 115 and 116 (now closed) of reset switch 117, conductor 118, contacts 112 and 128 (now closed) of relay 106, conductor 131, contacts 140 and 121 (now closed) of cam switch 122, conductors 123 and 72, alarm bell B, and through conductors 73 and 30, back to the negative side of the 6-volt battery. The alarm bell will thus be caused to ring, and by virtue of the stick circuit established by relay 124 (which has its winding in parallel with the bell B, as previously explained), the bell will continue to ring until the alarm reset switch 117 is manually operated. The attendant will thus be advised that something is wrong with the station.

If everything is in proper condition, however, the selective relay D responds, as previously explained, to the local testing signal, and the bell does not ring. Thereafter, contacts 138 and 139 of cam switch 133 are opened, removing the "B" battery from the oscillator F, and contacts 121 and 140 of the cam switch 122 are likewise opened, to prevent operation of the bell upon de-energization of relays D and 106. In fact, during the next 10 seconds, control of the bell is entirely removed from relay 106, in either of its positions. At the end of that 10 second interval contacts 120 and 121 are closed, so that the bell is now conditioned to ring if relay D, and consequently relay 106, are energized.

For the next 30 seconds, the receiving apparatus and the relay amplifier are maintained in operative condition, and with the alarm bell conditioned for operation in response to energization of relays D and 106 in the manner just described, it will be seen that if a signal is received from a remote transmitter during this 30 second interval, the alarm bell will be caused to ring and indicate reception of such signal. In other words, this 30 second interval constitutes an automatic listening period for such calls as may be made to the station.

Thereafter cam switch 133 returns (as cam switch 122 has already so returned) to its normal position, and both cam switches so remain in normal position until the motor 12 has driven the cams 134 and 135 respectively into position to repeat the described cycle of testing and listening operations. During the 13 minute "off" period, the receiving apparatus and the filaments of the oscillator and relay amplifier tubes are de-energized, so that a very considerable saving is effected in energy consumption and in the life of the tubes and other elements of the apparatus.

Under some conditions, it may be desirable to have the receiving apparatus continuously in listening condition, as would be the case, for example, where the arrangement is employed for effecting an automatic alarm upon reception of an "SOS" call during "off watch" periods of a ship station. For continuous listening, the selector switch 20 is placed in its central or "automatic" position and selector switch 21 is placed in the central or "continuous operation" position. With the switches so arranged, the receiving apparatus and the relay amplifier are maintained continuously energized and operative; it being understood that switch arm 27 now engages switch point 28*a* (connected to point 28), to connect the power input with the receiving apparatus, and switch arm 38 engages switch point 37*a* (connected to point 37), to energize the filaments of the oscillator and relay amplifier tubes 33 and 34—all in the same manner as when switch 21 was in its right-hand position. The cam switches 133 and 122, and other instrumentalities, intermittently operated by the cycling mechanism, continue their operation in the manner previously described, so that the microphone hummer 10 and the modulator relay 74 are preliminarily energized every 15 minutes, and thereafter plate voltage is applied to the oscillator F and a local modulated test signal is accordingly supplied by the latter to the receiving apparatus during the previously described 20-second period. This test, and the succeeding replacement of the various elements to normal listening condition occur in the manner previously described during the interval that cam switch 122 is operated; if the alarm bell B commences to ring during the testing interval, warning is given that something is wrong with the receiving apparatus. At all other times contacts 120 and 121 of the cam switch 122 are closed, and since the receiving apparatus and the relay amplifier are continuously energized, the station is connected for response to an incoming call. In other words, during 14½ minutes, the station automatically listens for calls from a remote transmitter; during the remaining 30 seconds of each 15 minute period, testing operations are carried out in the manner described, to ascertain the condition of the apparatus.

In cases where it is desired to operate the receiving apparatus manually, i. e., without the relay amplifier, or selective relay D, and so that the operator merely listens for calls with the loudspeaker 14, selector switch 20 may be set in its left-hand, or "manual" position, and selector switch 21 likewise set to its left-hand, or "intermittent" position. Inasmuch as the circuit of relay 141 is then permanently opened by the switch arm 144, and since no circuits are then closed by the selector switch 21, the cycling mechanism will have no effect and neither the local oscillator, nor the relay amplifier, nor the selective relay will be energized or operatively connected. At the same time, engagement of switch arm 24 (of selector switch 20) with switch point 160, will connect the power input to the radio receiving apparatus A, energizing the same; and by virtue of the engagement of switch arm 52 with switch point 162, the loudspeaker 14 will

be connected across the output of the receiving apparatus.

