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Sept. 17, 1946.

J. C. O'BRIEN

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RADIO COMMUNICATION SYSTEM

Filed Feb. 5, 1945

3 Sheets-Sheet 1

FIG. 1A

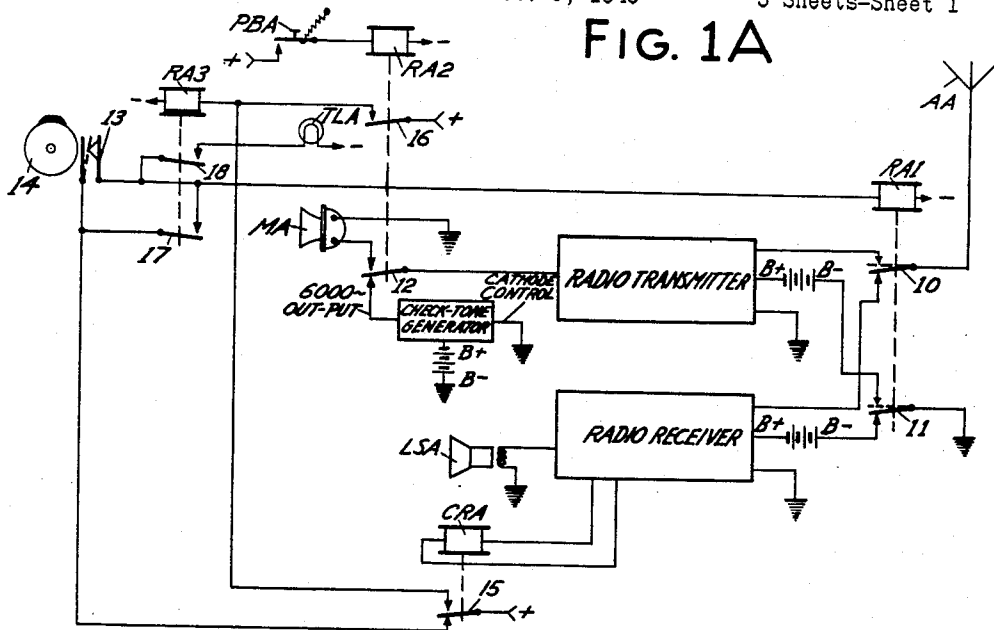


FIG. 1B

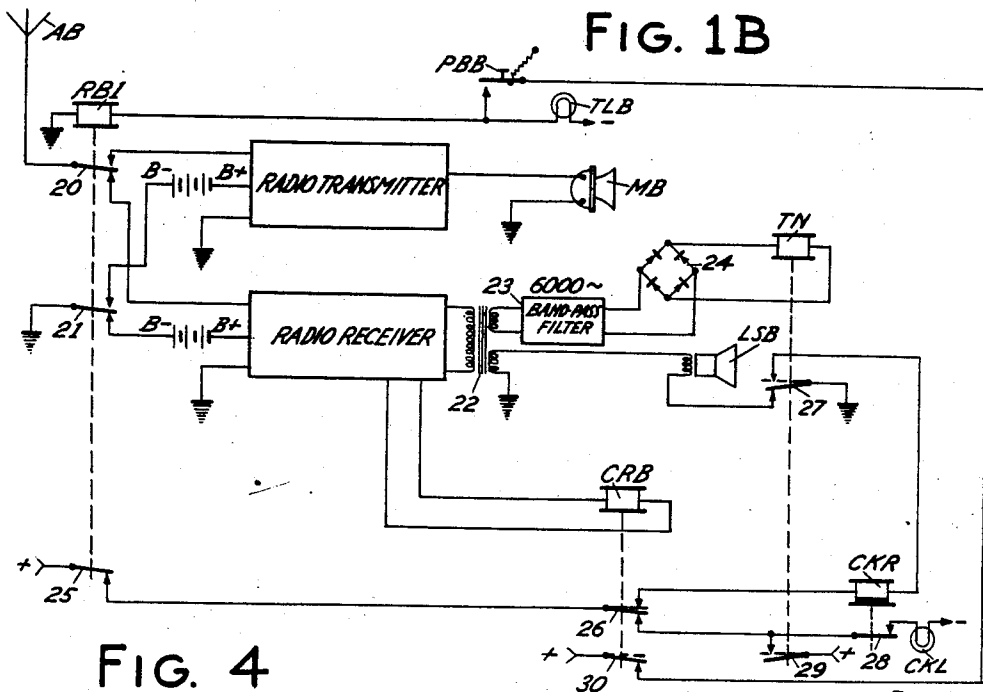
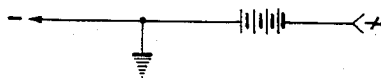


FIG. 4



By

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Sept. 17, 1946.

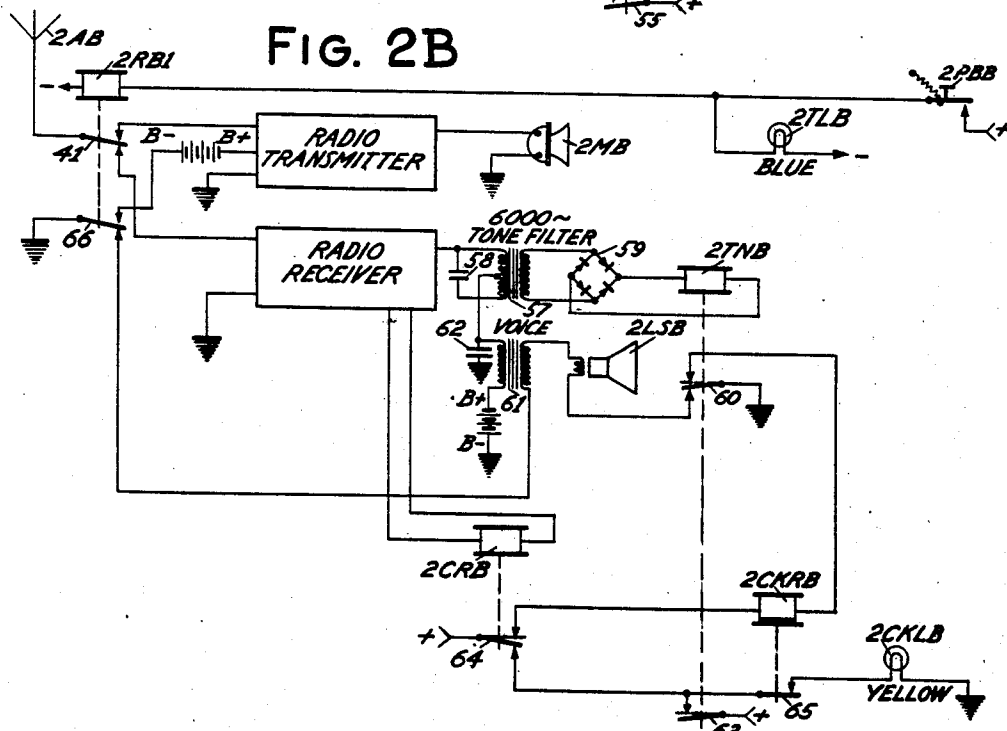
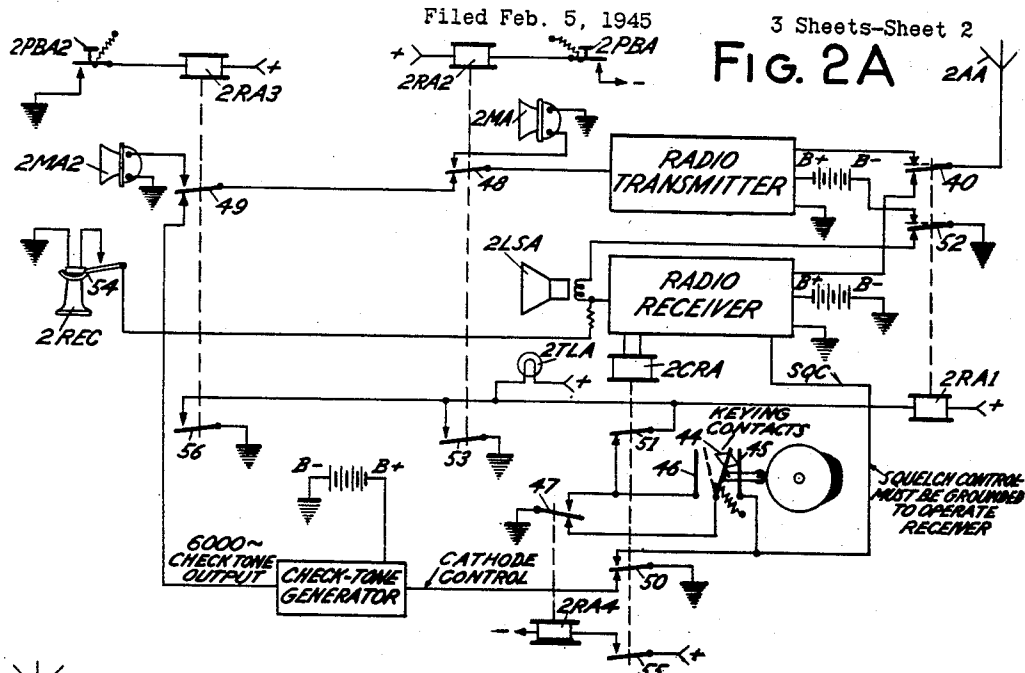
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RADIO COMMUNICATION SYSTEM

