

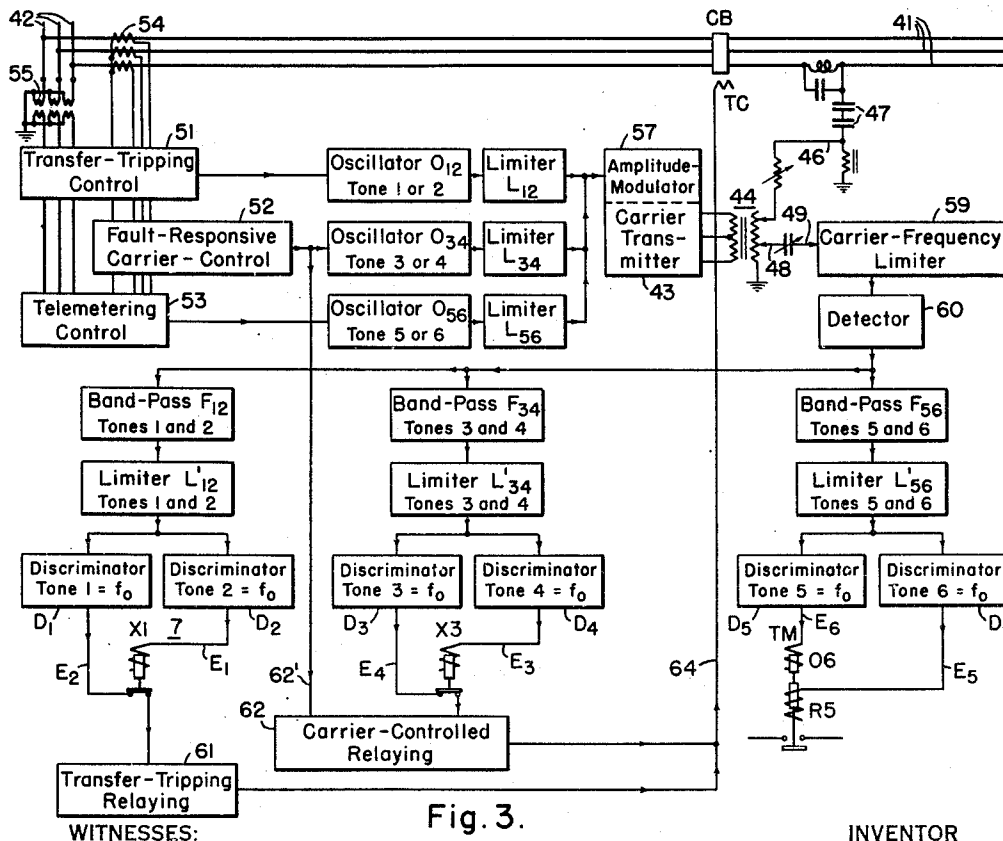
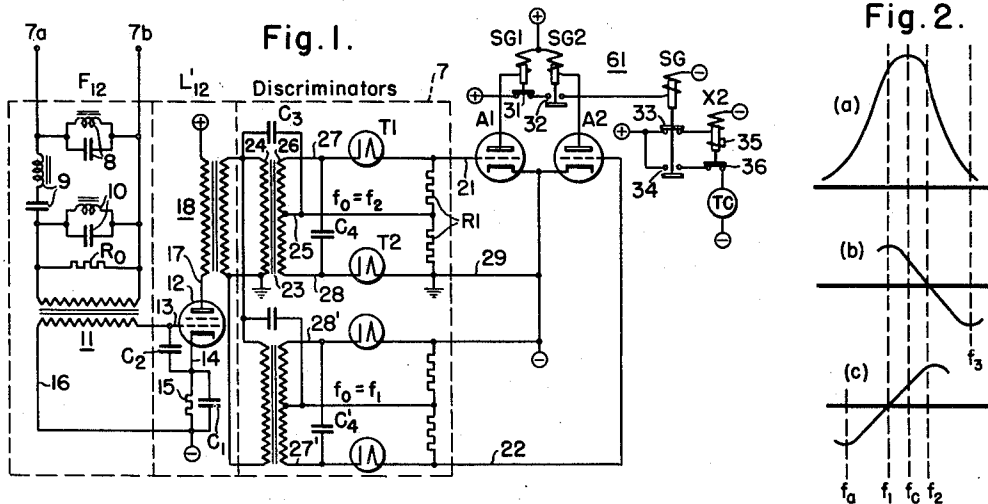
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TONE-SHIFT CARRIER