It should be noted that if a call comes in and causes operation of the alarm bell B when the receiver is set for automatic listening-in operation (either continuously or intermittently), the operator may then receive the message in the usual manner, merely by depressing the alarm reset switch 116 for a moment, to turn off the bell, and rotating both selector switches 20 and 21 to their left-hand positions. "Manual" operation of the receiving apparatus may then proceed, i. e., for reception of messages through the loudspeaker, and when the operator again goes off watch he may restore the selector switches to their previous positions for continuing the automatic testing and listening operations.

It will now be appreciated that the supervision provided by the instrumentalities heretofore described is of a manifold nature. That is, the receiving apparatus is in effect tested for proper operating condition of all its parts; if, for example, the tuning of the receiver has been carelessly adjusted by the operator or if, because of vibration, ambient temperature effects, or other causes, the tuning of the receiving apparatus should change or "creep", the apparatus will fail to respond to the test signal from the oscillator F, and the alarm bell will be rung. In similar fashion the alarm will be operated if any of the vacuum tubes of the receiver burns out or becomes deactivated, or if the power supply fails, or if a short or open circuit occurs anywhere, or as previously explained, if atmospheric or other disturbances are at such a high level as to prevent proper automatic response to a call from the remote transmitter. The relay amplifier E and the selective relay D are at the same time supervised in like manner, and it will be further noted that the remaining instrumentalities for monitoring the apparatus are, in an effective sense, self-supervised. That if, if any of the parts of the oscillator F, or its crystal control, or its modulating devices (such as the microphone hummer 10, or the cam switch 81) should fail, the local signal will not be properly impressed upon the receiving apparatus, and consequently the selective relay D will not be energized during the testing interval, and the alarm bell will ring. Furthermore, as previously explained, the alarm bell is also connected to ring if the motor mechanism 12 fails to keep the cycling mechanism up to its proper speed of rotation.

It will be understood that as a further precaution, a separate battery, i. e., separate from the 6-volt battery shown, may be provided for operating the alarm bell B whenever such operation should take place. Similarly, a series relay can be included in the circuit of the 6-volt battery shown, arranged to substitute another battery or power source upon failure of the first.

In Figure 3 a somewhat modified form of system is schematically shown. The radio receiving apparatus comprises the usual radio frequency amplifier 200, detector and automatic volume control 201, and audio amplifier 202, the loudspeaker or like communication translating device 203 being connected when desired, by closure of switch 214, across the output of the amplifier 202. In parallel with the loudspeaker there is also connected across the output of the amplifier 202 a further audio frequency amplifying stage 204 which is normally biased to cut-off and is only active when a modulated signal is impressed upon the receiving apparatus. This last audio stage 204 may comprise, for example, a relay amplifier of the type designated E in Figure 1. The receiving apparatus, including the automatic volume control, may be of any suitable type embodying the usual vacuum tubes and circuits, and having a power supply unit 205 for deriving the necessary receiver power from the line 206.

There is also provided a local source of modulated oscillations 207, which through an attenuating device 208 impresses modulated high frequency currents upon the receiving apparatus by means of the antenna coupling unit 209 associated with the receiver antenna lead 210. The oscillation source 207 may be of any suitable type, for example, a crystal controlled vacuum tube oscillator modulated by a microphone hummer, such as the apparatus generally designated F in Figure 1. Through the attenuator 208, and by the adjustments of the oscillator and receiving apparatus, the oscillator is so connected to the receiving apparatus that the automatic volume control 201 must vary to its position of maximum receiver response before the local signal, as set up by the oscillator 207 and eventually amplified by the last audio stage 204, will be of sufficient intensity to operate the relay 211 which is connected across the output of the last audio stage 204. That is, the impressed local signal preferably has a predetermined low intensity which will require the automatic volume control to assume its position of maximum receiver response in order that the audio frequency modulating characteristics of the local signal, as amplified by the amplifier 204, will effect sufficient energization of relay 211 to operate the latter.

In other words, when a carrier is not received from the distant transmitter 212, the automatic volume control will be in its position of maximum volume, and the signal locally generated by the oscillator 207 will be normally received by the receiving apparatus, and will effect the predetermined sufficient energization of the relay 211. In many cases, this relay need not be of selective type, and it is arranged to control an alarm bell 213, the latter being biased to operate, for example, unless the relay 211 is energized. Thus when the receiving apparatus properly responds to the local signal, relay 211 is energized and the bell does not ring.