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3 Sheets-Sheet 2



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RADIO COMMUNICATION SYSTEM

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3 Sheets-Sheet 3

FIG. 3A

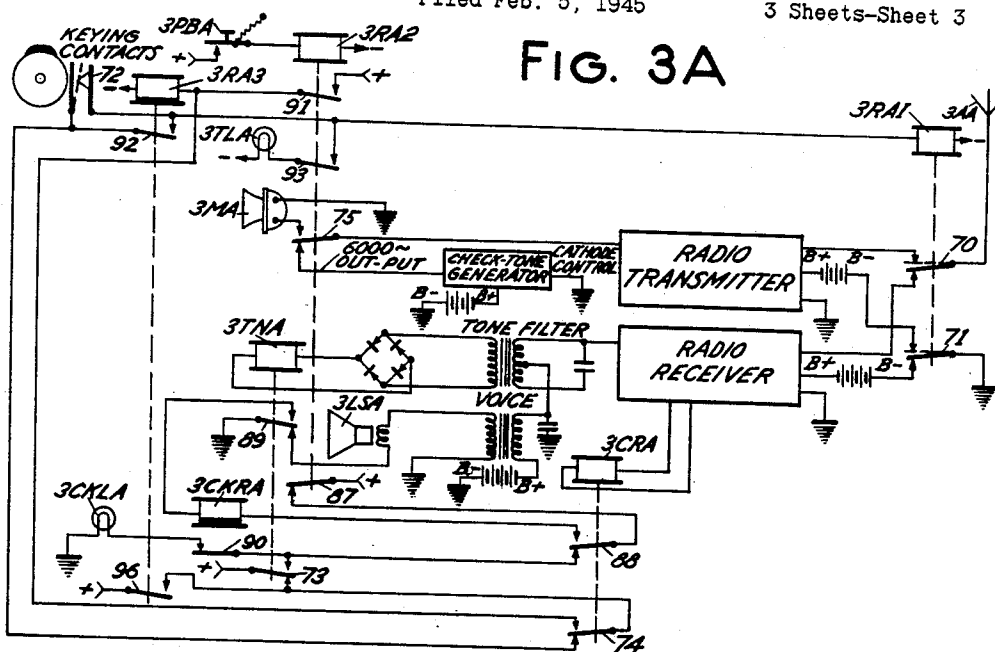
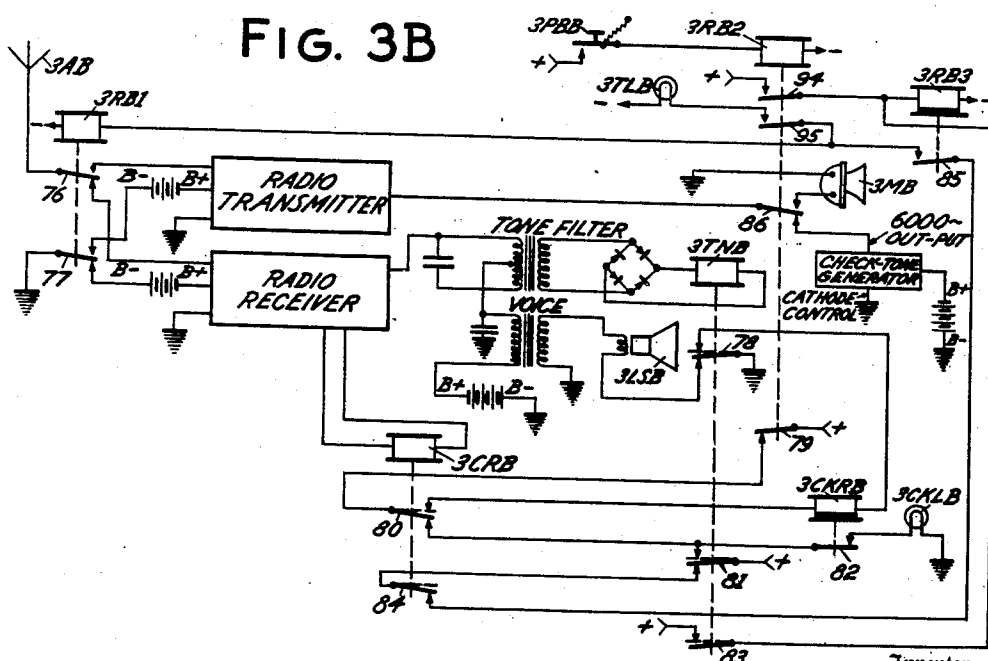


FIG. 3B



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RADIO COMMUNICATION SYSTEM

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Application February 5, 1945, Serial No. 576,325

22 Claims. (Cl. 250-13)

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This invention relates to communication systems for transmitting messages by the modulation of a carrier frequency, and more particularly pertains to improved means for continuously indicating the operative condition of such a system.

The present invention should be considered in the nature of an improvement over the disclosure of my prior application Ser. No. 552,833, filed September 6, 1944, and no claim is intended to be made herein to any subject matter common with such prior application.

In communication systems employed in connection with the governing of traffic, such as the governing of the movement of locomotives in a railroad classification yard, and the like, it is desirable to provide means for checking the operative condition of the system so that the trainman receiving instructions to move his train will either be assured of receiving further instructions for governing the train or be advised that the system is inoperative and that he should act accordingly on the side of safety. Obviously, such a checked communication system is applicable to the control of traffic of various kinds where it is deemed essential to the safety of the traffic that such a check be provided.

The type of communication system more particularly contemplated by the present invention is one in which carrier frequency signals modulated by voice frequencies and/or different distinctive tones, and the like, are transmitted for conveying the message. It is further contemplated that the carrier frequency signals may be directly radiated as in radio, or may be transmitted by induction commonly termed wired radio. Although the present invention is thus contemplated as being applicable to various basic forms of communication systems, it has been shown for the purposes of the present disclosure as embodied in a radio telephone communication system where voice messages are transmitted and distinctive tones are used for the checking control.

In a system of the above type, it is desirable to normally transmit a checking signal which will cause the display of a suitable indication at the receiving station. During voice transmission, this checking signal is removed so as to cause the display of a different indication at the receiving station. Thus, the operator is advised that he should receive a proper message; and in the event that no voice message is received, he is immediately advised that the communication system has failed, because of failure of a

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part of the system unchecked by the normally transmitted checking signal.

In a two-way communication system using the same channel for both directions of transmission, it is desirable to transmit the checking signal, such as by the transmission of a check-tone modulated carrier frequency, at spaced intervals since the transmission of the checking signal interferes with the proper reception of a carrier signal from a distant station. In other words, by making the check-tone modulated carrier signals intermittent, it is possible for the distant station to initiate transmission and cause the cessation of the check-tone modulated signal in an automatic manner such as disclosed for example in my above mentioned prior application Ser. No. 552,833, filed September 6, 1944. Thus, it should be understood that the present invention is in the nature of an improvement in the means and organization provided for effecting the checking operation.

More specifically, it will be appreciated that even though the check-tone modulated signals should be transmitted intermittently, it is desirable to have a steady indication at the receiving station, rather than an intermittent indication which would be a source of annoyance to the operator and also be difficult to distinguish between the regular checking indication and the actual initiation of a failing condition. Thus, one object of the present invention is to provide an organization of the above generally described type in which means is provided at the receiving station to give a steady indication so long as the checking signals are intermittently received, and at the same time being so controlled as to give a distinctive indication immediately upon the reception of a carrier signal for voice messages.

Another object of the present invention is to provide the immediate restoration of the checking signal at the end of a voice message although the continuously operating keying contacts for the checking signal do not happen to be at a signal initiating position in their cycle of operation when the voice message ceases. This feature is desirable so that the checking signal will immediately be displayed at the receiving station upon the cessation of the reception of a voice message.

A further characteristic feature of the present invention is that in the provision of a two-way communication system, it may be desirable to provide the checking feature for both directions of communication. This would be especially

true in providing communication between the front and rear ends of a moving train for example. Thus, another object of the invention is to provide the checking feature for both directions of communication in a manner that allows one station to be the primary station for originating the checking signal while the other or distant station acts as a secondary station causing a repeat of the checking signal back to the primary station. It is further proposed in such an organization that the initiation of communication for voice in either direction, shall immediately cause the cessation of the checking signal transmission and the display of a distinctive indication at both locations together with means effective at the end of such voice communication to cause the immediate restoration of the checking signal transmission and the cessation of said distinctive indication at both locations.

A further object of the present invention is to provide such an organization as above generally described which is adaptable to either amplitude or frequency modulation of the carrier frequencies employed by the transmitters and receivers, and the general organization of the system is contemplated as being particularly adaptable to provide the two-way communication over the same frequency channel.

A further object of the present invention is to provide an organization based upon what is commonly known as "the closed circuit principle" so that any failure of apparatus will immediately cause such fact to be brought to the attention of the operators at the receiving stations.

Other objects, purposes and characteristic features of the present invention will be in part obvious from the accompanying drawings, and in part pointed out as the description of the invention progresses.

In describing the invention in detail, reference will be made to the accompanying drawings, in which like reference characters designate corresponding parts throughout the several views, and in which:

Figs. 1A and 1B illustrate in a diagrammatic manner the transmitting and receiving equipment at each of two separated stations providing two-way voice communication with the checking feature for one direction of communication only as organized in accordance with the present invention;

Figs. 2A and 2B illustrate in a diagrammatic manner a modified form of transmitting and receiving equipment at each of two separated stations providing two-way voice communication with the checking feature of the present invention applied to communication in one direction only;

Figs. 3A and 3B illustrate in a diagrammatic manner the transmitting and receiving apparatus for each of two separated stations for providing two-way communication with the checking feature of the present invention applied to both directions of communication; and

Fig. 4 shows how battery sources are assumed to have their negative terminals grounded.

For the purpose of simplifying the illustration and facilitating in the explanation, the various parts and circuits constituting the embodiment of the invention have been shown diagrammatically and certain conventional illustrations have been employed, the drawings having been made more with the purpose of making it easy to understand the principles and mode of operation, than with the idea of illustrating the specific

construction and arrangement of parts that would be employed in practice. Thus, the various electron tubes and their elements as well as the various relays and their contacts are illustrated in a conventional manner, and symbols are used to indicate connections to the terminals of sources of electric current instead of showing all of the wiring connections to these terminals.

The symbols (+) and (−) are employed to indicate the positive and negative terminals respectively of suitable sources of direct current and the circuits with which these symbols are used always have current flowing in the same direction. It should be understood that certain terminals of the sources employed should be grounded in order to obtain proper operation of the system, and for the purpose of the present disclosure it is assumed that the negative terminal of the sources indicated are properly grounded, as shown in Fig. 4, but when storage batteries are used, it may be preferable to ground the positive terminals. The symbol (B+) is used to indicate the positive terminal of a suitable direct current source for the so-called "B battery supply" of the electron tubes, while the opposite terminal of such a source is indicated by (B−). It is to be understood that these different sources of direct current potential may be provided by suitable batteries as indicated in certain cases, or may be provided by the usual conventional power pack organization supplied with energy from an alternating current source.

Organization of Figs. 1A and 1B

Referring to Fig. 1A, a radio transmitting apparatus has been indicated by a rectangle designated "Radio transmitter"; and an associated receiving apparatus has been indicated by another rectangle designated "Radio receiver." Associated with the radio transmitter and receiver is a suitable antenna AA which is normally connected to the "Radio receiver" through back contact 10 of relay RA1, but when this relay RA1 is energized, the antenna AA is connected to the "Radio transmitter" through front contact 10. A suitable ground connection indicated in the usual way is provided for both the radio receiver and transmitter.

The radio receiver is provided with a suitable plate energy supply indicated by the usual "B battery" with its opposite terminals indicated by (B+) and (B−). The negative terminal (B−) of this plate supply is connected to ground through back contact 11 of relay RA1 so that the "Radio receiver" is normally activated, and the reception of a carrier signal is suitably amplified in a manner to cause the carrier-responsive relay CRA to be picked up. If the carrier is modulated with voice frequencies, the receiver causes them to be reproduced by the usual loudspeaker LSA.

Similarly, the radio transmitter has the usual plate supply having its opposite terminals indicated by the symbols (B+) and (B−), but its negative terminal (B−) is connected to ground through front contact 11 of relay RA1. Thus, when the relay RA1 is deenergized, the radio receiver is rendered active, but when this relay RA1 is picked up, the radio receiver is rendered inactive and the radio transmitter is rendered active to transmit carrier frequency signals that may be modulated either by a particular tone, such as provided by the "check-tone generator" which is normally connected through back contact 12 of relay RA2 or in accordance with the

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voice frequencies by the microphone MA which is connected to the transmitter whenever the relay RA2 is picked up.

