Oct. 27, 1942. A. W. HORTON, JR., ET AL 2,299,822

SIGNALING SYSTEM

Filed April 5, 1940 2 Sheets-Sheet 1

FIG. 1

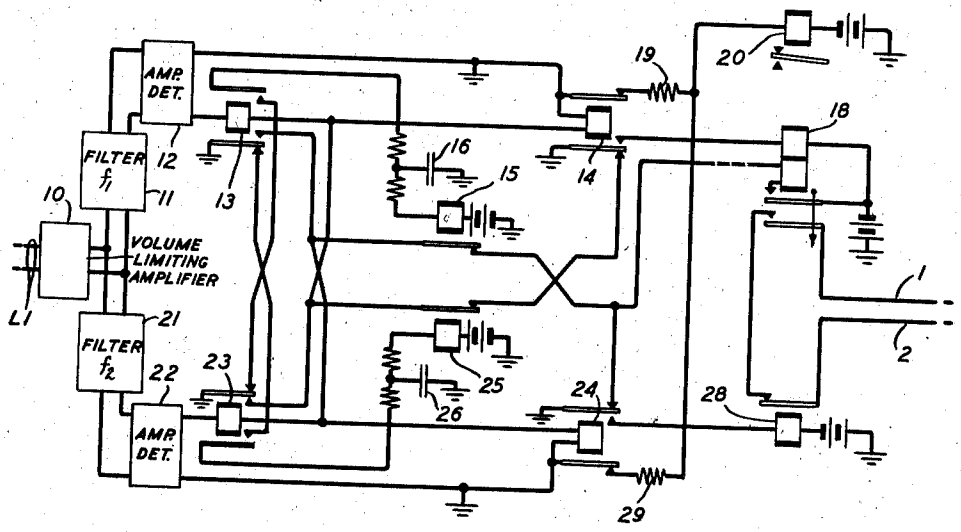
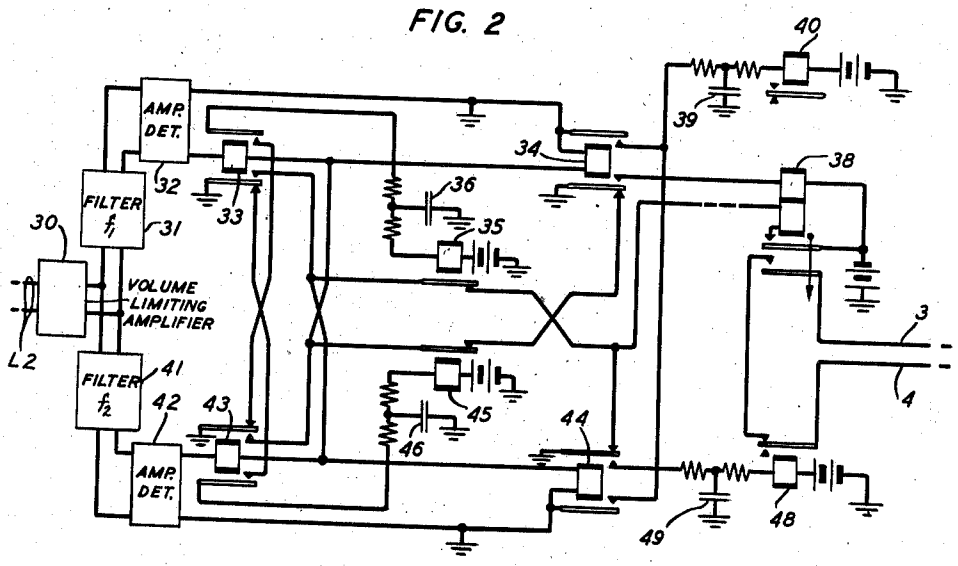