The distant transmitter 212, however, is adapted to transmit, to the receiver, an unmodulated calling carrier (or a carrier lacking any modulation to which the last audio stage 204 will respond) which is of such strength that the resulting signal intensity at the receiving apparatus compels the automatic volume control to vary from its condition of maximum receiver response to another value, and receiving operation on the local signal is correspondingly choked down to a point where relay 211 is not energized. In other words, reception of the anticipated unmodulated carrier, from the remote station, so affects the automatic volume control, e. g., by causing the latter to increase the grid bias on the radio frequency amplifying tubes, as to reduce the sensitivity of the receiving apparatus appreciably and at least to such extent that the audio frequency, i. e., modulation, characteristics, of the local signal fail to reach the last audio stage with sufficient energy to effect the predetermined operating energization of relay 211. At the same time, since the incoming signal, i. e. carrier, lacks the modulation to which the amplifier 204 would

respond, that signal itself, no matter how strong it is, will have no effect toward energizing relay **211**; in consequence, relay **211** remains de-energized and the bell **213** is caused to ring—thus indicating reception of a call from the remote transmitter.

On the other hand, if the local signal supplied by oscillator **207** fails to energize relay **211** for any other reason—such as failure of any part of the receiving apparatus, or failure of the oscillator **207** to supply such local signal—the alarm bell **213** will likewise ring, warning the operator that his attention is needed. It will be appreciated that the local oscillator **207** is preferably tuned to set up oscillations at the same radio frequency as that to which the receiving apparatus should be tuned for reception of the un-modulated carrier from the remote transmitter **211**.

A cycling mechanism may also be provided, for example, of a motor-driven type like that shown in Figure 1, whereby the receiving apparatus and the local oscillator **207** are turned on only at intermittent intervals for testing and listening purposes, the testing and listening operations being conveniently simultaneous; such cycling mechanism would include provision, as by cam-operated contacts, for interrupting the bell circuit during non-testing and non-listening periods. It will also be appreciated that a "manual" operation switch may be provided, which would open the bell circuit, disconnect the local oscillator **207**, and interrupt the operation of the cycling mechanism (if the latter is employed) so that upon reception of a call communication may be received via the loudspeaker **203**.

In the arrangement shown in Figure 4, the output of the receiver **300** is connected in parallel to a non-selective relay **301** and a mechanically tuned selective relay **302**, the latter being of any suitable type such as the selective relay D heretofore identified in connection with Figure 1. In this system, the calling signal from the remote transmitter **303** consists of a carrier modulated at a definite predetermined frequency, to which the selective relay **302** is tuned for response.

The local oscillator **304** impresses its local oscillations upon the antenna **305** of the receiver **300** by an inductance **306**, and is conveniently designed to set up such oscillations at the same radio frequency as that of the carrier transmitted by the remote transmitter **303**, but modulated at a frequency or in a manner which will not cause response of the selective relay **302**. Proper reception, however, of the locally generated signals by the receiving apparatus **300** will energize the non-selective relay **301**, which is so arranged that when its winding is thus energized, the circuit of alarm bell **307** is opened and the bell will not ring. On the other hand, the contacts of the selective relay **302** are arranged to close upon energization of that relay and are conveniently connected in parallel with the alarm circuit-controlling contacts of the relay **301** (normally open when relay **301** is energized). Thus when a signal is received from the remote transmitter **303**, the selective relay **302** will be energized, and closure of its contacts will close the alarm circuit and ring the bell, indicating reception of a call—even though the same signal, or the locally generated signal, may at the same time energize relay **301** so as to open its corresponding alarm circuit contacts. On the other hand, if for any reason the non-selective relay **301** fails to become energized at a time when the local oscillator **304** is supposed to be impressing a local testing signal upon the receiving apparatus **300**, the alarm bell **307** will likewise ring, summoning the attendant for investigation.

It will be seen that in the arrangements shown in Figures 3 and 4, means are provided for testing the tuning of the receiving apparatus to a predetermined carrier, and for ringing an alarm in case of a failure of such tuning or of any other part of the receiving apparatus or its power supply, or in fact, in case of any failure of the local source of testing signals **207** or **304** to supply the proper testing signal. Moreover, in the arrangement of Fig. 4, by means of proper placement of the local oscillator or its output relative to the antenna **305**, as at the far end of the latter, like supervision of the antenna itself is afforded; if, for instance, the antenna **305** is carried away by a storm, there may be nothing to pick up, for the receiver, the locally radiated signal from the inductance **306**, and consequently the bell will ring.