A suitable keying mechanism is associated with this station which is indicated as being cam operated keying contacts 13. The driving cam 14 is continuously operated and is assumed to close the keying contacts for a half second every three-and-a-half seconds. Or in other words, the keying contacts are closed approximately one-eighth of the time neglecting any transit time for the movable portion of the keying contacts 13, which transit time is very short. This relative timing of the keying contacts may of course be selected as desired, it being kept in mind that it is desirable to have the ratio of the check-tone transmission time to the total time as small as possible so as to give the greatest possible "break-in" time for the transmitters as will be described in detail later.

Each time the keying contacts 13 are closed, a circuit is closed for the transmit relay RA1 from (+), through back contact 15 of carrier relay CRA, keying contacts 13, windings of relay RA1, to (-). The momentary energization of the relay RA1, as above mentioned, renders the radio receiver inactive and the radio transmitter active so that a check-tone modulated carrier signal is radiated from the antenna AA. The check-tone generator may be of any suitable type, but for the purposes of the present invention, this check-tone generator may be assumed to be a suitable oscillator designed to give at its output frequency of around 6000 cycles per second. This check-tone generator is assumed to be normally operated and is so indicated by providing permanent source of plate energy and providing that the cathode of the output tube is permanently connected to ground while the system is in use. Since the radio receiver is rendered inactive, it is obvious that the carrier relay CRA will not respond to this check-tone modulated carrier signal. In this way, it will be seen that intermittently a check-tone modulated carrier signal is radiated by this station without local effect.

Whenever the operator at this station desires to transmit a voice message, he actuates the push button PBA to energize the relay RA2 by an obvious circuit. The closure of front contact 16 of relay RA2 energizes the relay RA3 which in turn closes front contact 17 to shunt out the keying contacts 13. In other words, if there is no carrier signal being received by the radio receiver so that the carrier relay CRA is deenergized, then a circuit is closed for the relay RA1 through back contact 15 and front contact 17. This renders the radio transmitter active so long as the operator maintains the push button PBA depressed, and he may transmit any desired voice message by use of the microphone MA because front contact 12 is now connecting such microphone to the radio transmitter.

If it should happen that a voice message was being received by the radio receiver, then the relay CRA would be picked up so that the relay RA1 could not be energized. This condition would be indicated to the operator because a talk lamp is illuminated only when the transmit relay RA1 can be picked up. More specifically, with the relay RA3 picked up, front contact 18 is closed and connects the talk lamp TLA to the bus wire leading to the relay RA1 so that the lamp TLA is energized only if the relay RA1 is steadily energized for transmitting a voice message.

Let us assume that the operator has transmit-

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ted a voice message and releases the push button PBA. This deenergizes the relay RA2 which in turn opens front contact 16 to deenergize the relay RA3, but since this relay RA3 is slightly slow-release, the back contact 12 of relay RA2 connects the check-tone generator to the radio transmitter before the relay RA3 releases and deenergizes the relay RA1. This causes a check-tone modulated carrier signal to be transmitted at the end of each voice message. The duration of this check-tone punctuating the voice message is equal to the release times of the relays RA3 and RA1. Since the usual check-tone signal is only about a half second long, it will be apparent that the relay RA3 will not need to be very slow but merely sufficient to give the desired signal length. This check-tone signal at the end of a voice transmitted message occurs immediately and irrespective of the position of the cam 14 in its cycle of operation.

The apparatus of Fig. 1A may for the purposes of the present disclosure be considered as located at the hump of a railroad classification yard. Also, it may be considered that there are a plurality of locomotives which are operating within the classification yard equipped with a transmitting and receiving apparatus as typically illustrated in Fig. 1B.

In this Fig. 1B, a radio receiver apparatus has been indicated by a rectangle designated "Radio receiver"; and a radio transmitting apparatus has been indicated by a rectangle designated "Radio transmitter." An associated antenna AB is normally connected to the "Radio receiver" through back contact 20 of relay RB1, but when the relay RB1 is picked up the antenna AB is connected to the "Radio transmitter" through front contact 20. A suitable ground connection indicated in the usual way is of course provided for the "Radio transmitter" and "Radio receiver" units. A suitable plate supply for the radio receiver indicated as the usual B battery with the associated (B+) and (B-) symbols is connected to ground through back contact 21 of relay RB1 so that the radio receiver is normally active, but when the relay RB1 is picked up, the radio receiver is rendered inactive by the disconnection of its (B-) plate supply from ground, and the plate supply for the transmitter indicated as the usual B battery with the symbols (B+) and (B-) is connected to the radio transmitter through front contact 21 to ground to render the radio transmitter active.

As typical of each of the locomotive equipments, the receiving apparatus of Fig. 1B is intermittently responsive to the check-tone modulated signals transmitted by the station at the hump as described in connection with Fig. 1A. These check-tone modulated signals act through the transformer 22, the band-pass filter 23, and the rectifier unit 24 to energize the tone-responsive relay TN for each check-tone signal received. The band-pass filter is preferably designed to pass a tone of approximately 6000 cycles per second but to exclude other frequencies and especially those in the voice range more particularly those below 3000 cycles per second.

Associated with the radio receiver is a suitable carrier-responsive relay CRB which is also picked up each time a check-tone signal is received. In this connection it should be understood that the carrier-responsive relay both of Figs. 1A and 1B may be controlled in any suitable manner in accordance with the presence and absence of that particular carrier to which the receiver is tuned.

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However, the control of such carrier-responsive relays is intended to be wholly dependent upon the reception of the carrier and independent of the voice or tone modulations thereof such as disclosed in the prior application of Knapp and O'Brien, Ser. No. 565,206, filed November 27, 1944.

Each time a check-tone signal is received it will be apparent that the relays CRB and TN are both picked up and this completes an energizing circuit for the check relay CKR from (+), through back contact 25 of relay RB1, front contact 26 of relay CRB, windings of relay CKR, front contact 27 of relay TN, to ground. This intermittent energization of the relay CKR causes it to be picked up and remain picked up since it is sufficiently slow-acting to remain picked up between successive energizations. In other words, the slow-release characteristics of this relay CKR are such as to maintain it picked up even though it is energized for only approximately a half second out of each four seconds.

With the relay CKR picked up and closing front contact 28, the check lamp CKL is energized during the absence of check-tone modulated carrier signals from (+) through back contact 25 of relay RB1, back contact 26 of relay CRB, front contact 28 of relay CKR, check lamp CKL, to (—). But during the presence of each check-tone modulated carrier signal, the back contact 26 is open and the front contact 29 is closed to connect (+) to the check lamp CKL through front contact 28. As the circuit for the check lamp CKL is shifted both at the beginning and at the end of a check-tone signal, it is desirable that the tone-responsive relay be designed to be quicker in response than the carrier-responsive relay CRB so that front contact 29 will be closed before back contact 26 is opened; and that the carrier-responsive relay CRB be designed to release more quickly than the tone-responsive relay TN so as to close back contact 26 before front contact 29 opens. This is somewhat facilitated by the fact that the rectifier unit 24 is connected in multiple with the tone-responsive relay TN thus giving it a tendency to be slow-releasing in its characteristics.

In this way, it is seen that even though the check-tone signals are received at the locomotive stations intermittently, the check lamps CKL are maintained steadily illuminated, but whenever the check-tone signals cease to be received, due to a failure in the receiver or transmitter, the relay CKR drops away after a short period of time opening its front contact 28 and extinguishing the check lamp CKL to advise the operator that a failure has occurred. In this connection, it should be explained that when the station at the hump is caused to transmit a carrier signal which may be modulated by a voice message, such carrier signal is effective to cause the immediate energization of the carrier-responsive relay CRB while the tone-responsive relay TN remains deenergized. The energization of the carrier-responsive relay CRB opens back contact 26 and immediately extinguishes the check lamp CKL. This distinctive indication given to the operator at this station of Fig. 1B advises him that he should receive a voice message. Thus, whenever the check lamp CKL is extinguished and the operator fails to receive a voice message, he is advised that there is a failure in the communication system and he must act accordingly on the side of safety. For example, if he had previously been instructed to move a string of cars over the hump, and the check lamp should

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be extinguished without the reception of a voice message, then the engineer of the locomotive would be required to immediately stop the movement of his locomotive. It can be seen that this gives a safe organization. But as above mentioned, there may be a failure in the communication when the operator at the hump is not endeavoring to transmit a voice message, and such a failure will cause the deenergization of the check relay CKR and the extinguishing of the check lamp CKL to give the engineer of the locomotive the same kind of an indication so that he will act on the side of safety.

It will also be noted that the immediate extinguishing of the check lamp CKL upon the reception of a carrier signal which is intended for voice modulation rather than the check-tone, precludes any possibility of a voice message being transmitted without reception by the receiver and without the extinguishing of the check lamp CKL. For example, it might happen that the hump operator would transmit a very short message, that is, shorter than the release period of the relay CKR, and if it were not for the back contact 26 of the relay CRB, the lamp CKL being wholly dependent for example upon front contact 28 of relay CKR would not be extinguished. In other words, there could be a failing condition which would not be brought to the attention of the operator under such a circumstance. This cannot occur in the present invention since the reception of a carrier signal which is intended to be modulated with voice frequency immediately causes the check lamp to be extinguished. Furthermore, the system is organized on the side of safety, so that if the carrier-responsive relay CRB should fail to properly respond to the reception of a carrier signal, the check relay CKL will not be energized intermittently during the check-tone signals so that it drops away and extinguishes the check lamp CKL. This organization gives a checking arrangement which is organized on what is known as the "closed circuit principle," so that the check-tone signals must be intermittently and properly received in order for the check lamp CKL to be maintained illuminated.

It is noted that the loudspeaker LSB is connected to the radio receiver through the transformer 22 and back contact 27 of the tone-responsive relay TN. This means that the loudspeaker LSB is disconnected each time the check-tone signal is received. This has been done not only to eliminate most of the check-tone from the loudspeaker, but also to eliminate the crash that occurs upon the termination of a check-tone signal when frequency modulation radio transmission and reception is employed. More specifically, it is to be understood that the radio transmitters and receivers of this form of the invention may be of either the amplitude or the frequency modulation type, but in the event that frequency modulation is employed, it is recognized that a crash would occur in the loudspeaker upon the cessation of the frequency modulated carrier signal, and it is to avoid this crash that the back contact 27 is more particularly included in the circuit for the loudspeaker LSB. Although this same noise or crash would occur at the termination of a voice message, with this organization it is not present since a voice message is punctuated with a check-tone which causes the tone-responsive relay to be picked up at the end of each voice message so that when the carrier ceases, the relay TN has opened back contact 27

and no crash is received in the loudspeaker LSB. It may also be mentioned in this connection that the transmission of the check-tone signal at the end of a voice message causes the immediate establishment of the circuit for the check relay CKR and since this relay is relatively quicker in picking up than it is in releasing, the check lamp CKL is immediately illuminated at the end of the voice message.