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TONE-SHIFT CARRIER

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My invention relates to an intelligence-transmitting means using two tones which are impressed upon a carrier-current wave, preferably by amplitude-modulation of the carrier, although the carrier might be frequency-modulated. It is a distinctive feature of my invention that one of the two tones which are used in the transmission of any bit of intelligence is normally being transmitted, when there is no intelligence to be transmitted, and is used, at the receiving end, as a restraining means or as a lock-out means, for preventing any signal-response. When intelligence is to be transmitted, the tone-frequency is changed or shifted from the normal tone-frequency to the other tone-frequency of the pair of tones which are associated with that particular piece of intelligence, and hence, at the receiving end, the restraint or response-prevention is removed, and the receiving apparatus is free to respond to the second tone, thus completing the transmission of the intelligence in question.

The word carrier is here used as indicative of any high-frequency currents which are used as a carrier for transmitting a superimposed tone-signal having a much lower frequency than the carrier. The carrier current may be either a radio-frequency current which is superimposed upon one of the line-conductors of a transmission-line, or an ultra-high-frequency microwave current which is beamed to a remote terminal of a transmission system by means of a directional antenna located at the relaying station or line-terminal, or any other kind of carrier wave which is used in any kind of communication system.

Heretofore, the use of tone-signals has been considered for relaying purposes, but the time-delays which are involved have been such as to make the direct keying of the tone-transmitter too slow for many relaying purposes. It requires about five cycles of the tone-frequency, after keying-on a tone, to build up the magnitude of the tone to a usable value. After the turning off of the tone-transmitter, it requires about ten cycles of the tone-frequency for the tone to die out. With my frequency-shifting system, it requires only about two cycles of the tone-frequency to shift from one tone-frequency to a distinguishably different tone-frequency.

An important advantage of my present system is to avoid the possibility of incorrect operations or responses, as a result of interference caused by transients. Generally, a transient that will generate one tone-frequency, will generate a wide band of tone-frequencies in that vicinity, due to the steep wave-front of the transient, thus simultaneously producing both of the tones which are associated with any particular kind of intelligence which is to be transmitted. In using my invention, the restraint which is produced by one

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of these tones is so strong, or so effectively applied, that no response can be obtained when both tones are being received, as was the case in previous tone-responsive intelligence-transmitting means.

My shifting-tone signalling-means is advantageous over means which depend upon the amplitude of the carrier-current modulation, as distinguished from the tone-frequency of the carrier-current modulation, particularly in those carrier-systems which are subject to wide and sudden fluctuations of attenuation in the carrier-current transmission, because, in my system, no attention needs to be paid to either the amplitude of the modulation or signal, or the amplitude-ratio of the signal to the unmodulated carrier wave. In my system, it is possible to selectively pick out the tone or the pair of tones to which a response is to be obtained, and then amplify said tones to a constant amplitude, which will be the same regardless of the carrier-current attenuation, and then the response can be made to the frequency of the tone or to the frequency-shift of the tone.

With the foregoing and other objectives in mind, my invention consists in the circuits, systems, combinations, apparatus, parts, and methods of design and use, hereinafter described and claimed, and illustrated in the accompanying drawing, wherein:

Figure 1 is a diagrammatic view of circuits and apparatus illustrating the receiving end of a tone-shifting carrier-current transfer-tripping relaying system using my invention;

Fig. 2 is a tone-frequency diagram illustrative of my invention; and

Fig. 3 is a block diagram of circuits and apparatus illustrating a complete six-tone carrier-current system using my present invention.

Fig. 1 shows the tone-responsive end of an exemplary application of my two-tone carrier-current receiver, as applied to a transfer-tripping operation in which the intelligence which is to be received is information concerning the necessity for energizing the trip-coil TC of a line-section-alizing circuit breaker, in response to fault-conditions which are detected at another terminal of the protected line-section. The apparatus shown in Fig. 1 includes a band-pass filter F_{12} , a limiter L_{12} , a discriminator I , amplifier-tubes $A1$ and $A2$, and relays $SG1$, $SG2$, SG , and $X2$.