For some purposes, the relay **301** is preferably of the slow release type, so that, for example, if a signal comes in at the proper radio frequency but modulated at some other low audio periodicity than that to which relay **302** will respond (e. g., a signal for calling another station), and if such signal should block out the local signal from oscillator **304**, the opening of the contacts of relay **301** will be sustained rather than periodically interrupted in accordance with the audio periodicity of such incoming signal.

In Fig. 5, the arrangement is generally the same as that shown in Fig. 4, except that the signaling means which is controlled in accordance with the supervision of the receiver **300** comprises a transmitter **308** conveniently having its own antenna and adapted, for example, to transmit a warning call to a remote station. That is, relays **301** and **302** are arranged to control separate circuits; the contacts of non-selective relay **301** are included in the circuit which supplies "A" or filament current to the tubes of transmitter **308** from battery **309**, while the contacts of selective relay **302** control the circuit of the foghorn **307***a* or other device to be operated upon reception of signals from the remote transmitter **303**. Thus if the receiver **300** properly responds to the local test signal from oscillator **304**, relay **301** is energized, opening the energizing circuit for transmitter **308**, and keeping the transmitter **308** silent, but if something goes wrong, say, with the receiver **300**, relay **301** will fail to receive the local test signal and will be deenergized, closing the circuit of transmitter "A" battery **309** and bringing the transmitter **308** into operation. The transmitter **308** thus constitutes an alarm device, whereby a distinctive signal may be sent to a remote station upon failure of the receiving apparatus **300**—an arrangement particularly useful where the receiver **300** is to be employed for remote control of apparatus such as a marine beacon, fog-horn or the like.

On the other hand, as explained in connection with Fig. 4, reception of the predetermined modulated signal from the remote transmitter **303** will operate relay **302** and in consequence the call bell **307** or such other device (light, horn or the like) as is to be operated by that signal; the local or the distant signal, or both, serving at the same time to keep non-selective relay **301** energized and the transmitter **308** silent.

The apparatus shown in Fig. 6 is essentially similar to that of Figs. 4 and 5, relay **301** being normally energized upon proper reception by

receiver 300 of the local test signal from oscillator 304, and relay 302 being energizable to operate bell 307 only upon reception of the predetermined call signal from the remote transmitter 303. A spare receiving apparatus 310, conveniently having its separate antenna 311, is provided, and relay 301 is so arranged that upon its deenergization, as by failure of the receiver 300 to respond to the local test signal, contacts 312 and 313 of relay 301 close, as shown, to connect the receiver power supply line 314 to energize receiver 310, contacts 315 and 316 also close, as shown, to connect the selective relay 302 for control by the output of receiver 310, and contacts 315 and 317 open, removing the relay from its previous connection (with contacts 315 and 317 closed) in parallel with relay 301 across the output of receiver 300.

It will consequently be seen that upon failure of receiver 300 or its antenna 305, a spare receiver 310 and antenna 311 are automatically brought into play for control of the relay 302 and thus for effecting operation of the bell 307 or other device upon reception of the predetermined signal from the remote transmitter 303. It will now be appreciated that this arrangement, too, is of particular advantage in remote control systems, where there would be no attendant at the receiving station to make immediate repairs should anything go wrong.

If desired, as in the case of Fig. 1, a cycling mechanism may be provided for automatic intermittent operation of any of the systems shown in Figs. 4, 5 and 6; and as will likewise now be understood, the systems of Figs. 1 and 3 can be readily adapted for automatic operation of an alarm transmitter or automatic substitution of a spare receiver upon failure of the receiver or its parts. It should further be noted that where the system of Figs. 1, 3 or 4 are used as receiving stations of a remote control system, for example to operate a marine beacon, foghorn or the like in lieu of the bells B, 213 or 307 respectively, the system is biased, so to speak, on the side of safety. That is, if the receiving apparatus should fail, even at the crucial moment when it is desired to turn on the beacon or horn by a signal from the remote transmitter, the beacon, horn or other device will automatically be turned on (like the alarm bell shown) by reason of the receiver failure itself.