The station of Fig. 1B is provided with a push button PBB which the operator may depress when he desires to transmit an answer to a message received from the hump station. However, transmission from this station cannot be initiated until the cessation of reception from the other station. This is because the operation of push button PBB closes a circuit for the relay RB1 only providing back contact 30 of relay CRB is closed. In other words, if the carrier-responsive relay CRB is picked up due to the reception of a carrier modulated either by a voice message or by the check-tone, the relay RB1 is not picked up until the cessation of such signal. This is indicated to the operator, since the talk lamp TLB is not illuminated until the back contact 30 is closed. Also, the reception of a voice message causes the check lamp CKL to be extinguished, and since this check lamp CKL is immediately illuminated at the end of a voice message, the operator should not depress his push button PBB until this check lamp CKL is again illuminated. However, since the interlock is employed, the operation of the push button PBB at any time causes no particular difficulty. The energization of the transmit relay RB1 renders the associated radio receiver inactive and the radio transmitter active so that the operator may modulate the radiated carrier signal by using the microphone MB. This transmission to the station of Fig. 1A is of course received by the radio receiver located thereat which causes the response of the carrier relay CRA. The opening of back contact 15 of Fig. 1A renders the keying contacts 13 ineffective to cause the intermittent transmission of the check-tone modulated carrier signals so that proper reception is assured from the distant station. Also, at the locomotive station of Fig. 1B, the energization of the relay RB1 opens back contact 25 and extinguishes the check lamp CKL and since the relays CRB and TN are not intermittently energized, the check relay CKR of course drops away. At the station of Fig. 1A, front contact 15 of relay CRA closes an obvious energizing circuit for the relay RA3 which closes front contact 17 to prepare for the momentary transmission of a check-tone signal at the termination of the voice message transmitted from the distant station.

Assuming that the message at the distant station ceases because the operator releases the push button PBB, then the carrier-responsive relay CRA of Fig. 1A releases and closes a circuit through front contact 17 of relay RA3 to energize relay RA1. Since the relay RA2 is deenergized back contact 12 is closed and the carrier radiated by the radio transmitter is modulated in accordance with the check-tone. This persists, however, only during the release period of the relay RA1 and RA3 since the opening of front contact 15 of course deenergizes relay RA3. This immediate transmission of the check-tone signal, is of course received at the distant station and causes the relays CRB and TN to be energized to immediately restore the picked up condition of the check relay CKR and the illumination of the check lamp CKL. In other words, immediate

restoration of the check lamp CKL is provided at the termination of each voice message irrespective of whether it originates from the hump station or the locomotive station, and this immediate restoration is also effected irrespective of the position of the cam 14 in its cycle of operation of the keying contacts.

Although in the above discussion, only a single distant station has been considered with respect to Fig. 1B, it is to be understood that there may be a number of such stations, such as moving locomotives in a classification yard, and that the checked communication is effective between the station at the hump and each of the locomotive stations. Also, whenever any locomotive station transmits, its transmission is received by each of the other locomotive stations as well as at the hump station and each of the other stations are locked out, i. e., prevented from transmitting so long as any given station is in control of the communication channel. This avoids mutilation of messages but assumes of course that the operator of each station does not unduly monopolize the communication channel but releases his associated push button as soon as he has completed his particular voice message.

Organization of Figs. 2A and 2B

Referring to Fig. 2A, a radio transmitting apparatus has been indicated by a rectangle designated "Radio transmitter"; and the associated receiving apparatus has been indicated by another rectangle designated "Radio receiver." Associated with the radio transmitter and receiver is a suitable antenna 2AA and each is provided with its respective ground connection indicated in the usual way. However, the antenna 2AA is normally connected to the "Radio receiver" through back contact 40 of relay 2RA1, but when this relay 2RA1 is energized, the antenna 2AA is connected to the "Radio transmitter" through front contact 40.

Similarly, at the distant station of Fig. 2B, a radio transmitting apparatus has been indicated by a rectangle designated "Radio transmitter"; and the associated receiving apparatus has been indicated by another rectangle designated "Radio receiver." This distant station has a suitable antenna 2AB normally connected through back contact 41 of relay 2RB1 to the associated "Radio receiver," but when this relay 2RB1 is energized, the antenna 2AB is connected through front contact 41 to the "Radio transmitter."

It will thus be seen that the general organization of Figs. 2A and 2B is quite similar to that of Figs. 1A and 1B in that a central or hump station is assumed to have a radio transmitter and receiver, and one or more mobile stations such as on the locomotives operating in a classification yard are assumed to have transmitter and receiver stations organized as typically shown in Fig. 2B. In general, it may be stated that one difference between the present form of the invention and that shown in Figs. 1A and 1B, is that the radio transmitters and receivers are assumed to be of the frequency modulation type, and the control circuits are organized on the basis of certain characteristic features of such a system of communication. Also, another characteristic of this form of the invention is that the central station i. e. the one assumed to be located at the hump of the classification yard, is shown as including positions for two different operators with the control circuits organized to provide for such conditions. Other characteristic features

of this form of the invention will of course be pointed out as the description progresses.

The radio receivers of Figs. 2A and 2B are normally operative, that is, they are sensitive to the reception of signals, and when the associated radio transmitter is rendered active, the antenna is disconnected from such receiver and connected to the radio transmitter, but the radio receiver itself is not rendered inactive, since a receiver of the frequency modulation type, is provided with a limiter stage which prevents an excessive overloading of the audio amplifier stages even though an associated transmitter is in operation. In other words, each receiver reproduces what is transmitted by its associated transmitter by reason of the local leakage coupling.

Referring to Fig. 2A, it will be seen that two operator's positions are provided in connection with this station. One position is provided with a loudspeaker 2LSA, the microphone 2MA, and an associated self-restoring push button 2PBA; while the other operator's position is provided with a head-set or receiver 2REC, a microphone 2MA2, and an associated self-restoring push button 2PBA2.

Normally, the movable keying contact 44 is being operated to its opposite positions by a suitable cam that is continuously motor driven. The movable contact 44 is so operated by its driving cam that it contacts with fixed contact 45 for three-and-a-half seconds, and is operated to contact with fixed contact 46 for a half second.

The transit time for movable contact 44 to move from one position to another is very short. These relative times may of course be changed as desired in accordance with the particular design of apparatus employed, but it is desirable to have the ratio of check-tone time to total time as small as possible so as to give the greatest possible "break-in time" for the transmitters as will be described in detail later.

While the back contact 45 is closed, the squelch control circuit SQC is grounded through back contact 47 of relay 2RA4 so that the receiver is responsive to the reception of a carrier signal. However, it should be understood that this squelch control circuit SQC, which may be of any suitable type, is effective to mute the audio amplifiers of the receiver whenever this circuit is not grounded. These conditions for muting the receiver are chosen merely for the purposes of the present disclosure, it being understood that any suitable squelch control may be employed. The purpose of this in connection with the keying contacts is that, whenever the radio transmitter is caused to transmit a check-tone modulated carrier signal, the squelch control circuit SQC is disconnected from ground to render the associated receiver unresponsive to the check-tone signal due to local coupling.

Under normal operations, the relays 2RA2 and 2RA3 are deenergized so that the output of the "Check generator" is connected to the "Radio transmitter" through back contact 48 of relay 2RA2, back contact 49 of relay 2RA3.

The check-tone generator is assumed to be of the oscillator type having electron tubes with plate circuits applied in the usual way. This plate circuit supply has been indicated by (B+) with the (B-) connected directly to ground. However, the cathode of the output tube of the oscillator is indicated as connected through back contact 50 of relay 2CRA to ground, so that the check-tone generator is normally active, but when back contact 50 is opened the generator is

rendered inactive. For convenience in the disclosure, the output is considered to be in the order of 6000 cycles per second but any other suitable frequency may be selected as desired. With the check-tone generator rendered active, then each time the movable keying contact 44 operates to the left and closes with fixed contact 46, the relay 2RA1 is energized by reason of a circuit from (+), through relay 2RA1, back contact 51 of relay 2CRA, keying contacts 44-46, back contact 47 of relay 2RA4, to ground. This energization of the transmitting relay 2RA1 closes front contact 52 connecting the negative terminal (B-) of the plate supply to ground so that the "Radio Transmitter" is rendered active as well as being connected through front contact 40 to the antenna 2AA. Since the check-tone generator is already connected to the radio transmitter, a check-tone modulated carrier signal is transmitted during the time that the relay 2RA1 is energized. This check-tone does not activate the radio receiver since the squelch circuit SQC is disconnected from ground by reason of the opening of keying contacts 44-45.

It is apparent that each time the relay 2RA1 is energized, the transmitter lamp 2TLA is also energized in multiple therewith so that the operator can tell that the check-tone modulated signals are being regularly transmitted, and also when he transmits a voice message this lamp is steadily energized advising that the intermittent transmission has ceased and that the system is capable of transmitting a voice message.

Whenever the operator desires to transmit a voice message from the first position, he operates the self-restoring push button 2PBA which energizes the relay 2RA2 by an obvious circuit. This closes front contact 48 to connect the microphone 2MA to the radio transmitter and disconnect the check-tone generator. The closure of front contact 53 of relay 2RA2 connects ground to the relay 2RA1 so that it picks up and renders the "Radio Transmitter" active for the transmission of a voice message. As soon as the transmitter radiates a carrier signal there is sufficient leakage radiation to activate the "Radio Receiver" while the keying contacts 44-45 are closed so that the carrier-responsive relay 2CRA picks up and closes front contact 50 to steadily connect ground to the squelch control circuit SQC so long as the associated transmitter is radiating a carrier signal. This carrier relay 2CRA is energized whenever a carrier signal for which the radio receiver is tuned is received.

Since the relay 2RA1 is energized, it opens back contact 52 and mutes the loudspeaker 2LSA so that an acoustic feed-back will not occur through the associated microphone 2MA. The operator at the second position may listen in on the message being transmitted by removing the receiver 2REC from its associated hook allowing the hook contact 54 to close. This is because the radio receiver produces an output even though the antenna 2AA is disconnected. However, the operator at the second position cannot transmit since the contact 48 of relay 2RA2 acts to connect the microphone 2MA and opens back contact so that the microphone 2MA2 at position 2 cannot possibly be connected to the radio transmitter.

While the operator at the first position is holding the push button 2PBA in an operated position, thus rendering the radio transmitter active as above described, the associated receiver in activating its carrier relay 2CRA, closes front contact 55 to energize the relay 2RA4. The closure

of front contact 47 cannot in any way act on the relay 2RA1 since back contact 51 of relay 2CRA is open. When the operator at the first position releases the push button 2PBA and the relay 2RA2 drops away, the relay 2RA1 is then deenergized. This renders the radio transmitter inactive and the cessation of the reception of a carrier by the radio receiver allows the relay 2CRA to drop away. As soon as it closes back contact 51, ground is applied through front contact 47 of the slow release relay 2RA4 to the relay 2RA1 so that it again immediately picks up and renders the radio transmitter active. Since the back contacts 48 and 49 of relays 2RA2 and 2RA3 are now closed together with back contact 50 of relay 2CRA, the check-tone generator is effective to cause the radio transmitter to radiate a check-tone modulated carrier signal. This occurs irrespective of the position of the keying contacts 44-45-46. Since the back contact 47 and the front contact 50 are both open, the radio receiver is muted because there is no ground connection to the squelch control circuit SQC. For this reason the carrier relay 2CRA does not pick up and this check-tone modulated carrier signal is transmitted during the release times of the relays 2RA4 and 2RA1. It is obvious that as soon as the relay 2RA4 releases, the relay 2RA1 is deenergized and the check-tone modulated signal is terminated. In this way, a check-tone modulated carrier signal is transmitted at the end of a voice transmission from the central station by either operator, because each such message acts to energize the carrier-responsive relay 2CRA of the associated radio receiver. Although there are several relay operations after the termination of a voice message before the check-tone is transmitted, this time is relatively short compared to the time which might elapse if the keying contacts were relied upon alone.

