

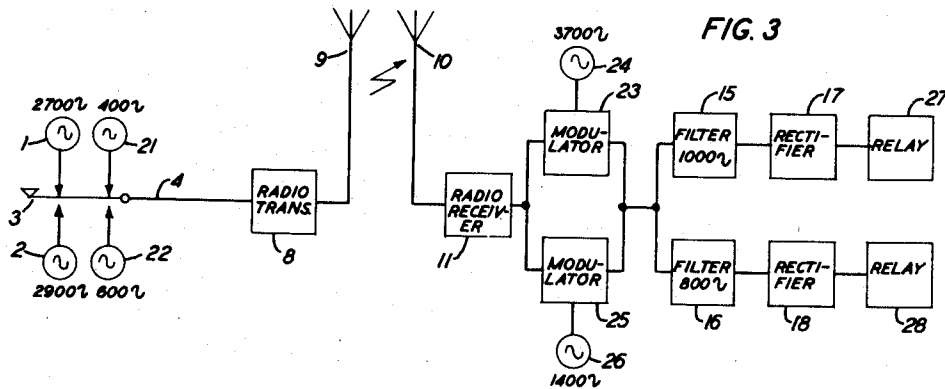
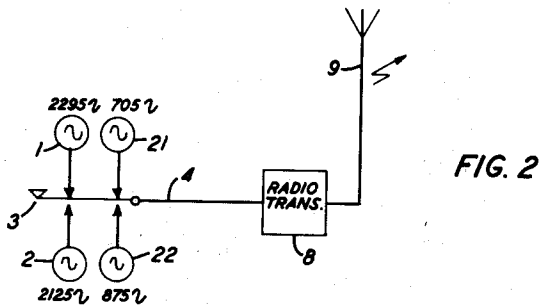
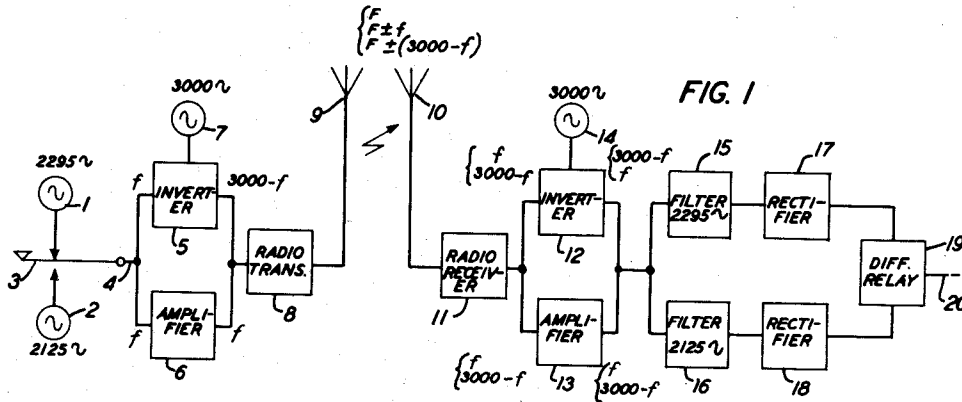
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SIGNALING SYSTEM

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SIGNALING SYSTEM

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The invention relates to signaling systems and in particular to systems employing impulses transmitted in accordance with a code, as in telegraphy and in the dialing of impulses for use in remote switching or other control operations. More particularly, the invention relates to means for insuring against loss of signals due to fading in radio transmission and other interfering effects, particularly those that are selective as to frequency.

It has been proposed to send waves of two frequencies alternately, one to form a "marking signal" and the other to form a "spacing signal", as it has been found that a definite signal is better than a space devoid of a signal, when protection against interference is desired. It has also been proposed to send out waves of two or more frequencies simultaneously to form a signal, because experience has shown that the probability that two or more waves of different frequency will fade out at the same time is much less than the probability that a single wave will fade out at any given time.