Referring again to Figure 1, more particularly, it may be noted that the local modulating means can be dispensed with where the receiving station is designed to respond to a call consisting of a simple unmodulated carrier,—i. e., the local oscillator F need then transmit only pure "C. W." corresponding to the transmission from the remote station, and the arrangement would then also supervise such beat note generating devices as the receiver might include for proper reception of the pure C. W. It will also be noted that the alarm bell is arranged to "lock in" upon operation in response to a calling signal or in indication of a failure of any part of the apparatus during a testing period. By this arrangement, which may be employed with any of the other forms of the invention, the bell rings not only during actual calling or testing but continuously until the operator arrives to turn it off. It will be further understood that the present invention may be conveniently applied to automatic radio telephone or like systems of the type disclosed and claimed in my hereinabove identified applications Serial Nos. 730,127 and 11,783, wherein arrangement is already provided for intermittent listening periods in accordance with the operation of a motor driven cycling mechanism.

It will now be further appreciated that the present invention affords a thorough supervision of the receiving apparatus and its associated parts, and provides for an alarm or other circuit-controlling operation upon failure or improper functioning of that apparatus in almost an infinite number of different respects—thus affording far more complete supervision than is provided by previously known arrangements wherein under-voltage and similar relays have been placed in the filament and "B" battery leads to cause operation of an alarm (or substitution of another receiving apparatus) in case one or more vacuum tubes burn out or the batteries fail.

In accordance with the provisions of the patent statutes, I have herein described the principle of operation of my invention, together with the apparatus which I now consider to represent the best embodiments thereof, but I desire to have it understood that the apparatus disclosed is only illustrative and that the invention can be carried out by other means. Also, while it is designed to use the various features and elements in the combinations and relations described, some of these may be altered and others omitted and some of the features of each modification may be embodied in the others without interfering with the more general results outlined, and the invention extends to such use within the scope of the appended claims.

I claim:

1. In a radio signaling system, an alarm device, a local signal generator, wave receiving apparatus having an output circuit, means for causing said generator to impress a local signal upon the receiving apparatus and for conditioning said alarm device to operate, means for intermittently bringing said last mentioned means into play, means controlled by the output circuit of the receiving apparatus for preventing operation of said alarm device upon performance of normal receiving operations by the receiving apparatus upon the local signal, and means brought into play upon operation of the alarm device for preventing the intermittent means for interrupting operation of the alarm device.

2. A receiving station for a radio signaling system, comprising wave receiving apparatus adapted to effect predetermined receiving operations in response to predetermined waves having predetermined signaling characteristics from a remote transmitter, means including a local oscillator for setting up and impressing upon the receiving apparatus a local signal simulating said predetermined waves and including means for imparting said predetermined signaling characteristics to said waves, a control circuit, and means for effecting energization of said control circuit upon failure of the receiving apparatus to effect normal receiving operations upon the local signal set up by the first mentioned means.

3. In a receiving station for a radio signaling system, in combination, a test-responsive circuit adapted to effect a predetermined energization of an electrical device, wave receiving apparatus, supervising apparatus including means for applying to the receiving apparatus a local test signal of a character which the receiving apparatus is adapted to receive from a remote station, for opening said test-responsive circuit upon normal energized operation of the receiving apparatus in response to said local test signal, and means con-

trolled by the receiving apparatus and in response to waves of a predetermined nature, for closing said test-responsive circuit irrespective of the operation of said supervising apparatus.

4. In a receiving station for a radio signaling system, in combination, wave receiving apparatus adapted to establish a warning indication upon reception of waves modified with a predetermined signaling characteristic, and means for supervising the operation of said apparatus to effect a predetermined response upon failure thereof, said supervising means comprising means for applying to the receiving apparatus, a local testing signal comprising waves modified with said predetermined signaling characteristic and means for performing a predetermined circuit-controlling operation, and said receiving apparatus including means responsive to normal operation of said local signal applying means, for preventing operation of said circuit-controlling operation performing means, when the receiving apparatus is in normally energized operative condition, for its aforesaid response to waves modified with the predetermined signaling characteristic.