FIG. 2



INVENTORS A. W. HORTON JR.
O. J. MURPHY
H. E. VAUGHAN

BY W. T. McKenney

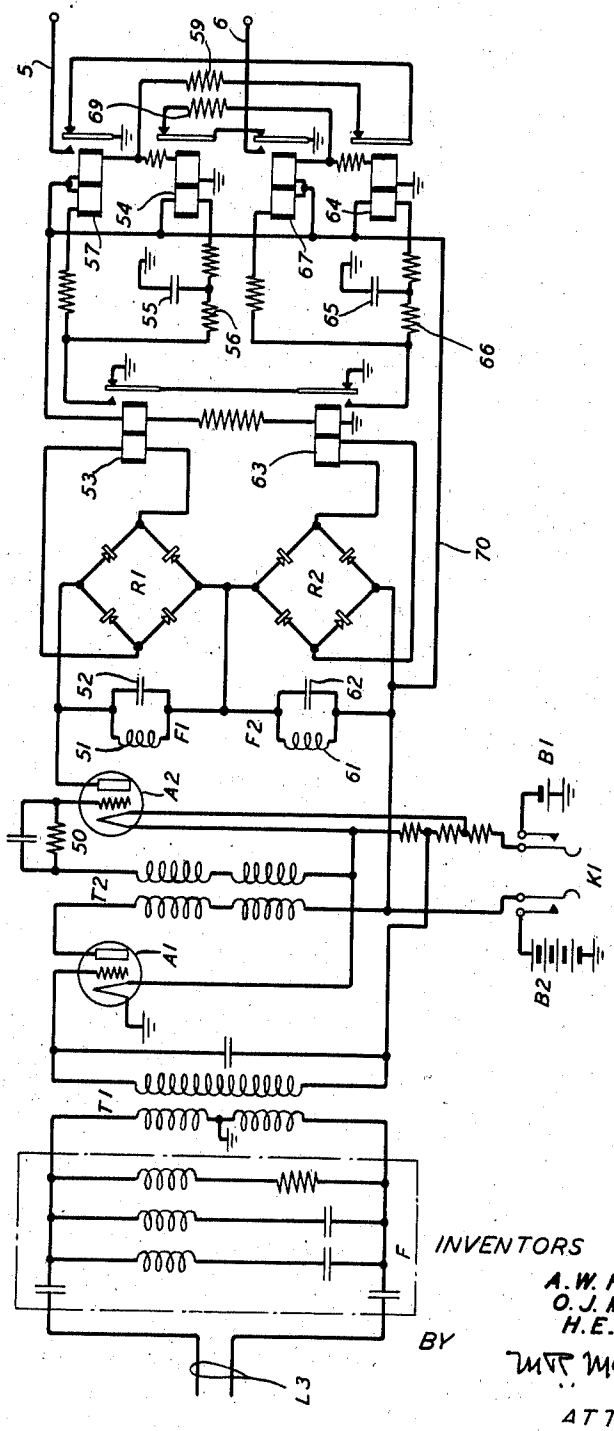
ATTORNEY

Oct. 27, 1942. A. W. HORTON, JR., ET AL 2,299,822

SIGNALING SYSTEM

Filed April 5, 1940 2 Sheets-Sheet 2

FIG. 3



INVENTORS
A. W. HORTON JR.
O. J. MURPHY
H. E. VAUGHAN

BY W. W. McKenney

ATTORNEY

Patented Oct. 27, 1942 2,299,822

UNITED STATES PATENT OFFICE

2,299,822

SIGNALING SYSTEM

Arthur W. Horton, Jr., South Orange, N. J., and Orlando J. Murphy, New York, and Henry E. Vaughan, Valley Stream, N. Y., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application April 5, 1940, Serial No. 327,962

16 Claims. (Cl. 179—84)

This invention relates to signaling systems and particularly to telephone systems employing voice frequency signaling currents.

Objects of the invention are an increase in the adaptability, efficiency and reliability of voice frequency signaling in communication systems. A particular object is a reduction in the probability of false operation of the signaling receiving means in a system in which the signals are transmitted by voice frequency currents and in which the signal receiving means is exposed to voice currents and other interference currents which may include the particular frequencies used for signaling.

According to one feature of the invention, a signal receiver is arranged for responding to signals consisting of current of one or more particular frequencies followed by current of a different frequency or combination of frequencies, false operation of the signal receiver in response to interference currents which include signal frequency components being prevented by limiting the current of all frequencies to a value sufficient for operating a signal relay only when substantially all of the current is of the one or the other of the signaling frequencies or signaling frequency combinations.

Another feature of the invention is a signal receiver of the above-described character in which false operation is further prevented by making the receiver non-responsive to current of the second frequency or frequency combination unless this current follows within a definite interval of time after the current of the first frequency or frequency combination ends.

A further feature is a signal receiver of either of the above-described characters in which false operation is further prevented by an interlocking relay arrangement.