In accordance with the present invention two or more waves of different frequency are used to form a signal and it is so arranged that at the receiving station the waves of different frequency are shifted or translated to a common frequency before they are filtered to separate them from extraneous waves or disturbances. The filtered waves, representing one or more of the transmitted, signal-bearing waves, are then used to actuate the receiving relay or other useful device. The advantages of this system include a simplification of apparatus, particularly a decrease in the number and complexity of the filters required. Other advantages and features will be apparent from the following detailed description taken in conjunction with the accompanying figures, of which

Fig. 1 represents in diagrammatic fashion the preferred form for complete transmitting and receiving stations arranged for one-way operation in accordance with the invention;

Fig. 2 shows a modified form of transmitting circuit; and

Fig. 3 shows a system illustrating a modified form of the invention.

Referring to Fig. 1, a pair of tone generators 1 and 2 supply 2295-cycle-per-second and 2125-cycle-per-second tone currents respectively. A key 3 has a back contact connected to the 2295-cycle generator and a main contact connected to the 2125-cycle generator. The key lever is connected to a line 4 which has branches con-

nected respectively to an inverter 5 and an amplifier 6. Also connected to the inverter is a carrier generator for supplying a 3000-cycle current. The output circuits of the inverter 5 and of the amplifier 6 are jointly connected to a radio transmitter 8 and the latter is connected to a transmitting antenna 9.

At a receiving station a receiving antenna 10 is provided together with a radio receiver 11. The output circuit of the radio receiver is connected to an inverter 12 and an amplifier 13. In conjunction with the inverter 12 there is provided a second carrier generator 14. The output circuits of the inverter 12 and of the amplifier 13 are jointly connected to a pair of filters 15, 16, tuned to 2295 cycles and 2125 cycles respectively. Connected to the respective outputs of the filters are two rectifiers 17, 18 which are in turn jointly connected to a differential relay 19. The relay is coupled to a local circuit or line section 20.

In the operation of the system of Fig. 1, the key 3 is manipulated to form marking and spacing signals alternately in accordance with a code. During a marking signal the key is depressed, thereby connecting the 2125-cycle generator 2 to the line 4. During a spacing signal the key is raised, thereby connecting the 2295-cycle generator 1 to the line 4. Whichever tone generator is connected at a given instant, let the tone frequency be designated as f . The function of the inverter 5 and carrier generator 7 is to invert the frequency f with respect to 3000 cycles. By this is meant that the inverter upon receiving a tone current of the frequency f , produces in its output circuit a current of the frequency $3000-f$. The process of inversion and apparatus for effecting the result are not a part of the present invention and are well known in the art. For an example of an inverter of this sort, reference may be had to U. S. Patent 1,603,287, issued October 19, 1926 to J. Mills. The frequency in the output of the amplifier 6 is, of course, unchanged and equal to f .

The inverted and uninverted currents from the inverter 5 and the amplifier 6 respectively are impressed jointly upon the input circuit of the radio transmitter 8 wherein is produced in well-known manner a radio frequency carrier wave modulated by the two-tone frequencies, f and $3000-f$. If the carrier frequency is designated by F , then the side frequencies produced are $F+f$ and $F \pm (3000-f)$ and either the upper or the lower or both pairs of side frequencies, with or without the carrier, according to the method of operation desired, are transmitted to and radi-

ated from the antenna 9. The essential requirement of the transmission is that provision be made for transmitting waves from which the tone frequencies f and $3000-f$ may be reproduced at the receiving station.

At the receiving location the waves radiated by antenna 9 are intercepted by antenna 10 and detected in the radio receiver 11 in the usual manner to reproduce the tone frequencies f and $3000-f$, providing that one or both of the corresponding radio waves are not lost due to fading of the waves in the course of transmission through space between the antennae. Assuming that both tone frequency currents are present in the output of the radio receiver, they are then impressed jointly upon the inverter 12 and the amplifier 13. The inverter 12 is supplied by the source 14 with substantially the same frequency, here 3000 cycles, as was supplied by the source 7 to the inverter 5. The inverter 12 converts the frequency f to the frequency $3000-f$, and likewise converts the frequency $3000-f$ to $3000-(3000-f)$, or f again. The purpose of this inversion will appear more fully below when the effects of fading are considered. The amplifier 13 passes the frequencies f and $3000-f$ without inversion.