5. In a receiving station for a radio signaling system, in combination, wave receiving apparatus adapted to receive wave signals from a remote station and having an output circuit, and means for supervising the operation of said apparatus to effect a predetermined response upon failure thereof, said supervising means including means for applying to the receiving apparatus a local testing signal which comprises a carrier wave equivalent to that of a calling signal which said apparatus is adapted to receive, and said receiving apparatus comprising means responsive to normal operation of said local signal applying means, for effecting a predetermined energization of said output circuit when the receiving apparatus is in normally energized operative condition, and means associated with said receiving apparatus and responsive to reception thereby of a predetermined calling signal, for suppressing said predetermined energization of the output circuit.

6. A receiving station for a radio signaling system, comprising wave receiving apparatus, a relay controlled thereby and responsive to reception by the receiving apparatus of a predetermined signal from a distant transmitter, means including a local oscillator, for setting up and impressing upon the receiving apparatus a local signal simulating the aforesaid predetermined signal, control means adapted to bring said last mentioned means into play, an alarm device, and means responsive to operation of said control means for operating said alarm device upon failure of the aforesaid relay to respond to the local signal.

7. The combination of claim 6 in which the relay is a selective relay tuned for response only to a signal having a predetermined modulation, and in which the local oscillator has means associated therewith for imparting said predetermined modulation to the local signal.

8. The combination of claim 6 in which is included means having an actuating device therefor, for intermittently operating the control means to afford supervision of the receiving apparatus during the intervals of said intermittent operation, and governor means for operating the alarm device upon failure of the actuating device to actuate the intermittent operating means.

9. In a receiving station for a radio signaling system, in combination, a relay, wave receiving apparatus having an input circuit for receiving signals from a remote transmitter, means for generating and impressing upon said input circuit a local test signal comprising radio frequency oscillations, said receiving apparatus including means controlled thereby for causing the relay to become energized upon reception of the local test signal by the receiving apparatus, and means under the control of the relay for effecting a predetermined emergency control upon failure of the relay to become energized when the local test signal is impressed on the aforesaid input circuit.

10. In a receiving station for a radio signaling system, in combination, an alarm device, wave receiving apparatus having control means for effecting control of the alarm device therefrom, supervising means including a local radio frequency oscillator for impressing local oscillations on the receiving apparatus and means conditioning said control means to operate the alarm device upon failure of the receiving apparatus to respond to the local oscillations impressed thereon, and means for conditioning the control means to operate the alarm device upon response of the receiving apparatus to a predetermined signal from a remote transmitter.

11. In a receiving station for a radio signaling system, in combination, wave receiving apparatus adapted to be set for response to calling signals from a remote transmitter, an alarm device, normally inoperative means for generating and impressing upon the receiving apparatus a local signal to which said apparatus is normally adapted to respond, normally inoperative means controlled by the receiving apparatus for causing operation of the alarm device upon failure of said receiving apparatus to perform normal receiving operations on the local signal, monitoring means for intermittently placing both said last-mentioned means in operative condition, whereby the receiving apparatus is intermittently supervised, alarm control means, and operating means therefor associated with said monitoring means and operable in response to failure of said monitoring means to effect its aforesaid intermittent operation.

12. In a receiving station of a radio signaling system, in combination, normally deenergized wave receiving apparatus, means intermittently supplying energy to said apparatus to render it operative during the intervals of energy supply, a relay, a source of local signals, means cooperating with said energy-supplying means for causing said source to impress a local signal upon the receiving apparatus during a portion of the intervals of energy supply, and means brought into play when said cooperating means is operative, for energizing said relay upon normal response of the receiving apparatus to the local signal.

13. The combination of claim 12, which includes a common driving motor for the intermittent energy supplying means and the means cooperating therewith, and also includes an alarm device and means for energizing the same upon failure of the motor to effect its aforesaid driving operation.

14. In a receiving station of a radio signaling system, in combination, wave receiving apparatus adapted to respond to radio wave signals, including waves having a predetermined modulation, means including a local oscillator for generating and impressing upon the receiving apparatus a local radio wave signal lacking said predetermined modulation, and means controlled by the receiving apparatus for indicating reception of waves from a remote transmitter having the

predetermined modulation and for indicating departure of the receiving apparatus from normal operative condition irrespective of reception of waves from a remote transmitter, said last-mentioned means including selective relay means adapted to close an indicator circuit only upon response of the receiving apparatus to waves having the predetermined modulation, and relay means adapted to open an otherwise closed indicator circuit upon normal response of the receiving apparatus to the local radio wave signal at times when waves are not being received from a remote transmitter.