A clear and complete understanding of the invention will be facilitated by considering specific circuit arrangements in which the invention is embodied, three such arrangements being shown schematically in the drawings which form a part of this specification.

Referring to the drawings:

Fig. 1 shows a line L1 and a signal receiver comprising a volume limiting amplifier 10, filters 11 and 21, detectors 12 and 22, signal responsive relays 13, 14, 23 and 24, timing relays 15 and 25, a cut-off relay 20 and signal repeating relays 18 and 28;

Fig. 2 shows a line L2 and a signal receiver comprising a volume limiting amplifier 30, filters 31 and 41, detectors 32 and 42, signal responsive relays 33, 34, 43 and 44, timing relays 35 and 45, a cut-off relay 40 and signal repeating relays 38 and 48; and

Fig. 3 shows a line L3, a filter F, transformer T1, an amplifier A1, a transformer T2, a volume limiting amplifier A2, filters F1 and F2, rectifiers R1 and R2, signal receiving relays 53 and 63, timing relays 54 and 64, and signal repeating relays 57 and 67.

Each of the signal receiving devices shown in Figs. 1, 2 and 3 is particularly adapted to respond to voice frequency signals comprising current of two frequencies in sequence. Signal operation is effected by a current of one of the two signal frequencies followed within a short and predetermined interval of time by current of the other frequency in the line. Due to the use of a volume limiting amplifier, there is no signal operation in response to current comprising more than one of the signal frequencies at a time. The character of the signals and the sequence of the currents of the two frequencies are as follows:

Seizure signal—Current of f_2 followed by current of f_1.

Dial impulses and rering signal—Current of f_1 followed by current of f_2.

Supervisory signal:

Off hook—Current of f_2 followed by current of f_1.

On hook—Current of f_1 followed by current of f_2.

Disconnect signal—Current of f_1 followed by a long application of current of f_2.

Consider first the arrangement shown in Fig. 1, in which all current in line L1, signaling current, voice current, and noise or other interference current, is amplified by the volume limiting amplifier 10 which may be similar to any one of those disclosed in the patent to G. T. Lorance No. 1,654,085, granted December 27, 1927, or to any one of those disclosed in the patent to E. Peterson No. 1,830,240, granted November 3, 1931. The output of the amplifier 10 is limited to a value which is slightly in excess of that required for operating each of the signal receiving relays 13 and 23. The two signal frequencies f_1 and f_2 are within the voice frequency range and may, for instance, be 1100 cycles and 1750 cycles. The output of the amplifier 10 is connected to the input side of two filters 11 and 21, which are designed so that one passes current of one of the two signaling frequencies, and the other passes current of the other of these frequencies. The currents passed by filters 11 and 21 are am-

plified and rectified by amplifier-detectors 12 and 22 which may be of well-known thermionic type.

Assume now that the line L1 is seized at its distant end and that responsive to seizure a source of current of frequency f_2 is connected to the line for an interval long enough to effect the operation of relay 23 and that a source of current of frequency f_1 is connected to the line within a short and predetermined interval after the source of frequency f_2 is disconnected. The current of frequency f_2 is amplified by the volume limiting amplifier 10. There being no other frequencies present, the amplified current of frequency f_2 passes through filter 21, is rectified by detector 22, and effects the operation of relay 23; but relay 24 does not operate because its winding is short-circuited through a back contact of relay 15. Relay 23 closes circuits including a back contact of relay 13 for operating relay 25 and short-circuiting condenser 26. While relay 23 is operated it maintains a short circuit across the winding of relay 14, although the normally closed short circuit is opened by the operation of relay 25. When the current of frequency f_2 ceases, relay 23 releases, opening the operating circuit of relay 25; but relay 25 is held operated for a short and predetermined interval of time by current charging condenser 26. Before relay 25 releases, the current of frequency f_1 in line L1 causes the operation of relays 13 and 14. Relay 13 closes circuits including a back contact of relay 23 for operating relay 15 and short-circuiting condenser 16. Relay 14 opens the circuit through resistor 19 and winding of relay 20 to reduce the current through the winding of normally operated relay 20 to effect its release. It is the function of relay 20 to disconnect from line L1 any other line or trunk to which a connection has been extended while signals are being received over line L1, so that the signals will not be further transmitted over the connected line or trunk. Relay 14 also closes a circuit for operatively energizing the upper winding of relay 18. Relay 18 locks through its lower winding and closes a circuit including the back contact of relay 28 through conductors 1 and 2, this closure constituting response to the seizure signal consisting of a current of frequency f_2 followed within the holding time of relay 25 by current of frequency f_1. The circuit through conductors 1 and 2 may lead to the line relay of a selector switch or to a register, depending on the type of switching control employed.