The filter F_{12} is any suitable type of band-pass filter which will permit the passage of the two tone-frequencies f_1 and f_2 which jointly cooperate in the transmission of the particular kind of intelligence in question. This filter should have sharp cutoff points, so as to substantially prevent the transmission of any higher or lower frequencies through said filter. There are a number of forms of band-pass filters which will per-

form such a service. The illustrated filter F_{12} , in Fig. 1, has two input-leads $7a$ and $7b$. A first parallel-resonance device 8 is connected across said leads, followed by a series-resonance device 9 , which is in turn followed by a second parallel-resonance device 10 , connected in shunt across the supply-conductors, and finally a shunt-connected resistance R_0 .

The output of the band-pass filter F_{12} is supplied to a limiter or limited-amplitude amplifier L'_{12} , through a transformer 11 . The purpose of the limiter L'_{12} is to neutralize the effects of a variable strength or amplitude in the incoming tone-frequency wave, and to produce a tone of the same frequency, having a constant predetermined amplitude or intensity. There are a number of limiters which are available for producing such a function. The particular one which is illustrated in Fig. 1 consists of an overloaded class-C amplifier-tube 12 in which the grid-circuit 13 is connected to one output-terminal of the transformer 11 , and in which the cathode-circuit 14 is connected to a cathode-circuit resistor 15 , and thence to the other output-circuit 16 of the transformer 11 , and also to the negative battery-terminal ($-$). The cathode-circuit resistor 15 is shunted by a capacitor C_1 . A second capacitor C_2 is connected between the grid-circuit 13 and the cathode-circuit 14 .

The plate-circuit 17 of the limiter-tube 12 serves as the output-circuit of the limiter L'_{12} , which is coupled to the discriminator 7 by means of a transformer 18 . The essential feature of the discriminator 7 is that it shall have two direct-current output-circuits 21 and 22 , the voltages of which shift in opposite directions with respect to each other, the direction of shift being dependent upon whether the one tone or the other is being received.

In the particular discriminator 7 which is shown in Fig. 1, there are two separately tuned discriminators, one of them having the tone-frequency f_1 of tone 1 for its resonant-frequency f_0 , while the other discriminator has the other tone-frequency f_2 , corresponding to tone 2 , for its resonant-frequency f_0 . The connections of these two discriminators are such that each produces a zero output-voltage, in its output-circuit 21 or 22 , as the case may be, when it receives a pure tone of the same frequency as its resonance-frequency, but produces a unidirectional output-voltage at any other frequency of tone-signal. I am not limited, however, to this particular type of discriminator, the only really essential thing being that I shall obtain a discriminator-response which discriminates between the two input-frequencies for which the discriminator is adjusted.

In the discriminator 7 of Fig. 1, the two individual discriminators are alike, so that a description of one will suffice for both, with the understanding that the resonant-frequencies are different. A very simple form of discriminator is shown, having a discriminator-transformer 23 in which the primary winding 24 is coupled to the mid-point 25 of the secondary winding 26 by a coupling-capacitor C_3 . The secondary terminals 27 and 28 are connected by a tuning-capacitor C_4 , which tunes the secondary circuit to the selected resonance-frequency f_0 which is the same, say, as the shifted-tone frequency f_2 of tone 2 . The secondary terminal 27 is connected to the output-circuit 21 through a rectifier-tube T_1 . The other secondary terminal 28 is connected to an output-circuit 29 through a second rectifier

tube T_2 . The two output-circuits 21 and 29 are joined by means of a resistance R_1 , the mid-point of which is connected to the mid-point 25 of the secondary winding 26 .

The adjustment of this discriminator-circuit is such that the direct-current output-voltages across the two halves of the resistance R_1 are equal and opposite to each other when the input-frequency into the discriminator is the same as the resonance-frequency f_0 to which this discriminator-circuit is tuned, so that no voltage appears in the output circuit 21 under these circumstances. When the other tone-frequency is fed into the discriminator-circuit in question, a predetermined positive voltage appears in the output-circuit 21 .