15. In a receiving station of a radio signaling system, in combination, wave receiving apparatus including an automatic volume control device automatically variable to a position of maximum receiver response only upon reception of signals of no greater than a predetermined signal intensity, and an output circuit energizable under control of the receiving apparatus only by signals having an audio frequency modulation, said output circuit having means adapted to operate an alarm device unless said output circuit is energized at a predetermined energizing intensity at least as low as that resulting from reception by the receiving apparatus of signals having the aforesaid predetermined signal intensity, and means including a local oscillator and modulating means, for setting up and impressing upon the receiving apparatus a local signal that has a carrier frequency to which the receiving apparatus is adapted to respond, and that is modulated at a frequency capable of effecting energization of the aforesaid output circuit, and that is of no greater than the aforesaid predetermined signal intensity, whereby operation of an alarm device can be effected both upon failure of the receiving apparatus to respond normally to reception of the local signal and upon reception of an unmodulated carrier at least strong enough to cause the automatic volume control to prevent the local signal for energizing the output circuit at the predetermined energizing intensity.

16. In a receiving station for a radio signaling system, in combination, wave receiving apparatus normally adapted for reception of signals from a remote transmitter, a second wave receiving apparatus, and supervising means for said first-mentioned receiving apparatus, said supervising means including a local oscillator adapted to introduce in the first-mentioned receiving apparatus oscillations adapted to effect a predetermined response of said apparatus upon normal operation of said apparatus, and means controlled by the first-mentioned receiving apparatus for controlling the second wave receiving apparatus to bring the latter into operative condition for reception of signals from a remote transmitter, upon failure of the first-mentioned receiving apparatus to effect the said predetermined response to the aforesaid oscillations.

17. In a receiving station for a radio signaling system, in combination, wave receiving apparatus, an alarm device comprising wave transmitting apparatus for transmitting a warning signal to a remote station, and means for supervising the operation of the receiving apparatus, said supervising means including a local oscillator adapted to impress local oscillations on the receiving apparatus, and means controlled by the receiving apparatus for effecting operation of said alarm device to transmit a warning signal, upon failure of the receiving apparatus to effect a predetermined response to said local oscillations.

18. A receiving station of a radio signaling system, comprising wave receiving apparatus adapted to be tuned for reception of signals of predetermined frequency from a remote transmitter, and means for supervising the response of said apparatus to signals of said frequency, including means for locally generating and impressing upon the apparatus a signal of said frequency, an alarm device having connections for control by the receiving apparatus in accordance with the response of the latter to the locally generated signal, and means for controlling the control of the alarm device by the receiving apparatus, said controlling means including a testing switch and being selectively settable to cause operation of the alarm device, independently of the testing switch, upon failure of the receiving apparatus to respond to the local generated signal, and to cause operation of the alarm device, in response to operation of the testing switch, upon normal response of the receiving apparatus to the locally generated signal.

19. In a radio wave receiving system, radio wave receiving apparatus, means for introducing local test signals in said apparatus, said apparatus including means for normally effecting a predetermining response of said apparatus to said signals, means limiting the intensity of reception of said local test signals whereby operation of said second-mentioned means is prevented when atmospheric disturbances received by said receiving apparatus have more than a predetermined intensity, and means controlled by the receiving apparatus for effecting a predetermined emergency control upon absence of said predetermined response to the local signals.

20. A method of supervising a radio receiving apparatus, comprising applying a signal of predetermined character and frequency to the input of said apparatus and thereby causing a predetermined response to said signal to be established by the output of said apparatus when the latter performs normal receiving operation on the signal, subjecting a control circuit to control by the output of said receiving apparatus, causing said control circuit to effect a predetermined emergency operation upon absence of the predetermined response to the applied signal in the output of the receiving apparatus, and limiting the intensity of the applied signal to such level as will effect the aforesaid predetermined response only when atmospheric and like disturbances are below a predetermined level of intensity.

21. A method of supervising a radio receiving apparatus, comprising applying a signal of predetermined character and intensity to the input of said apparatus and thereby causing a characteristic response to said signal to be established by the output of said apparatus when the latter performs normal receiving operations on the signal, varying the intensity of said characteristic output response inversely in accordance with the intensity of other currents received by the input of said receiving apparatus, subjecting a control circuit to control by the output of said receiving apparatus, and causing said control circuit to effect a predetermined emergency control upon absence of characeristic response of at least a predetermined intensity in said ouput.