It is believed unnecessary to point out in detail the same operation which occurs when the operator at the second position pushes his associated button 2PBA2, but it is believed sufficient to note that the energization of the relay 2RA3 closes front contact 56 to energize the transmit relay 2RA1, and the other operations remain the same as pointed out in connection with the operation by an operator in the first position.

Referring to Fig 2B, the normal condition of the apparatus is for the intermittent reception of a check-tone modulated carrier signal which is received by the antenna 2AB and through back contact 41 is supplied to the radio receiver in the usual way. The reception of such a check-tone modulated carrier signal acts through the receiver to supply the trap circuit including the primary winding of transformer 57 and condenser 58 with current at the check-tone frequency such as 6000 cycles per second for example. The secondary winding of transformer 57 supplies the check-tone frequency to the rectifier 59 giving a unidirectional current to relay 2TNB. This causes relay 2TNB to be energized opening back contact 60 to mute the loudspeaker 2LSB although the frequency of such check-tone is shunted away from the voice-responsive transformer 61 by reason of condenser 62. This condenser 62 also serves to reduce the over-emphasis of the high tones in the voice range which is placed on the voice tones by pre-emphasis at the transmitting station. This action on the high tones of the voice range is commonly known as pre-emphasis and de-emphasis and is used for the purpose of increasing the signal to noise ratio in a frequency

modulation system. This feature is mentioned to bring out that the condenser 62 serves the double purpose of a de-emphasis and also filtering the check-tone frequency away from the loudspeaker.

Each time the tone-responsive relay 2TNB is picked up in response to a check-tone modulated carrier signal, the carrier-responsive relay 2CRB is also picked up. This closes front contacts 60 and 64 causing the energization of relay 2CKRB through an obvious circuit. This relay 2CKRB is thus intermittently energized by the reception of the successive check-tone modulated signals transmitted by the central station at the hump. Since this relay 2CKRB is sufficiently slow-releasing in its characteristics, its contacts are maintained picked up during the time period between the successive receptions of check-tone modulated signals.

With front contact 65 of relay 2CKRB steadily closed, it will be seen that between the successive check-tone modulated carrier signals, the check lamp 2CKLB is energized through back contact 64 and front contact 65; but during each of the check-tone modulated carrier signals, the check lamp 2CKLB is energized through front contact 63 of relay 2TNB and front contact 65. The tone-responsive relay 2TNB is preferably slightly quicker in its response to a check-tone signal than relay 2CRB is to the carrier so that front contact 63 is closed before back contact 64 opens. Also, it is preferable that upon the termination of the check-tone signal that the relay 2TNB release slightly later than the relay 2CRB so that back contact 64 is closed slightly before contact 63 opens. This is facilitated by the fact that the rectifier unit 59 tends to make the relay 2TNB slightly slower in its release. Thus, under normal conditions the check lamp 2CKLB is maintained steadily illuminated although the check-tone signals are intermittently transmitted.

Let us assume that the central station of Fig. 2A initiates the transmission of a carrier signal for modulation by a voice message. The reception of this carrier signal by the receiver of Fig. 2B causes the carrier-responsive relay 2CRB to be picked up regardless of whether the signal is voice modulated or not, but the tone-responsive relay 2TNB is not picked up because there is no tone present. This causes the extinguishing of the check lamp 2CKLB immediately upon the opening of back contact 64, so that the operator at the station of Fig. 2B is advised that he should receive a voice message. If he fails to receive a voice message then it is apparent that there is some fault in the communication system and he is thus advised to take proper action on the side of safety. This organization has the advantage that there is no time in which a short voice message may be transmitted without the immediate extinguishing of the check lamp 2CKLB.

At the termination of the voice message, a check-tone modulated carrier signal is transmitted from the central station in a manner previously described which of course energizes both the relays 2CRB and 2TNB causing the immediate energization of the check relay 2CKRB and the re-illumination of the check lamp 2CKLB.

It should be noted that the back contact 60 of the tone-responsive relay 2TNB is opened during the reception of a check-tone modulated carrier signal so that upon the cessation of such signal the crash or noise due to its cessation is prevented from being reproduced by the loudspeaker 2LSB. Also, any failure in the circuit control of

either the tone-responsive relay 2TNB or the carrier-responsive relay 2CRB, results in the failure of the check relay 2CKRB to be intermittently energized so that it would drop away opening front contact 65 and extinguishing the check lamp 2CKLB. In such an event, the operator, in the absence of the reception of a voice message, is advised that the communication system has failed and he is instructed to take proper action accordingly.

The operator at the mobile station of Fig. 2B may transmit a voice message by depressing the push button 2PBB which energizes the transmit relay 2RBI through an obvious circuit, and which circuit also illuminates the talk lamp 2TLB advising the operator that the transmit relay has become energized. The opening of back contact 66 renders the loudspeaker 2LSB inactive, and the closure of front contact 66 renders the radio transmitter active by connecting the plate supply (B—) to ground, so that the operator may transmit a voice message through the medium of the microphone 2MB. This message is of course received at the central station of Fig. 2A, and the local receiver is also acted upon even though the antenna 2AB is disconnected by back contact 41 from the radio receiver. Thus, the carrier-responsive relay 2CRB is energized by local reception, which immediately extinguishes the check lamp 2CKLB and the relay 2CKRB of course drops away after its measured time period. When the transmission ceases at this station of Fig. 2B, the carrier-responsive relay 2CRB of course is deenergized, but the check lamp 2CKLB is not again energized until a check-tone modulated carrier signal is received. This of course assumes that the message transmitted from this station of Fig. 2B is longer than the release period of the check relay 2CKRB.

The reception of the voice modulated carrier signal at the central station of Fig. 2A not only actuates the loudspeaker 2LSA and the receiver 2REC, if 2REC is removed from the hook contact 54, but also acts to pick up the carrier-responsive relay 2CRA and energize the relay 2RA4. It is of course assumed that the voice message was initiated between successive transmissions of check-tone modulated signals, so that keying contacts 44—45 are closed to permit the initial picking up of relay 2CRA while back contact 47 is closed. Once the initial reception of the voice modulated frequency causes the carrier relay 2CRA to be picked up and close front contact 50, the radio receiver can continue operation although back contact 47 is opened. As soon as the voice modulated message ceases to be received, the carrier relay 2CRA is released, but the closed condition of front contact 47 when back contact 51 becomes closed, effects the energization of relay 2RA1 and causes the transmission of a check-tone modulated carrier signal immediately following the reception of such voice message. This of course occurs irrespective of the position of the movable contact 44 of the keying contacts in its cycle of operation. In this way, the check lamp 2CKLB of Fig. 2B is immediately illuminated after the operator at the station of Fig. 2B ceases his voice message and releases button 2PBB.

From the above it will be seen that it is desirable that the operator of the distant station Fig. 2B initiate his voice modulated carrier signal between the successive check-tone signals. These check-tone modulated signals last for a very short period, such as a half second out of

each four seconds, as an example, so that the operator can easily initiate his transmission between such successive check signals. This is facilitated by the fact that a tone of very short duration can be heard in the loudspeaker 2LSB slightly before the relay 2TNB picks up so that if the operator actuates the push button 2PBB immediately following such slight tone, then waits a moment, he can be assured of proper voice transmission.

This form of the invention contemplates, as above pointed out, that the equipment of Fig. 2A is located at the hump of a railroad classification yard and that the apparatus of Fig. 2B is typical of the apparatus for one or more locomotives operating in such classification yard. Since the operator at the hump or central station will give instructions to the various locomotives when to move and when to stop while they are pushing a string of cars over the hump, it is essential that the communication between the hump and the locomotives be checked so that in the event of failure, as indicated by the extinguishing of the check lamp, a locomotive will stop until the difficulty has been determined. This is so as to provide operation on the side of safety. Such a check in the communication between the various locomotives and the station at the hump is not essential for the safe operation of the yard, and such a check in the communication system has been omitted from the forms shown in Figs. 1A—1B and 2A—2B. However, it is to be understood that a check in the communication between the locomotives and the hump station may be provided if desired as disclosed in the further modifications of the present invention shown herein.

Organization of Figs. 3A and 3B

In these figures of the present invention, a two-way system of radio telephone communication is provided with check-tone modulated carrier signals transmitted in both directions. Such a system is contemplated for use more particularly in connection with two stations only, such as between the front and rear ends of a moving train, where it is desirable to supply two-way checked communication between such locations. However, it may be understood that the present invention as disclosed in these figures may be modified for control of any number of stations as disclosed in my prior application Ser. No. 552,833, filed September 6, 1944, where different times of answer-back are allocated to different distant stations being checked with a central station. Although these various modifications may be made to the organization of Figs. 3A and 3B, one of the primary purposes of the present invention as disclosed in these Figs. 3A and 3B is to provide a reliable and simple checking organization for both directions of transmission between the two stations with suitable interlocking means to prevent confusion in effecting the proper voice communication between the two stations.

With reference to Fig. 3A, a "Radio transmitter" and a "Radio receiver" are respectively represented by rectangles designated with corresponding legends, and are associated with an antenna 3AA as normally connected through back contact 70 to the radio receiver, but when relay 3RA1 is picked up front contact 70 connects the antenna 3AA to the radio transmitter. The radio receivers and transmitters of Figs. 3A and 3B may be of any suitable type, such as frequency modu-

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lation or amplitude modulation type equipment, but in either case, the radio receiver or radio transmitter is rendered active one at a time at each location. Thus, back contact 71 of relay 3RA1 normally connects the (B-) plate supply of the receiver to ground but when the transmit relay 3RA1 is picked up, the radio receiver is rendered inactive and front contact 71 connects the (B-) plate supply of the transmitter to ground. A suitable ground connection indicated in the usual way is of course provided for both the transmitter and receiver.

Under normal conditions, the keying contacts 72, which are operating continuously, and which close for a half second for example every three-and-a-half seconds, intermittently cause the energization of the transmit relay 3RA1 by a circuit closed from (+), through back contact 73 of tone-responsive relay 3TNA, back contact 74 of carrier-responsive relay 3CRA, keying contacts 72, windings of relay 3RA1, to (-). The picking up of this relay renders the radio transmitter active as previously mentioned, and when rendered active the "check-tone generator" effects the modulation of the radiated carrier signal, since back contact 75 of relay 3RA2 is closed.