The other discriminator-circuit, shown in Fig. 1, is similar to the discriminator-circuit just described, except that its secondary-winding terminals $27'$ and $28'$ are reversed, and its tuning capacitor C_4' is of such size as to tune the secondary circuit to a resonance-frequency f_0 which is the same as the unshifted tone-frequency f_1 of tone 1 , so that this second discriminator-circuit develops a zero voltage in its output-circuit 22 when tone 1 is received, while it develops a predetermined positive voltage in its output-circuit 22 when tone 2 is received.

The operation of my apparatus, as thus far described, is illustrated in Fig. 2, wherein responses (current-strengths or voltages) are plotted against frequencies. Curve (a) of Fig. 2 shows the effect of the band-pass filter F_{12} , which is tuned to a center-frequency f_c , halfway between the two tone-frequencies f_1 and f_2 which are to be passed by the filter. This curve (a) shows how the filter passes the two desired tone-frequencies f_1 and f_2 , but does not pass a substantial amount of current having either the next higher tone-frequency f_3 or the next lower tone-frequency f_a .

In Fig. 2, the second curve (b) shows the magnitude of the output-voltage of the first discriminator-circuit, as it appears in the output-circuit 21 , plotted as a function of the frequency. It shows that this output-voltage is zero at the resonant frequency, which is f_2 for this discriminator-circuit, while, for the other received tone-frequency f_1 , the output-voltage of this discriminator-circuit has its maximum positive value.

In Fig. 2, the third curve (c) shows the magnitude of the output-voltage of the second discriminator-circuit, as it appears in output-circuit 22 , and shows that this output-voltage is zero when the frequency f_1 is being received, while it has its maximum positive value when the other frequency f_2 is being received.

The first output-circuit 21 of the discriminator 7 , in Fig. 1, is applied to the grid of an amplifier tube A_1 , the plate-circuit of which contains the coil of a relay SG_1 which thus responds to the frequency f_1 of tone 1 . In like manner, the second output-circuit 22 of the discriminator 7 is applied to the grid-circuit of an amplifier tube A_2 which energizes the operating coil of a second relay SG_2 , which thus responds to the frequency f_2 of tone 2 .

The first relay SG_1 has a back-contact 31 , which is connected in series with a make-contact 32 of the second relay SG_2 , to energize the operating coil of a relay SG . The last-mentioned relay SG has a back-contact 33 and a make-contact 34 . The back SG contact 33 is in an energizing circuit for the operating coil of a slow-dropout relay X_2 , which is shown as having a

short circuited coil or slug 35 which delays its dropout action for a suitable time. The slow-dropout relay X2 has a back-contact 36 which is connected in series with the SG make contact 34 in a tripping circuit which energizes the breaker trip-coil TC in response to the SG relay, before the slower-acting X2 relay can open its back-contact 36.

In Fig. 3 I have indicated, by block diagram, an illustrative system in which my invention can be used or applied. In any tone-signal or frequency-signal system, where the transmission of intelligence is dependent upon the transmission or non-transmission of one or two selected frequencies, whether audio-frequency tones, or supersonic tones or radio frequencies, it is practically always true that there will be other information-transmitting channels using other selected tones or frequencies in the adjacent spectrum. This will be true, whether the selected tone or frequency is superimposed on a carrier wave, or transmitted by itself. There are also various kinds of intelligence which are to be transmitted, including printing telegraph systems, as well as the kind of intelligence-transmitting system which is associated with the operation of alternating-current power-transmitting systems for which my invention was primarily designed. By way of illustration, therefore, I have chosen to represent a system, using my invention, which is adapted to the needs of power-line operation, with the understanding, however, that my invention is not limited to this particular field of application.

In Fig. 3, therefore, I have shown a three-phase transmission-line section 41 which is connected to a station-bus 42 through a circuit breaker CB having a trip coil TC. Various types of intelligence need to be transmitted from one station to another, during the successful operation of the line 41. Such information can be transmitted through various kinds of communicating channels, such as a radio-frequency carrier-wave which is superimposed upon the power-line 41, pilot wires owned by the power company, telephone or telegraph wires or channels leased by the power company, or directional radio or microwaves which are not guided by the power-line conductors.