The inverted and uninverted tone currents are next impressed upon the filters 15 and 16. Filter 15 is designed to pass only frequencies in the neighborhood of the frequency generated by source 1, in this case 2295 cycles. Filter 16 is designed to pass only frequencies close to that of source 2, here 2125 cycles. As the frequency f represents either the frequency of source 1 or the frequency of source 2, it will be noted that the current of frequency f is passed by one of the filters and stopped by the other. The current of frequency $3000-f$ is stopped by both filters. In the case of a marking signal, f is 2125 cycles as illustrated. The 2125-cycle tone current, which may come either from the inverter 12 or from the amplifier 13 or from both, is passed through the filter 16 and then rectified by the rectifier 18. The rectified current is impressed upon the differential relay 19 to operate the relay in the proper direction to cause a marking signal to be made in the local circuit or line section 20. In the case of a spacing signal, f is 2295 cycles as illustrated. The 2295-cycle current from inverter 12, amplifier 13, or both, is passed through filter 15 and rectified by rectifier 17. The rectified current acts upon the relay 19 to cause a spacing signal to be made in local circuit or line 20.

In the event of selective fading of the radio waves in traversing the space between antennae 9 and 10, the waves of one or more of the side frequencies $F+f$, $F-f$, $F+3000-f$, or $F-3000+f$ may be attenuated, or even practically eliminated before reaching the radio receiver 11. Especially in case of single side-band transmission, where $F+f$ and $F+3000-f$ are the transmitted frequencies assuming that it is the upper side-band that is transmitted, one of the frequencies f or $3000-f$ may at times be absent from the output of receiver 11. Suppose, for example, that f is absent. Provided $3000-f$ is present, the current of this frequency causes a current of frequency f to be produced in the inverter 12. This inverted current will pass filter 16, assuming a marking signal, and will actuate the relay 19 through the action of the rectifier 18. If at another time, the frequency f alone is present, the current of this frequency passing through the amplifier 13 will cause relay 19 to be actu-

ated as before. Thus positive action of the relay 19 is secured regardless of failure of one of the tone currents. The probability of simultaneous fading, which would eliminate frequencies f and $3000-f$ together, has been found by experience to be much less than the probability of selective fading of the kind assumed above wherein if either tone frequency is eliminated temporarily the other remains. Therefore an effect of the invention is to reduce the chances of loss of signals in the presence of fading.

Fig. 2 shows an alternative arrangement of the transmitting circuits. As indicated, the key 3 has two back contacts which are connected respectively to the tone generator 1, producing the 2295-cycle current and to another tone generator 21, producing a 705-cycle current. The key also has two main contacts which are connected respectively to the generator 2, of 2125 cycles, and to a generator 22 producing current of 875 cycles. The key is connected through the line 4 directly to the transmitter 8. At the receiving station the circuits may be as shown in the receiving portion of Fig. 1.

In the operation of the system of Fig. 2, there is no inverter required at the transmitting station, for the frequencies f and $3000-f$ are supplied by individual generators. A marking signal is sent, as before, by depressing the key. Now the main contacts of the key connect generators 2 and 22 jointly to line 4, the generator 2 supplying frequency f and the generator 22 supplying frequency $3000-f$, where f is the marking frequency. A spacing signal is sent, as before, by releasing the key, this time connecting generators 1 and 21 to the line 4, thus supplying the frequencies f and $3000-f$, where f is the spacing frequency. From this point on the operation is the same as in the system of Fig. 1.

Fig. 3 shows a modified system using in reception two modulators, either or both of which may be inverters. The transmitting station is arranged the same as the station shown in Fig. 2, except that the frequencies assigned to the oscillators are changed. At the receiving station, the general arrangement is like that shown in Fig. 1. A modulator 23 and attendant oscillator 24 are shown in place of the inverter 12 and oscillator 14. Another modulator 25 with attendant oscillator 26 is shown in place of the amplifier 13. The filters 15 and 16 have had their tuning changed to 1000 cycles and 800 cycles respectively. The rectifiers 17, 18 are shown connected to individual relays or other responsive devices 27 and 28 respectively.