The check-tone generator in this form of the invention is assumed to be of the same general type as discussed in connection with the prior forms of the invention, i. e., it is assumed to be of the oscillator type having electronic tubes. In this form of the invention, however, the check-tone generator is indicated as being continuously operative with the plate energy supply having its negative terminal (B-) continuously grounded, and also having the cathode of the output tube of the oscillator continuously connected to ground. The output of this tone generator is assumed for the purpose of definiteness in disclosure to be in the order of 6000 cycles per second, but it is to be understood that any other suitable frequency may be chosen as desired. This particular frequency has been chosen since it is substantially above the effective voice range of frequencies and can be readily filtered so as to distinguish such check-tone from the voice frequencies. On the other hand a 6000-cycle tone is sufficiently low to provide for proper modulation of almost any frequency that may be selected for the carrier frequency signals.

At the secondary station of Fig. 3B, the antenna 3AB is connected to the "radio receiver" through back contact 76 of relay 3RB1 and the radio receiver has its (B-) plate energy supply connected to ground through back contact 77 of relay 3RB1. The reception of the check-tone modulated carrier signals transmitted from the primary station of Fig. 3A causes both the carrier-responsive relay 3CRB and the tone-responsive relay 3TNB to be picked up. This carrier-responsive relay 3CRB may be suitably controlled in any desired manner, such as for example in the above mentioned prior application Ser. No. 565,206, filed November 27, 1944, the main point being that the reception of a carrier signal causes the response and energization of this relay regardless of whether or not it is modulated with a check-tone frequency or with voice frequencies. Of course, the relay 3CRB could be normally energized and then deenergized by the reception of the carrier signal, it being understood that this is merely a matter of choice of apparatus as described in connection with the above mentioned application.

The tone-responsive relay 3TNB is responsive

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only to the reception of the check-tone modulated carrier signal by reason of its associated tuned circuit described in detail in connection with Figs. 2A and 2B. The opening of back contact 78 of the tone-responsive relay 3TNB, mutes the loudspeaker 3LSB, although a very slight response of the loudspeaker 3LSB may be heard, if listened for, at the beginning of each check-tone signal. This can be reduced substantially to zero by the proper design of the filter circuits if desired. The intermittent picking up of both the relays 3CRB and 3TNB by the check-tone modulated carrier signals causes the relay 3CKRB to be energized from (+), through a circuit including back contact 79 of relay 3RB2, front contact 80 of relay 3CRB, windings of check relay 3CKRB, front contact 78 of relay 3TNB, to ground. Since the relay 3CKRB is slow-releasing in its characteristics although relatively quick picking up, it maintains its front contacts closed between the successive energizations of the relays 3CRB and 3TNB.

Also, the tone-responsive relay 3TNB is preferably made slightly quicker in response than relay 3CRB so that front contact 81 is closed to connect (+), through front contact 82 of relay 3CKRB to the check lamp 3CKLB before the back contact 80 of relay 3CRB opens to thereby steadily energize the check lamp 3CKLB. Thus, under normal conditions, the intermittent reception of the check-tone modulated carrier signals causes the continuous illumination of the check lamp 3CKLB.

Each time a check-tone modulated carrier signal is received and causes the picking up of the relay 3TNB, the closure of front contact 83 energizes the relay 3RB3. Then at the termination of the check-tone signal, the relay 3RB1 is energized by a circuit closed from (+) and including back contact 81 of relay 3TNB, back contact 84 of relay 3CRB, front contact 85 of relay 3RB3, windings of relay 3RB1, to (-). This energization of relay 3RB1 is during the release time of the relay 3RB3, but is sufficiently long to produce the transmission of an answer-back check-tone modulated signal from this station of Fig. 3B. In other words, the picking up of relay 3RB1 renders the radio receiver inactive and activates the radio transmitter which causes a check-tone modulated carrier signal to be transmitted because back contact 86 of relay 3RB2 is closed connecting the "check-tone generator" to the radio transmitter. It is apparent that this answer-back check-tone signal cannot occur until the cessation of each check-tone modulated signal received from the primary station by reason of back contacts 81 and 84 of relays 3TNB and 3CRB.

At the primary station of Fig. 3A, the reception of the check-tone modulated carrier signal causes energization of the tone-responsive relay 3TNA and the carrier-responsive relay 3CRA which energizes the check relay 3CKRA from (+) through a circuit including back contact 87 of relay 3RA2, front contact 88 of relay 3CRA, windings of relay 3CKRA, front contact 89 of relay 3TNA, to ground.

The carrier-responsive relays 3CRA and 3CRB of this form of the invention are assumed to be suitably controlled in accordance with the reception of a carrier signal irrespective of whether or not such carrier is modulated with voice or check-tone signals. The control of these relays may be effected in any suitable way, such as disclosed for example in the prior application of

Knapp and O'Brien, Ser. No. 565,206, filed November 27, 1944.

Also, the tone-responsive relays 3TNA and 3TNB are assumed to be controlled in response to a check-tone signal through the same type of trap circuit and rectifier organization as shown in connection with Fig. 2B, and thus this organization will not be described in detail at this point.

Since each check-tone modulated carrier signal transmitted from the primary station effects the transmission of an answer-back check-tone modulated carrier signal from the secondary station, then this check relay 3CKRA is maintained picked up because it is sufficiently slow-acting, although relatively quick in picking up, to maintain its contacts picked up between successive energizations. Since the relay 3TNA is slightly quicker in picking up than the relay 3CRA, the front contact 73 connects (+) through front contact 90 of relay 3CKRA to the check lamp 3CKLA before back contact 88 is open. Check-tone responsive relay 3TNA is slightly slower release than the carrier-responsive relay 3CRA and thus acts to close back contact 88 before front contact 73 is opened at the termination of a check-tone signal. Thus, under normal conditions, the check lamp 3CKLA is maintained steadily illuminated.

Let us assume that the operator at the primary station desires to transmit a voice modulated carrier signal. To do this he merely actuates the button 3PBA and holds it in an operated position to energize the relay 3RA2. The closure of front contact 91 of relay 3RA2 energizes the relay 3RA3 through an obvious circuit which closes front contact 92 and shunts the keying contacts 72. This closes an energizing circuit for the transmit relay 3RA1 from (+) and including back contact 73 of relay 3TNA, back contact 74 of relay 3CRA, front contact 92 of relay 3RA3, windings of relay 3RA1, to (-).

The energization of the relay 3RA1 renders the radio receiver inactive and the radio transmitter active, and since the front contact 75 of relay 3RA2 is now closed, the operator can talk into the microphone 3MA and transmit a voice message. It will be apparent that the relay 3RA1 cannot be energized during the reception of an answer-back check-tone signal, since at such time the back contacts 73 and 74 of the relays 3TNA and 3CRA would be open. Also, the talk lamp 3TLA connected to front contact 93 to the circuit for the relay 3RA1, does not become energized until the transmit relay 3RA1 is also energized thus advising the operator when the transmitter is rendered active so that he can begin his voice message.

Immediately upon the picking up of the relay 3RA2, the opening of back contact 81 causes the deenergization of the check lamp 3CKLA so that so long as the operator depresses the self-restoring push button 3PBA, the check lamp 3CKLA is extinguished advising that no checking signal is effectively received from the secondary station.

As soon as the carrier signal for voice modulation is received at the secondary station of Fig. 3B, the carrier relay 3CRB is picked up which deenergizes the check lamp 3CKLB at open back contact 80 because the check-responsive relay 3TNB is not picked up at such time. This advises the operator that he should receive a voice message from the loudspeaker 3LSB, and if no voice message is received within a reasonable length of time after the extinguishing of the lamp 3CKLB, 75

then such operator is advised that the communication system has failed and he should take steps accordingly.

Immediately at the termination of the voice message transmitted by the operator at the primary station of Fig. 3A, he releases the push button 3PBA which deenergizes the relay 3RA2. This extinguishes the talk lamp 3TLA by the opening of front contact 93 and also connects the check-tone generator through back contact 75 to the radio transmitter which remains active until the relay 3RA3 drops away following the opening of front contact 91 of relay 3RA2. In this way, a check-tone modulated carrier signal is transmitted at the end of each voice message without interruption of the carrier signal.

This check-tone modulated carrier signal is received at the secondary station and causes the immediate restoration of the relay 3CKRB by reason of the closure of its circuit through front contacts 80 and 78. The closure of front contact 82 allows front contact 81 to initially energize the check lamp 3CKLB and upon the termination of the check-tone modulated carrier signal, the system is then restored to normal.

More specifically, the closure of front contact 83 causes the energization of the relay 3RB3 so that the secondary station effects the transmission of an answer-back check-tone signal which is received at the primary station of Fig. 3A and acts to cause the immediate energization of the relay 3CKRA and the reenergization of the check lamp 3CKLA. In this way, each voice message transmitted from the primary station is punctuated with a check-tone modulated carrier signal resulting in the regular answer-back transmission from the secondary station.

When the operator at the secondary station desires to communicate with the operator at the primary station, he actuates the push button 3PBB and energizes the relay 3RB2 in an obvious manner. The closure of front contact 94 obviously energizes the relay 3RB3. Thus, a circuit is closed which energizes the transmit relay 3RB1 from (+), through a circuit including back contact 81 of relay 3TNB, back contact 84 of relay 3CRB, front contact 85 of relay 3RB3, windings of relay 3RB1, to (-). This transmit relay 3RB1 can of course be energized only when back contacts 81 and 84 are closed so that if a check-tone signal is being received, it is apparent that this relay cannot be energized until the termination of such signal. The operator is advised of this condition because front contact 95 connects the talk lamp 3TLB to the circuit for relay 3RB1 and this lamp is not energized until the transmit relay is energized. Thus, the operator is advised when to begin talking.

It will be apparent that the closure of front contact 86 of relays 3RB2 renders the microphone 3MB effective to control the radio transmitter which is now active. The opening of the back contact 79 of relay 3RB2 causes the immediate deenergization of the check lamp 3CKLB and advises the operator that reception of the check-tone signals from the primary station has been interrupted.

As soon as the secondary station initiates the transmission of a carrier signal, which may be voice modulated, the relay 3CRA of Fig. 3A is picked up without the relay 3TNA being picked up, which extinguishes the check lamp 3CKLA at the primary station advising the operator located thereat that he should receive a voice mes-

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sage. If he fails to receive a voice message through the medium of the loudspeaker 3LSA with the check lamp 3CKLA extinguished, he is advised that the system of communication has failed and that he should accordingly take proper action.

It will also be noted that the picking up of the carrier-responsive relay 3CRA opens back contact 74 which prevents the keying contacts from operating to transmit the usual check-tone signals during transmission from the secondary station. This is so that there will be no interruption in the reception of the message from the secondary station.

The closure of front contact 74 of relay 3CRA of Fig. 3A completes a circuit for relay 3RA3 by reason of the closed condition of back contact 73 of relay 3TNA. The picking up of the front contact 92 of relay 3RA3 cannot do anything at this time since back contact 74 is open, but upon the cessation of the reception from the secondary station, this relay 3RA3 is effective to render the transmission of a check-tone signal immediately irrespective of the point in the cycle of operation of the keying contacts.