I have chosen to illustrate, in Fig. 3, a communicating channel consisting of a carrier wave which is produced by a carrier transmitter 43, and which is coupled, by a transformer 44, to one of the phase-conductors of the power-line 41, through a tuned circuit 46 and coupling capacitors 47. At the same station, there will generally be carrier-receiving apparatus, which may be connected onto a tapped point 48 in the coupling-transformer 44, through a tuned receiver-circuit 49. As the same equipment is, or may be, used at both ends of the protected line-section 41, I have illustrated only one end or line-terminal, with the understanding that the other terminals may be duplicates of the illustrated terminal, except possibly for the tone-frequencies which are used.

In Fig. 3, I have illustrated, by block diagrams, three typical kinds of information which have to be transmitted, at times, from one end of the protected line-section to the other, during the successful operation of the line, and for protecting the line against faults. Thus the block 51 indicates a transfer-tripping control-apparatus, which determines, from information available at the relaying station in question, that a fault exists within the protected line-section 41, and that it is necessary to transfer or transmit this informa-

tion to the remote terminal of the protected line-section, in order to trip the circuit breaker which is located at said remote terminal.

I have also illustrated a fault-responsive carrier-control apparatus 52, in which information which is received, by carrier, from the remote terminal of the protected line-section is compared with information obtainable at the relaying station, for the purpose of determining whether any given fault on the transmission-system is located within the confines of the protected line-section 41.

I have also illustrated a telemetering control-apparatus 53, whereby information concerning the generating conditions and the load-distribution at the relaying station can be transmitted to a load-dispatcher at some other point in the transmission system, or whereby the dispatcher at the relaying station can operate automatic load-control equipment at some remote station.

As various means are known, for these three types of carrier-controlling apparatus, they are indicated only by block-diagram, as being under the control of a set of line-current transformers 54 and potential transformers 55.

Two tones or frequencies are assigned to each carrier-control apparatus, thus making a spectrum of six tones or frequencies which are involved in the transmission of three kinds of intelligence, as in the particular communication-system which is shown in Fig. 3. Thus, the transfer-tripping control-apparatus 51 controls an oscillator O₁₂ which is continuously oscillating to produce either tone 1 or tone 2, or either the frequency f₁ or the frequency f₂, shifting from one tone to the other, under the control of the transfer-tripping control-apparatus 51. The output of this oscillator O₁₂ is shown as being next passed through a limiter or wave-shaper L₁₂, and thence on into the modulator-part 57 of the carrier-current transmitter 43. The carrier-current modulation may be either amplitude-modulation or frequency-modulation. At present, amplitude-modulation is the preferred kind, and I have so indicated, in the diagrammatic representation of the modulator 57.

In like manner, the fault-responsive carrier-control apparatus 52 controls a tone-oscillator O₃₄, which produces either tone 3 or tone 4, having either the frequency f₃ or f₄, according to the control which it receives; and this oscillator O₃₄ is connected to the amplitude-modulator 57 through its own limiter L₃₄. In the same way, the telemetering-control apparatus 53 controls its oscillator O₅₆, producing tone 5 or tone 6, having the frequency f₅ or f₆, transmitting the same, through its limiter L₅₆, to the modulator 57.

The carrier-receiving equipment, in Fig. 3, is illustrated as including, first, a carrier-frequency limiter 59, which is coupled to the tuned receiver-circuit 49, and which limits the amplitude of the carrier-wave which is passed on to the sensitive detector 60, so that the detector will not be damaged by the high-amplitude carrier-wave which is received from the local transmitter 43.

The detector 60 has an output which contains all of the tone-frequencies which are included in the received carrier wave. This detector-output is passed on to three band-pass filters F₁₂, F₃₄ and F₅₆, each of which is designed to pass only the two adjacent tones, in the tone-spectrum, to which its apparatus is intended to be selectively responsive. While I have used the same numbers to designate the tones in the receiving apparatus, as in designating the tones in the corresponding transmitter-controlling ap-

paratus, it is to be understood that the receiving apparatus is designed to respond to certain tones which are transmitted from the other line-terminal, which is not illustrated, while the transmitter-controlling tones are intended to actuate the receiving apparatus at the remote line-terminal. In most cases, a different set of tones is used in the transmitter-controlling apparatus at each station or line-terminal, in order that separate information may be transmitted both ways, without interference. This is not necessarily so, however. At any rate, it should be understood that the tones which are referred to, in describing the receiving apparatus, are the tones which are used in controlling the transmitter at the other end of the protected line-section 41.