22. Means for revealing undesired detuning of a radio receiving system which comprises the combination with a radio receiving system tuned for response to waves of a predetermined radio frequency from a remote station, of a local oscillator sharply tuned to produce waves of said

predetermined frequency and having means for impressing said waves on the input of the receiving system, and means controllable by the receiving system for effecting a predetermined emergency control in response to failure of the receiving system to perform normal receiving operations on the waves produced and impressed by the local oscillator, whereby said emergency control will be produced unless both the local oscillator and the receiving system are tuned to the same radio frequency.

23. The combination of claim 22, wherein the local oscillator includes a piezo-electric crystal and connections for controlling the tuning of the oscillator thereby.

24. The combination of claim 22, which also includes a relay device under control of the receiving system for selectively effecting a predetermined control operation in response to reception of waves having a predetermined signaling modification, means associated with the local oscillator for impressing said predetermined signaling modification on the locally produced waves, and means controllable by the relay device for bringing the predetermined emergency control means into operation in response to failure of the relay device to respond to the signaling modification of the locally produced waves.

25. In a receiving station for a radio signaling system, in combination, an alarm device, wave receiving apparatus having means for producing a predetermined control only upon reception of waves having a predetermined signaling characteristic, and supervising means for said apparatus, including means for locally generating testing waves and impressing same on the receiving apparatus, associated means for imparting the aforesaid predetermined signaling characteristic to the locally generated waves, and means controllable by said predetermined control means for operating said alarm device upon failure of said receiving apparatus and its said control means to respond to the locality generated waves.

26. The combination of claim 25 wherein the supervising means is normally inoperative, and wherein are provided means for intermittently bringing the supervising means into operation to test the receiving apparatus at intermittent intervals, and means responsive to operation of the alarm device operating means, for thereafter maintaining the alarm device in operation, whereby the intermittent means is prevented from interrupting said operation.

27. In a receiving station for a radio wave signaling system, in combination, wave receiving apparatus adapted to respond to waves having a predetermined signaling modification and to waves lacking said predetermined modification, a signaling device, means for effecting a predetermined emergency control, selecting means controllable by the receiving apparatus in accordance with its reception of both of said kinds of waves and simultaneously selectively responsive to operate the signaling device upon response of said apparatus to one of said kinds of waves and to operate the emergency control means upon failure of said apparatus to respond to the other of said kinds of waves, and supervising means for locally generating and impressing on said apparatus the kind of waves for which failure of the receiving apparatus will cause the selecting means to operate the emergency control means, whereby the receiving apparatus may be supervised while it is listening for the other kind of waves.

28. In a receiving station for a radio wave signaling system, in combination, wave receiving apparatus having an automatic volume control circuit, a local generator for producing test signals, and impressing same on the receiving apparatus and having means for limiting the test signals, as applied, to an intensity which will cause variation of the volume control circuit to the condition of maximum receiver gain, means normally biased to effect a predetermined emergency control, and means controllable by the receiving apparatus and responsive to normal receiving operation of the local test signal, for preventing operation of the last-mentioned means, whereby the emergency control will be effected upon reception of other waves having sufficient intensity to drive down the automatic volume control circuit.

29. In a receiving station for a radio signaling system, in combination, normally deenergized wave receiving apparatus, normally inoperative supervising means therefor comprising a local signal generator, means for producing a predetermined emergency control, and means controllable by the receiving apparatus for operating said last-mentioned means upon failure of said apparatus to respond to local signals from said generator, monitoring means for intermittently bringing said supervising means into operation, and means synchronized with said monitoring means for intermittently supplying energy to the receiving apparatus to render it operative during the intervals of energy supply, including the intervals of supervision under control of the monitoring means.

JOHN R. MacKAY.

CERTIFICATE OF CORRECTION.

Patent No. 2,165,064. July 4, 1939.

JOHN R. MacKAY.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, second column, line 65, for the reference numeral "75" read 70; page 5, first column, line 50, before "switch" insert reset; and second column, line 64, for "test" read tests; page 6, second column, line 23, for "swtch" read switch; line 64, for "aparatus" read apparatus; line 72, for "wth" read with; page 7, first column, line 11, for "swtch" read switch; page 8, first column, line 42, for "That if" read That is; page 10, second column, line 48, claim 1, for "for" read from; page 12, second column, line 18, claim 18, for "local" read locally; line 27, claim 19, for "predetermining" read predetermined; page 13, first column, line 43, claim 25, for "locality" read locally; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 26th day of September, A. D. 1939.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)