After the operator at the secondary station of Fig. 3B has terminated his message, he releases the push button 3PBB and deenergizes 3RB2. Since the relay 3RB3 is still picked up closing front contact 85 because of its slow-releasing characteristics, the transmit relay 3RB1 is maintained picked up during the drop away time of this relay 3RB3, and during this time the check-tone generator is rendered active in place of the microphone 3MB because back contact 86 of relay 3RB2 is now closed. In this way, the termination of the voice message from the secondary station is punctuated with a check-tone signal without interruption of the carrier signal which is immediately received at the primary station of Fig. 3A picking up the tone-responsive relay 3TNA to cause the immediate reenergization of the relay 3CKRA to close contact 90 and energize the check lamp 3CKLA. It is noted that the picking up of the tone-responsive relay 3TNA opens back contact 73 to remove positive (+) energy from the energizing circuit for the relay 3RA3, but since the relay 3RA3 has already been picked up, it has closed front contact 96 so that the opening of back contact 73 does not deenergize the relay 3RA3 so long as the carrier-responsive relay 3CRA is picked up. With this organization, the relay 3RA3 can be held up when the check-tone signal immediately follows a voice message, but the relay 3RA3 cannot be picked up by the reception of the usual answer-back check-tone modulated carrier signal. At the end of this punctuation mark, so to speak, the relays 3TNA and 3CRA drop away and the relay 3RA3 being picked up allows the immediate energization of the transmit relay 3RA1 through back contacts 73 and 74 and front contact 92. This transmission of the check-tone signal causes immediate reenergization of the check relay 3CKRB at the secondary station of Fig. 3B and the reenergization of the check lamp 3CKLB. In this manner the system is restored to normal and the operation of the keying contacts causes the regular and intermittent transmission of the check-tone signals as previously described.

In this form of the present invention, the initiation of the system for the transmission of a voice message in either direction over the two-way channel of communication results in the immediate extinguishing of the check lamps at

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both locations. This indicates at the transmitting station that the check-tone signal operation of the system has been interrupted, and indicates at the other station that a voice message should be received. If no voice message is received within a reasonable time, then the operator at such station should take such action as he may deem necessary in the interest of safety. On the other hand, when the system operates properly, then the termination of a voice message immediately restores the check lamps so that both operators are advised that the system is restored to normal. The restoration of the check lamp at a station having just received a voice message advises the operator at that station that the voice message is terminated and that he may transmit a voice message if he so desires. This immediate response of the check lamps at the termination of a voice message is effected by the punctuation of the carrier signal with a check-tone modulation without an interruption of the carrier between its modulation by voice frequencies and the modulation by the check-tone frequency. This gives an immediate check and a positive interlock between stations in the shortest possible time. Such an interlock between stations where one station cannot interrupt another and where an indication is given as to when a receiving station begins to transmit, also acts to avoid confusion in transmission since it is essential to synchronize, so to speak, the transmission and reception between the stations involved.

It will thus be seen that each operator must wait for the other operator to cease transmission before he can render his transmitter effective to transmit. This is because of the inclusion of the back contacts of the carrier-responsive relay in the circuit for the energizing of the respective transmit relays. Also, each operator is prevented from endeavoring to transmit during the reception of a check-tone modulated carrier signal and in this way is assured of transmitting a proper voice message if he waits to talk until the talk lamp is illuminated even though he has actuated the associated push button.

In each form of the invention, it will be seen that the loudspeaker is muted or rendered inactive when the associated tone-responsive relay is operated. This has a special advantage in a system of communication employing frequency modulated carrier signals, since the termination of a carrier signal in such a system causes a radio noise or crash in the loudspeaker. But in the present system, the tone-responsive relays (relays TN) are still operated upon the termination of a carrier signal modulated with check-tone frequency, i. e. such relays have not dropped away and the loudspeakers are not rendered active until such relays have closed their back contacts. Thus, radio noise or crash occurring at the end of each check-tone signal is eliminated in accordance with the present invention.

In Figs. 3A and 3B where each carrier signal for voice messages has a check-tone modulation applied before the carrier signal ceases, the tone responsive relay at the receiving station is thus picked up to mute the loudspeaker so that the radio noise crash is also eliminated from the carrier signals for voice messages. This gives an added advantage for punctuating each voice message with a check-tone in a system where frequency modulation is employed.

Having thus described several forms of radio communication systems as embodiments of the present invention, it is to be understood that these

forms are selected to facilitate in the disclosure of the invention rather than to limit the number of forms which the invention may assume; and, it is to be further understood that various modifications, adaptations and alterations may be applied to the specific form shown to meet the requirements of practice, without in any manner departing from the spirit or scope of the present invention.

What I claim is:

1. A system for transmitting voice messages on a carrier frequency between a first station and a second station comprising, means including a transmitter at the first station normally operating to transmit a check-tone modulation of the carrier intermittently at time spaced intervals, a microphone at said first station for modulating said carrier frequency with voice frequencies, manually operable means for rendering said microphone effective and at the same time stopping the tone modulation of said carrier frequency, slow-acting means at the second station biased to assume a deenergized condition after a limited time following its last energization, indicating means governed by said slow-acting means and automatically rendered effective when said slow-acting means assumes its biased deenergized condition, means including a receiver at said second station responding to said tone modulation of the carrier frequency for intermittently energizing said slow-acting means as said check tone modulation is transmitted from said first station, and means at said second station governed by said receiver and responsive to said carrier for rendering said indicating means effective independently of the condition of said slow-acting means, whereby an immediate indication is given at said second station when a voice message is about to be sent from the first station.

2. A two-way telephone system operating on a carrier frequency between two stations comprising, means including a transmitter at one of said stations for normally transmitting at time spaced intervals a tone-modulated carrier signal, a microphone at said one station, manually operable means for automatically suppressing said tone modulation when said microphone is rendered effective for voice communication, a receiver at the other station responsive to the carrier frequency when modulated by either said tone or a voice message, relay means at said other station governed by said receiver and operated only by a tone-modulated carrier signal, other relay means at said other station governed by said receiver and operated by said carrier frequency independently of its modulation, indicating means at said other station rendered effective for a limited time only if both of said relay means are operated in response to a tone-modulated carrier signal, and means for rendering said indicating means ineffective whenever said relay means governed by the carrier frequency is operated alone.

3. In a system for checking the integrity of the voice communication facilities of a two-way telephone system operating between two stations on a carrier frequency, means including a transmitter at one of the stations for intermittently transmitting at time spaced intervals a check-tone modulated carrier signal, a microphone at said one station, manually operable means at said one station for rendering said microphone effective and at the same time automatically suppressing the transmission of said check-tone modulated carrier signal, means governed by said manually

operable means for immediately transmitting said check-tone modulated carrier signal as soon as said manually operable means is restored to its normal inactive condition after termination of a voice message, indicating means at the other station, and means at said other station including a receiver and a slow-acting device for rendering said indicating means effective for a limited time only in response to the reception of said check-tone modulated carrier signal.

4. In a system for checking communication in a telephone system providing communication between spaced locations by voice modulation of a carrier frequency, a transmitter capable when rendered effective of transmitting modulated carrier signals, keying means continuously operating to intermittently render said transmitter effective to transmit a check-tone modulated carrier signal, manually operable means for rendering said transmitter effective to transmit voice modulated signals independently of said keying means, and circuit means acting after each manual operation of said transmitter for causing the immediate rendering effective of said transmitter for transmitting a check-tone modulated carrier signal independently of said keying means.

5. In a system for providing communication between spaced locations by modulation of a carrier frequency, a transmitter at one location capable when rendered effective for transmitting modulated carrier frequency signals, keying means continuously operated through successive cycles of operation, circuit means controlled by said keying means for normally rendering said transmitter effective to intermittently transmit check-tone modulated carrier signals, said means being manually operable to steadily render said transmitter effective to transmit voice modulated carrier signals independently of said keying means, means acting in response to each manual control of said transmitter for causing said transmitter to be rendered effective to transmit a check-tone modulated carrier signal independently of the condition of said keying means in its cycle of operation, a receiver at another station including a tone-responsive relay and a carrier-responsive relay, and indication means controlled by said tone-responsive and carrier-responsive relays to indicate when said check-tone modulated carrier signals cease and a voice modulated carrier signal should be received, whereby said indication means is rendered immediately inactive at the end of each voice modulated carrier signal irrespective of the condition of said keying means in its existing cycle of operation.

6. In a system for checking communication in one direction over a two-way telephone communication system employing a modulated carrier frequency between two spaced stations, a radio transmitter and receiver at each station, means at one station normally effective to cause its transmitter to intermittently transmit check-tone modulated carrier signals but being rendered ineffective whenever voice modulated carrier signals are transmitted or received at such station, indicating means at the other station normally giving a distinctive indication during the continued intermittent reception of said check-tone modulated carrier signals but giving a different indication upon the cessation of the reception of such signals, and means at said one station acting immediately upon the termination of the transmission or reception of a voice modulated carrier signal to render the associated transmitter effective to transmit a momen-

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tary check-tone modulated carrier signal, whereby said indicating means at said other station immediately gives said distinctive indication.

7. In a system for communicating between two spaced stations, a transmitter at one station acting intermittently to transmit check-tone modulated carrier signals under normal conditions but being manually rendered operable to transmit voice modulated carrier signals without said check-tone modulations, a receiver at the other station including a carrier-responsive relay operated to an active position whenever either a check-tone or voice modulated carrier signal is received, a tone-responsive relay operated to an active position only when a check-tone carrier signal is received, indicating means, and circuit means for maintaining said indicating means in an active condition if a check-tone carrier signal is intermittently received and both said relays are operated to active positions at the same time, said means acting to immediately render said indicating means inactive whenever a carrier signal is received without said check-tone modulations.

8. In a telephone system of the carrier frequency type for communicating between spaced stations, a transmitter at one station including a tone generator and a microphone, circuit means normally acting to connect said tone generator to said transmitter but manually operable to connect said microphone, keying means for rendering said transmitter intermittently active to transmit check-tone modulated carrier signals when said tone generator is connected but for rendering said transmitter steadily active for transmitting voice modulated carrier signals when said microphone is connected, a receiver at the other station including relay means distinctively responsive to the reception of a check-tone modulated signal, a loudspeaker responsive to a voice modulated carrier signal but muted when said relay means responds to a check-tone carrier signal, indicating means, and circuit means controlled by the intermittent operation of said relay means for maintaining said indicating means in an active condition and controlled by the reception of a voice modulated carrier signal for immediately rendering said indicating means inactive.

9. In a system for checking communication in one direction over a two-way radio telephone communication system in which time spaced check-tone modulated carrier signals are transmitted in said direction and both directions of transmission are on the same frequency channel, a carrier-responsive relay, a check-tone responsive relay, a slow-release quick pick up relay, a circuit for said slow-release quick pick up relay including front contacts of said carrier-responsive relay and said check-tone responsive relay, indication means, and circuit means for controlling said indication means including a front contact of said slow-acting relay in series with a back contact of said carrier-responsive relay in multiple with a front contact of said tone-responsive relay.