The outputs of the three band-pass filters F_{12} , F_{34} and F_{56} are first passed through their respective limiters or amplitude-limited amplifiers L'_{12} , L'_{34} and L'_{56} , which bring up the respective pairs of tones, if they are present in sufficient volume, to a substantially fixed amplitude, regardless of fluctuations in attenuation during the course of transmission.

The constant-amplitude tones which are produced by the respective limiters L'_{12} , L'_{34} and L'_{56} are next passed on to suitable discriminators which have a separate output-circuit for producing direct-current voltages which are selectively varied in response to each of the received tones, respectively. Any sort of discriminator-apparatus or arrangement, which will accomplish such a function, may be used, so far as the workings of the system as a whole are concerned. I have indicated separate discriminators D_1 , D_2 , D_3 , D_4 , D_5 and D_6 , one for each tone, where the subscript designates the number of the tone to which the resonant-frequency f_0 of the discriminator is tuned, but I intend such illustration to be indicative, broadly, of the use of any sort of discriminator-means for distinguishing between the frequencies of the pair of tones which are used in each of the intelligence-transmitting channels.

The limiter L'_{12} is shown as feeding the discriminators D_1 and D_2 , while the limiter L'_{34} feeds the discriminators D_3 and D_4 , and the limiter L'_{56} feeds the discriminators D_5 and D_6 . Thus, each of the six discriminators is impressed with input-currents having either one or both of two tone-frequencies. Each discriminator produces no (significant) voltage in response to an input-tone having the same frequency as its resonant-frequency f_0 . Hence each discriminator produces a (significant) direct-current output-voltage only in response to the other one of the two input-frequencies with which it is supplied. Thus, the discriminator D_1 produces an output-voltage E_2 which is responsive to the received tone 2, while the discriminator D_2 produces an output voltage E_1 which is responsive only to the received tone 1. In like manner, the discriminators D_3 , D_4 , D_5 and D_6 produce the output voltages E_4 , E_3 , E_6 and E_5 , each of which is responsive only to the received tone designated by its subscript.

There are thus produced two discriminator-voltages for each of the types of information which are to be received by the receiving equipment illustrated in Fig. 3. In each case, it is assumed that the corresponding transmitter-controlling apparatus at the remote station is normally continuously producing the lower-numbered of the two tones which are assigned

to the transmission of that particular class of intelligence, and it is assumed that the intelligence is transmitted by shifting the tone from the lower numbered tone to the higher numbered tone, of that pair, and back again, in accordance with the transmitter-controlling apparatus.

In accordance with my present invention, the first, or lower-numbered, tone of each pair is used, in the receiving apparatus, as a signal-blocking, signal-restraining or signal-preventing means, while the other tone of that pair is used as the signal-operating means, the restraint being so strong or so effective that a signalling operation is not obtained if both of the tones should be received or detected simultaneously. It is obvious that various means could be used whereby this sort of receiver-operation could be obtained, whereby an operation is produced only if a second tone is received in the absence of a first tone. It is intended, therefore, that the illustration in Fig. 3 be regarded as a diagrammatic illustration representative of any receiver-means for effecting the broad objectives just explained.

In Fig. 3, the first pair of discriminators D_1 and D_2 are used to control a transfer-tripping relaying-apparatus 61. Thus, the tone 2 discriminator-voltage E_2 is fed into the transfer-tripping relaying-apparatus 61 through the back contact $X1$ of a relay $X1$, the operating coil of which is energized by the discriminator-voltage E_1 which is produced when tone 1 is being transmitted.

The second pair of discriminators D_3 and D_4 are similarly used to control a carrier-controlled relaying-apparatus 62. The discriminator-voltage E_4 , which is responsive to the second tone 4 of that pair, is supplied to said carrier-controlled relaying-apparatus 62, through the back-contact $X3$ of a relay $X3$ which is energized by the discriminator-voltage E_3 which is responsive to the tone 3 of the pair. The carrier-controlled relaying-apparatus 62 is shown as having a second input or control-line 62' which is energized from the output of the local fault-responsive carrier-controlling apparatus 52, so that the carrier-controlled relaying-apparatus 62 can comparatively respond to both local line-conditions and remote-end line-conditions at the other terminal of the protected line-section 41.