The signaling current of frequency f_1 may be maintained until dialing begins or may be ended as soon as the operation of relays 13 and 14 has effected the operation of relay 18. If the application of current of frequency f_1 terminates before dialing begins, relays 13 and 14 release. The release of relay 13 opens the circuit for operating relay 15, the release of relay 15 being delayed for a predetermined interval of time while condenser 16 is being charged.

The dial and impulse transmitting apparatus at the distant end of line L1 may be arranged so that the source of current of frequency f_1 is applied to the line when the dial is moved off normal to prepare for the transmission of dial impulses, each opening of the impulse contacts of the dial effecting the disconnection of the source of frequency f_1 and the connection of the source of frequency f_2 to the line L1, and each closure of the impulse contacts effecting the disconnection of the source of frequency f_2 and reconnection of the source of frequency f_1 to the line.

The current of frequency f_1, occurring after the seizure signal is ended, causes the operation of relay 13; but relay 14 does not respond because its winding is short-circuited. Relay 13 closes the circuit for operating relay 15 and maintains a short circuit across the winding of relay 24 after relay 15 operates. When the current of frequency f_1 ends at the beginning of the first dial impulse, relay 13 releases; and after condenser 16 is charged, relay 15 releases. The impulse of current of frequency f_2, which follows the current of frequency f_1 before relay 15 releases, causes the operation of relays 23 and 24. Relay 23 closes the circuit for operating relay 25. Relay 24 closes a circuit for operating relay 28 and opens the circuit through resistor 29 to effect the release of relay 20, the release of relay 20 occurring before relay 28 operates. Relay 28 opens the circuit through conductors 1 and 2, this opening constituting the beginning of the response to the first dial impulse. Relay 24 also opens the locking circuit of relay 18, but relay 18 is slow in releasing and the openings of its locking circuit during the receipt of dial impulses are not long enough to cause the release of relay 18. When the impulse of current of frequency f_2 end, relays 23 and 24 release. The release of relay 24 causes the release of relay 28 and the release of relay 28 ends the opening of the impulse receiving circuit through conductors 1 and 2, thus completing the response to the first dial impulse. The current of frequency f_1, which follows the current of frequency f_2 before relay 25 releases, effects the operation of relay 13 and also the operation of relay 14. The operation of relay 14 opens the circuit through resistor 19 to prevent the reoperation of relay 20 and closes the operating circuit through the upper winding of relay 18. Each succeeding dial impulse, transmitted over line L1, effects an opening of the impulse receiving circuit through conductors 1 and 2 in the same manner. When all of the dial impulses in a train have been received, current of frequency f_1 effects the operation of relays 13, 14 and 15. When the current of frequency f_1 ceases, relays 13, 14 and 15 release and relay 20 reoperates; but relay 18 is held operated by its locking winding.

Additional trains of impulses, if any, transmitted over line L1 to complete a desired connection, are received in like manner. The transmission of a ringing signal, which signal consists of a sequence of currents similar to that transmitted for a single dial impulse, effects an operation of the signal receiver to open and close the circuit through conductors 1 and 2. The release of relay 20, during response to a ringing signal, disconnects a connected outgoing trunk or line.

A disconnect signal consists of current of frequency f_1 followed by current of frequency f_2 for an interval of time long enough to effect the release of relay 13. Relays 13 and 15 are operated and released successively in response to the current of frequency f_1 and relays 23 and 24 are actuated by the current of frequency f_2 received before relay 15 releases. Relay 28 operates to open the circuit through conductors 1 and 2 and the operation of relays 23 and 24 is continued for a long enough interval to effect the release of relay 18 and thus prevent the reclosure of the circuit through conductors 1 and 2 when relay 28 releases. The opening of the circuit

through conductors 1 and 2 effects the release of any partially or completely established connection.