In the operation of the system of Fig. 3, a marking signal is sent by means of 2900 cycles from oscillator 2 and 600 cycles from oscillator 22. Upon receipt of a 2900-cycle current at modulator 23 the sum and difference frequencies 6600 cycles and 800 cycles are produced and impressed upon the filters 15 and 16, tuned to 1000 cycles and 800 cycles respectively. The 800-cycle current is transmitted by filter 16, and rectified at 18 to furnish current for operation of relay 28. The 6600-cycle current is readily rejected or attenuated by both filters. The 2900-cycle current is also incident upon the modulator 25 which produces therefrom currents of 4300 cycles and 1500 cycles respectively, which fail to pass either filter. Upon receipt of a 600-cycle current the modulator 23 produces currents of 4300 cycles and 3100 cycles respectively, which are rejected by both filters. The 600-cycle current incident upon the modulator 25 produces currents of 2000

cycles and 800 cycles respectively, of which the 800-cycle current passes through the filter 16 and is rectified, either causing or aiding relay 28 to operate. Thus either 2900-cycle current or 600-cycle current in the output circuit of the radio receiver 11 will serve to cause a signal to be received by relay 28. In either case the detected tone current, 2900 cycles or 600 cycles, is converted to a common value, namely 800 cycles, the frequency to which filter 16 is responsive.

A spacing signal is sent by means of 2700-cycle current from oscillator 1 and 400-cycle current from oscillator 21. Receipt of a 2700-cycle current by modulator 23 causes currents of 6400 cycles and 1000 cycles, respectively, to be produced, the 1000 cycles being then transmitted through filter 15 and used to operate the relay 27 in the same manner as current passed by filter 16 serves to operate the relay 28. The 2700-cycle current incident upon the modulator 25 produces 4100-cycle and 1300-cycle currents which are rejected by both filters. Receipt of a 400-cycle current by modulator 23 causes the production of 4100-cycle and 3300-cycle currents which are discarded, while the 400-cycle current produces 1800-cycle and 1000-cycle currents in modulator 25. The 1000-cycle current thus produced is transmitted through filter 15 to cause operation of relay 27. Therefore, either 2700-cycle current or 400-cycle current in the output of the radio receiver will be brought by modulation to the common value 1000 cycles and will be effective to cause a response in relay 27.

It will be observed that in the system as illustrated, the useful currents generated by the modulators 23, 25 are lower side frequencies in each case. In producing a lower side frequency the function of the modulator is the same as that of an inverter. It is not necessary, however, to employ only lower side frequencies. In other words, the modulators 23 and 25 need not be inverters, although one or both may be inverters similar to 5 and 12.

It will be evident that the particular frequencies assigned to the tone generators 1, 2, 21 and 22, and to the carrier generators 7, 14, 24 and 26, as illustrated herein, need not be used and others may be substituted as desired. It is, however, desirable to use substantially the same frequency in generator 14 as in generator 7, in order that a frequency inverted by inverter 5 may be reinverted to its original value by inverter 12. It is only essential that the two frequencies used in a marking signal be shifted to the same frequency value before reaching the filter 15 and that the two frequencies used in a spacing signal be brought to a different common value before entering the filter 16. The common value is, of course, the frequency to which the respective filter is tuned. By means of the system of Fig. 3, it is illustrated how the filters 15 and 16 may be tuned to any arbitrary frequency desired, provided two modulators or inverters are used instead of one as in Fig. 1. When the frequencies of the filters have been selected, the frequencies assigned to the oscillators 1, 2, 21, 22, 24 and 26 must be given a set of frequency values consistent with the choice of the filter frequencies. In such selection of frequencies, it is desirable to avoid having any frequency which the modulators can produce from a marking signal lie in or close to the filter assigned for the reception of spacing signals, and vice versa. In the system of Fig. 3 as illustrated, it will be noted that the closest approach to in-

terference between marking and spacing signals occurs on account of a 1300-cycle current produced by modulator 25 during a spacing signal, the 1300 cycles being but 300 cycles away from the resonant frequency of the filter 15. The frequency of filter 15 is 1000 cycles and the filter is intended to respond exclusively to marking signals.

It will be evident that the amplifiers 6 and 13 may not always be needed to bring the currents transmitted therethrough to a suitable energy level. It is desirable, however, in any case to protect the system from feedback effects which arise if the path through the amplifier is not restricted to unidirectional transmission in the forward direction. The usual unidirectional type of amplifier provides a convenient means of preventing feedback and at the same time the gain of the amplifier may be adjusted in known manner to regulate the amount of current impressed upon the succeeding apparatus.