The third pair of discriminators D_5 and D_6 , in Fig. 3, are shown, by way of illustration, as controlling a differential type of telemetering receiver-relay TM, which has an operating coil $O6$ which is energized from the discriminator-voltage E_6 in response to the second tone 6 of that pair, and a restraining coil $R5$ which is energized from the discriminator-voltage E_5 which is responsive to the first tone 5 of that pair. It is understood, of course, that the differential type of relaying apparatus, which is shown at TM, could be replaced by the type of control which is used for the relaying equipments 61 and 62, or vice versa.

The transfer-tripping relaying-apparatus 61 and the carrier-controlled relaying-apparatus 62 are both used to control the energization of the trip coil TC of the local line-sectionalizing breaker CB, as shown by the diagrammatically indicated trip-circuit 54. The telemetering relay TM is used to control telemetering apparatus (not shown), which may be conventional.

An important advantage of the shifting-tone intelligence-transmitting equipment, as illustrated in Fig. 3, is that the same number of tones are

always being transmitted by the communication-system, whether that transmission be by way of separate tone-frequencies which are being modulated onto a carrier wave, or whether said transmission be by way of separate independent tone-frequencies or radio-frequencies which are transmitted by themselves, without being superimposed upon a higher-frequency carrier-wave. Each tone, which is used, out of an available sequence or spectrum of tones or frequencies necessarily causes some interference with other tones of the same spectrum or series. This is inevitable, notwithstanding the fact that various precautions are used, such as by way of the limiters or wave-shapers L₁₂, L₃₄ and L₅₆ in the transmission-control. Such interference will tend to cause false tone-transmission, and hence false tone-reception; and that interference may load a receiver until said receiver cannot discriminate between tone and no-tone conditions.

The intelligence-communicating system, shown in Fig. 3, eliminates this tone-interference trouble by leaving each tone-transmitter O₁₂, O₃₄ and O₅₆ connected, and operating, at all times. Each tone-transmitter thus "loads" the other tone-transmitters, or produces side-band tones having the same frequencies as the other tone-transmitters, but this loading now becomes constant, because the tones are always there, and hence such a loading becomes negligible, because the receiving apparatus can be adjusted to discriminate against such constant interference. This system is broadly covered in a copending application of B. E. Lenehan, Serial No. 171,141, filed June 29, 1950.

In the intelligence-communicating system, as used in my present invention, and as shown in Fig. 3, a proper discrimination between tone and no-tone conditions is also achieved through the use of a type of receiving apparatus which responds to one tone, and is restrained or locked out by another tone. This sort of safeguard is particularly advantageous in protecting the apparatus against the sort of interference which comes from transients of various kinds. Generally, a transient which will generate one frequency will generate a wide band of frequencies in that vicinity, thus producing both tones of each pair of tones which are differentially used in my tone-receiving apparatus, the apparatus being so designed that it will not respond, if both tones are received at the same time.

While I have illustrated my invention, and indicated its principles of design, operation and application, with several examples, I wish it to be understood that my invention is susceptible of considerable modification, by way of substituting equivalents, or omitting or adding various parts and refinements, without departing from the essential spirit of the invention. I desire, therefore, that the appended claims shall be accorded the broadest construction consistent with their language.

I claim as my invention:

1. A frequency-shifting communication-system comprising a continuously transmitting transmitter normally transmitting a first frequency, signalling controller-means acting on the transmitter for shifting its frequency to a distinguishably different frequency, signal-receiving means for selectively responding to the shifted frequency of said transmitter, and signal-blocking means selectively responsive to the unshifted frequency of the transmitter for preventing a signal-response.

2. The invention as defined in claim 1, characterized by said signal-receiving means including a discriminator having its resonance-frequency substantially equal to the unshifted frequency of the transmitter, and said signal-blocking means including a discriminator having its resonance-frequency substantially equal to the shifted frequency of the transmitter.