10. In a system for checking communication in a particular direction over a telephone communication system in which time spaced check-tone modulated carrier signals are transmitted in said direction and in which said check-tone modulated carrier signals may be manually removed and replaced by voice modulated messages, a receiver including a carrier-responsive relay, a check-tone responsive relay, a slow-release re-

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lay, a circuit for said slow-release relay including front contacts of said carrier-responsive relay and said check-tone responsive relay, whereby said slow-release relay is normally picked up while time spaced check-tone modulated signals are being received but is dropped away a predetermined time after the cessation of the reception of such signals, a loudspeaker normally connected to said receiver but muted whenever said check-tone responsive relay is actuated, indicating means, circuit means rendered active whenever said slow-release relay is picked up and said check-tone modulated carrier signals are being intermittently received for giving a distinctive indication, said circuit means being rendered inactive whenever said carrier-responsive relay is alone picked up or whenever said slow-release relay is dropped away, whereby the cessation of said distinctive indication advises the reception of a voice modulated carrier message, which if not heard by an operator advises that the communication system is inoperative.

11. In a system for checking communication between two spaced locations in which time spaced check-tone modulated carrier signals are intermittently transmitted, a receiver including a carrier relay rendered active upon the reception of either a check-tone or voice modulated carrier signal, a check-tone relay rendered active only upon the reception of a check-tone modulated signal, a slow-release relay controlled by said check-tone relay so as to be picked up so long as the check-tone modulated carrier signals are intermittently received, indication means controlled by said slow-release relay so as to steadily indicate the reception of check-tone signals but to cease giving said indication when said slow-release relay is released, and means controlled by said carrier relay for causing said indication means to immediately cease indicating upon the reception of a carrier signal not modulated with said check-tone.

12. In a radio telephone system for communicating between two spaced locations, a radio transmitter and a radio receiver at each location adapted to operate on the same frequency channel, said receivers being normally connected to their respective antennas, manually operable means at each location for rendering the respective receiver inactive and rendering the associated transmitter effective for the transmission of voice modulated carrier signals, a carrier relay at each location controlled to an active position by its associated receiver upon the reception of a carrier signal, and circuit means at each location controlled by said carrier relay at that location for rendering said manually controlled means at that location ineffective until the cessation of the reception of a carrier signal.

13. In a system for checking the transmission of voice messages over a carrier frequency by frequency modulation of the carrier, a transmitter at a first station, manually controllable means at said station for normally causing said transmitter to be intermittently rendered active to transmit a carrier modulated by a check-tone frequency but acting when manually controlled for causing said transmitter to be rendered active to transmit a carrier modulated by voice frequencies without said check-tone frequencies, a receiving apparatus at a second station including a relay rendered active only during the reception of a carrier modulated by said check-tone, and a loudspeaker rendered active during the reception of a voice modulated carrier but muted

whenever said relay is rendered active, whereby said loudspeaker is not responsive to the radio noise present at the end of each carrier signal modulated by a check-tone signal, and indication means distinctively controlled only so long as said relay is intermittently rendered active.

14. In a two-way telephone system operating on a carrier frequency between a primary station and a secondary station, a transmitter and receiver at each station adapted to operate on the same carrier frequency channel, said receivers being normally active and their respective transmitters inactive, keying means at the primary station for intermittently rendering its associated receiver inactive and its transmitter active to transmit a check-tone modulated carrier signal, a tone-responsive relay at each station operated by its associated receiver only upon the reception of a check-tone modulated carrier signal, circuit means at the secondary station controlled by the tone-responsive relay at that station each time it is operated for momentarily rendering its associated receiver inactive and its transmitter active to transmit a momentary answer-back check-tone modulated carrier signal, indication means at each station rendered active by the intermittent operation of its associated tone-responsive relay, manually operable means at each station effective to render the associated receiver inactive and render the associated transmitter active for the transmission of voice modulated carrier signals, means at the primary station rendering said keying means ineffective both when that station is manually rendered active to transmit a voice modulated carrier signal and when that station is receiving a voice modulated carrier signal, and means at each station preventing said manually operable means from being effective while its associated tone-responsive relay is operated.

15. In a two-way telephone system operating on a carrier frequency between a primary station and a secondary station, a radio transmitter and receiver at each station adapted to operate on the same carrier frequency channel, each of said receivers being normally active but being rendered inactive when its associated transmitter is rendered active, keying means at the primary station for intermittently rendering its associated transmitter active to transmit check-tone modulated carrier signals, circuit means including a tone-responsive relay at the secondary station for rendering its associated transmitter effective to automatically transmit a momentary answer-back modulated carrier signal, manually operable means at each station effective to render the associated transmitter active for the transmission of a carrier signal for voice modulations, means at each station effective upon the restoration of said manually operable means to cause the immediate and momentary transmission of a check-tone modulated carrier signal by its associated transmitter before it becomes inactive, said means acting independently of said keying means, indication means at each station responsive to the intermittent reception of a check-tone modulated carrier signal to give one indication but immediately rendered effective to give a distinctive indication upon the reception of a carrier signal without said check-tone modulation, and circuit means at the primary station acting to prevent the transmission of said check-tone modulated signals during the transmission of a carrier signal for voice modulations in either direction, whereby a distinctive indication is given at each station as soon as transmission of carrier

signals for voice modulations is initiated, but is cancelled immediately upon the termination of each voice message.

16. In a two-way telephone system operating on a carrier frequency between a primary station and a secondary station, a transmitter and receiver at each station adapted to operate on the same carrier frequency channel, said receivers being normally active and said transmitters being normally inactive, manually operable means at each station effective to render the associated receiver inactive and to render the transmitter active for the transmission of a carrier frequency for voice modulated messages, keying means at the primary station for intermittently rendering its associated receiver inactive and its transmitter active to transmit check-tone modulated carrier signals, a check-tone responsive relay at each station controlled by its respective receiver upon the reception of a check-tone modulated carrier signal, a carrier-responsive relay at each station operated by its receiver upon the reception of a carrier signal independently of its character of modulation, indication means at each station jointly controlled by the carrier-responsive relay and the tone-responsive relay at that station so as to give a distinctive indication so long as check-tone signals are intermittently received but to immediately give a different indication when a carrier signal without a check-tone is received, and circuit means at each station acting to prevent the rendering active of its associated transmitter whenever the associated carrier-responsive relay is operated by its associated receiver.

17. In a two-way telephone system operating on a carrier frequency for communicating between two stations, a transmitter and receiver at each station, said receivers being normally active and said transmitters being normally inactive, keying means at one station acting intermittently to render its receiver inactive and its transmitter active to transmit a check-tone modulated carrier signal, a carrier-responsive relay at each station controlled by its associated receiver to an active position in response to the reception of a carrier signal independently of its character of modulation, manually operable means at each station for rendering its receiver inactive and its transmitter active for the transmission of a carrier signal for voice modulations, said means being manually operable only providing its associated carrier-responsive relay is inactive, means at said one station acting to prevent the transmission of said check-tone modulated carrier signals when its associated carrier-responsive relay is active, and indicating means at the other station distinctively controlled in accordance with the intermittent reception of said check-tone modulated carrier signals.

18. In a two-way telephone system operating on a carrier frequency between a primary station and a secondary station, a transmitter and receiver at each station adapted to operate on the same carrier frequency channel, said receivers being normally active and said transmitters being normally inactive but being so related that the rendering active of a transmitter at either station renders its associated receiver inactive, keying means at the primary station for intermittently rendering its associated transmitter active to transmit check-tone modulated carrier signals, indication means at the secondary station controlled by its associated receiver in response to the intermittent reception of a check-tone signal for giving a distinctive indication, manually op-

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erable means at each station effective to render the associated transmitter active for the transmission of a carrier signal for modulation by voice frequencies, said means also acting at said secondary station to immediately render said indicating means at that station inactive, and means at the primary station acting to prevent automatic transmission of said check-tone modulated carrier signals during the reception of a carrier signal modulated by voice message.

19. In a system for transmitting voice messages on a carrier frequency between a first station and a second station, a transmitter at the first station normally operating to intermittently transmit check-tone modulated carrier signals, a microphone at said first station, and manually operable means for rendering ineffective the automatic transmission of said check-tone modulated carrier signals and rendering said microphone effective for modulating the carrier signals from its associated transmitter in accordance with the voice message, a receiver at the second station including a loudspeaker and means distinctively responsive to said check-tone modulated carrier signals, indication means rendered active by the intermittent reception of said check-tone modulated carrier signals, and means controlled at said second station by its receiver for immediately rendering said indication means inactive upon the reception of a carrier signal not modulated by said check-tone.

20. In a system for checking the transmission of voice messages by frequency modulation of a carrier frequency, a normally inactive transmitter at a first station, keying means for intermittently rendering said transmitter active to transmit a carrier signal modulated by a check-tone frequency, manually operable means for rendering said transmitter active to transmit a carrier signal modulated by voice frequencies without said check-tone frequency, said means acting at the end of such a manual operation to cause a check-tone modulation of the carrier immediately following the voice message and before the termination of the carrier signal, a receiving apparatus at a second station including a relay operated only during the reception of a carrier signal modulated by said check-tone frequency, a loudspeaker rendered active by the reception of a voice modulated carrier signal but rendered inactive whenever said relay is operated, and indication means distinctively controlled by the intermittent operation of said relay, whereby the absence of said distinctive indication without the reception of a voice message through said loudspeaker indicates a failure in the communication system, and whereby the crash of radio noise accompanying the termination of a frequency modulated carrier signal is eliminated from said

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loudspeaker both for check-tone signals and voice messages since said relay is in an operated condition to mute said loudspeaker at the termination of each carrier signal.

21. In a system for checking communication in a telephone system providing communication between spaced locations by voice modulation of a carrier frequency, apparatus at one station including a transmitter capable when rendered effective of transmitting modulated carrier signals, check pulse transmitting means normally acting to intermittently render said transmitter effective to transmit time spaced check pulses of carrier signal, manually operable means for rendering said transmitter effective to transmit voice modulated carrier signals and at the same time rendering said check pulse transmitting means ineffective, circuit means acting upon said check pulse transmitting means after each manual operation of said transmitter for causing the immediate transmission of a check pulse signal, and apparatus at another station including a receiver responsive to the carrier signals transmitted by said one station, and having indicator means rendered active only in response to the reception of said intermittent check pulse carrier signals, whereby the reception of a voice modulated signal renders the indicating means inactive but which indicating means is immediately rendered active at the end of such voice modulated signal.

22. In a system for checking communication in a telephone system providing communication between two spaced locations by voice modulation of a carrier frequency, transmitting and receiving apparatus at each station, said receiving apparatus being normally active at each station but being capable of being rendered inactive and the associated transmitter being rendered active, check pulse transmitting means at one station effective to intermittently render its associated transmitter active to transmit a time spaced check pulse of carrier signal, manually operable means at each station for rendering its transmitter active to transmit voice modulated carrier signals and at the same time rendering the associated receiver inactive, circuit means at said one station acting upon said check pulse transmitting means after each operation of said transmitter and also after each reception by its associated receiver for causing the immediate transmission of a check pulse carrier signal, and indication means at said other station rendered active only in response to the intermittent reception of said check pulse carrier signals, whereby said indication means is rendered active immediately following the transmission of voice modulated signals regardless of the direction of their transmission.

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