The invention is not restricted to radio transmission but may be used for direct wire communication, with or without the use of a carrier wave, or in a system including any kind of communicating link in which a single frequency wave may be subject to uncontrolled attenuation or fading.

The key 3 may be replaced by a telephone dial switch or by any manually or automatically operated switch or impulse forming device. Also the terms "key" and "keying" are to be understood as including dial switches and the operation of dialing, respectively.

It will be evident that in the system of Fig. 1, the filters 15 and 16 need not be tuned to the frequencies designated by f above but may equally well be tuned to the frequencies designated by $3000-f$.

In the system of Fig. 1, the relay 19 need not be a differential relay but may be a relay of any desired type, or it may be a telegraph sounder, a local indicator of signals or any suitable electrically operated device. When a local device is to be operated the line 20 may not be needed. In case the relay 19 is operable by alternating current of the frequencies passed by the filters 15, 16, the rectifiers 17, 18 may be dispensed with. It should be noted that the use of the differential relay has a certain advantage in the presence of "static" or other extraneous disturbing effects, because any currents or transients of a nature to affect the filters 15, 16 equally well may be substantially balanced out so as to have no resultant effect upon the relay 19.

The terms "marking signal" and "spacing signal" as used are to be understood as illustrative of any two kinds of signals which it may be desirable to employ. It is evident that the system may be used to send marking signals alone with spaces between which will serve in the usual way as spacing signals. It will also be evident that the invention is not limited to the use of two frequencies for sending a signal. Three or more frequencies may be employed simultaneously in order further to increase the probability that one frequency will be transmitted if all the others fade out. An additional modulator may be provided for each added frequency and the attendant carriers may be so selected that all the frequencies used to carry the same signal are translated to a common frequency value before being used to operate the final receiving device.

What is claimed is:

1. A system comprising means for keying a

tone frequency wave to develop code signals, a source of carrier waves, means actuated by said source to translate the frequency of said keyed tone wave through a frequency interval fixed by the carrier frequency, means to transmit both the translated and the untranslated tone wave, means at a receiving station to translate one of said keyed waves by the said fixed frequency interval, whereby the received waves are brought to a common frequency, selective means tuned to said common frequency, and a detector for said selected wave.

2. A system comprising means for keying a tone frequency wave to develop code signals, means for inverting the frequency of said tone with respect to a substantially fixed carrier frequency, means to transmit both the inverted and the original tone wave, a pair of circuits at a receiving station, means in one of said receiving circuits for inverting the frequency of an impressed wave with respect to substantially the same carrier frequency above mentioned, means in the other of said receiving circuits to by-pass said inverting means, a filter tuned to said original tone frequency, said filter being connected both to the output of said last-mentioned inverting means and to said by-passing circuit, and means for detecting signals carried by waves passing through said filter.

3. A system comprising a source of tone frequency current, keying means for forming current from said source into pulses in accordance with a code, a divided circuit connected to the keying means and containing in one branch a unidirectional amplifier and in the other branch

a frequency inverting means, a transmission system connecting the combined output circuits of the amplifier and of the inverting means to a second divided circuit, said second circuit having component parts substantially identical with those in said first-mentioned divided circuit, a filter connected to the output terminals of said second divided circuit, and means in the output circuit of the filter for detecting code-formed current pulses.

4. In a telegraph system, a tone generator of a predetermined frequency for marking signals, a tone generator of another frequency for spacing signals, a transmission system subject to selective fading, keying means for connecting said generators alternately to the transmission system, frequency inverting means inserted between the keying means and the transmission system whereby there is caused to be superposed upon the current transmitted from whichever generator is connected through said keying means an auxiliary current, of a frequency other than that of said connected generator, tuned means at the far end of the transmission system for separately detecting marking signals and spacing signals, and frequency inverting means inserted between the transmission system and the detector for superposing upon the auxiliary current a current of the originally transmitted frequency whereby suitable signaling current is locally supplied to the detecting means in case of fading of the main current in the transmission system.

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