3. A frequency-shifting tone-signal communication-system comprising a continuously transmitting carrier-current transmitter, a shiftable-frequency tone-frequency modulator for continuously superimposing a tone-frequency modulation on the carrier current, said tone-frequency being much lower than the carrier frequency, signalling controller-means acting on the modulator for shifting its frequency to a distinguishably different tone-frequency, and receiving apparatus, including means for receiving said modulated carrier current, signal-responsive means for selectively responding to the shifted tone-frequency of said received modulated carrier current, and signal-blocking means selectively responsive to the unshifted tone-frequency of said received modulated carrier current for preventing a signal-response.

4. The invention as defined in claim 3, characterized by said signal-responsive means including a discriminator having its resonance-frequency substantially equal to the unshifted tone-frequency of the received modulated carrier current, and said signal-blocking means including a discriminator having its resonance-frequency substantially equal to the shifted tone-frequency of the received modulated carrier current.

5. A multi-channel frequency-shifting tone-signal communication-system comprising a continuously transmitting carrier-current transmitter, a plurality of shiftable-frequency tone-frequency modulators, each continuously superimposing a distinctive tone-frequency modulation on the carrier current, said tone-frequencies being much lower than the carrier frequency, a separate signalling controller-means acting upon each modulator for shifting its frequency to a distinguishably different tone-frequency, and receiving apparatus, including means for receiving said modulated carrier current, a plurality of signal-responsive means, each selectively responding to a particular shifted tone-frequency of said received modulated carrier current, and a signal-blocking means associated with each signal-responsive means for preventing a signal response, each signal-blocking means being selectively responsive to the corresponding unshifted tone-frequency.

6. The invention as defined in claim 5, characterized by each signal-responsive means including a discriminator having its resonance-frequency substantially equal to the corresponding unshifted tone-frequency, and each signal-blocking means including a discriminator having its resonance-frequency substantially equal to the shifted tone-frequency to which the associated signal-responsive means is selectively responsive.

7. A frequency-shifting communication-system comprising a continuously transmitting transmitter normally transmitting a first frequency, signalling controller-means acting on the transmitter for shifting its frequency to a distinguishably different frequency, receiver-means for selectively receiving a frequency-band including said shifted and unshifted frequencies as substantial limiting-frequencies of the received band, and signal-receiving means for selectively

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responding to the shifted frequency of said transmitter, said signal-receiving means including a discriminator having its resonance-frequency substantially equal to the unshifted frequency of the transmitter.

8. A frequency-shifting tone-signal communication-system comprising a continuously transmitting carrier-current transmitter, a shiftable-frequency tone-frequency modulator for continuously superimposing a tone-frequency modulation on the carrier current, said tone-frequency being much lower than the carrier frequency, signalling controller-means acting on the modulator for shifting its frequency to a distinguishably different tone-frequency, and receiving apparatus, including means for receiving said modulated carrier current, band-pass means for selectively receiving a frequency-band including said shifted and unshifted tone-frequencies as substantial limiting-frequencies of the received band, and signal-responsive means for selectively responding to the shifted tone-frequency of said received modulated carrier current, said signal-responsive means including a discriminator having its resonance-frequency substantially equal to the unshifted tone-frequency of the received modulated carrier current.

9. A multi-channel frequency-shifting tone-signal communication-system comprising a continuously transmitting carrier-current transmitter, a plurality of shiftable-frequency tone-frequency modulators, each continuously superimposing a distinctive tone-frequency modulation on the carrier current, said tone-frequencies being much lower than the carrier frequency, a

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separate signalling controller-means acting upon each modulator for shifting its frequency to a distinguishably different tone-frequency, and receiving apparatus, including means for receiving said modulated carrier current, a plurality of signal-responsive means, each including a band-pass means for selectively receiving a frequency-band including, as substantial limiting-frequencies of said band, the shifted and unshifted tone-frequencies of one of said modulators, and a plurality of signal-receiving means, each selectively responsive to the shifted tone-frequency of its band, each signal-receiving means including a discriminator having its resonance-frequency substantially equal to the corresponding unshifted tone-frequency.

10. In a relay system, a device to be controlled responsive to an intelligence signal, actuating means associated with said device, means comprising frequency shift apparatus for applying a blocking signal to said actuating means at all times when an intelligence signal is absent and for removing said blocking signal during all times when an intelligence signal is present.

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