On a call outgoing over line L1, supervisory signals will be received. An answering supervisory, or "off-hook," signal consists of current of frequency f_2 followed by current of frequency f_1, the same as a seizure signal; and the closure of the circuit through conductors 1 and 2 is effected responsive to this sequence of signaling currents in the manner hereinbefore described. If the called subscriber replaces the receiver, an "on-hook" supervisory signal is received over line L1, constituting current of frequency f_1 followed by current of frequency f_2, the same as for a dial impulse, and the opening and reclosure of the circuit through conductors 1 and 2 is effected in response to this signal in the manner hereinbefore described. When the connection is released at the calling end, the locking circuit of relay 18 is opened by means not shown in the drawings to restore the signal receiver to normal.

Consider next the signal receiver shown in Fig. 2 which is arranged so as to respond to dial impulses, each consisting of current of frequency f_1 followed by current of frequency f_2. The volume limiter 30, filters 31 and 41, amplifier-detectors 32 and 42, relays 33, 34, 43, 44 and 38, and condensers 36 and 46 are similar in function and operation to like elements of the signal receiver shown in Fig. 1. The cut-off relay 40, which is similar in function to the cut-off relay 20 of Fig. 1, is a normally released relay which is operated when either of relays 34 or 44 is operated and which remains operated after its operating circuit is opened, for a predetermined interval of time, while condenser 39 is being charged. This interval is long enough to prevent the release of relay 40 during response to a train of dial impulses. The operation of relay 40, in response to an operation of relay 34, is effected just before relay 38 operates. The condenser 49, connected in series with the winding of relay 48, is charged when the operating circuit of relay 48 is opened, thereby holding relay 48 for a predetermined interval of time to prevent distortion in repeating a train of dial impulses.

Upon transmission of the seizure signal, relay 43 responds to the current of frequency f_1, closing the circuit for operating relay 45. At the end of this current, relay 43 releases, opening the circuit through the winding of relay 45. Relay 45 is held operated for a predetermined interval by the current charging condenser 46. The current of frequency f_2, following the current of frequency f_1 before relay 45 releases, effects the operation of both of relays 33 and 34. Relay 33 operates relay 35. Relay 34 operates the cut-off relay 40 and operates relay 38. Relay 38 locks through its lower winding and closes the signal responsive circuit through conductors 3 and 4. Upon transmission of dial impulses, current of frequency f_1 effects the operation of relays 33 and 35; and current of frequency f_2, following the current of frequency f_1 before relay 35 releases, effects the operation of relays 43, 44, 45 and 40. After relay 40 has operated, relay 48 operates, opening the signal responsive circuit through conductors 3 and 4. At the end of the current of frequency f_2, relays 43 and 44 release and, after condenser 46 is charged, relay 45 releases. The release of relay 44 opens the circuit through the winding of relay 48; and, when condenser 49 is charged, relay 48 releases, reclosing the circuit through conductors 3 and 4. The interval during which the release of relay 48 is delayed, by the charging of condenser 49, is equal to the interval during which current of frequency f_1 is transmitted for each dial impulse so that the duration of the opening of the circuit through conductors 3 and 4 is of the same duration as a dial impulse and there is, therefore, no distortion of the dial impulses in the signal receiver.

The signal receiver of Fig. 2 responds to ringing and supervisory signals in similar manner to that in which it responds to seizure and to dial impulses. Response to the disconnect signal is similar to response to a dial impulse except that the prolonged current of frequency f_2 holds relay 44 operated long enough to cause the release of relay 38.

Consider now the signal receiver shown in Fig. 3 of the drawings which includes a filter F which is connected between the line L3 and the input transformer T1. This filter is tuned to pass currents of the incoming signaling frequencies but not to pass current of the frequencies used for transmitting signals outgoing over the line L2, the apparatus for transmitting such outgoing signals not being shown in the drawings. This signal receiver is arranged to respond to signals of current of one of two signaling frequencies followed within a definite interval of time by current of the other signaling frequency. All current in line L1 except that of the frequencies used for outgoing signals is passed through filter F and transformer T1 and is amplified by the triode A1. The output circuit of tube A1 includes the left winding of transformer T2, the voltage induced in the right winding being applied through a high resistance element 50, in parallel with a condenser, to the grid of triode A2. Due to the high resistance of element 50, the current in the output circuit of tube A2 is limited to a value which is not sufficient to effect the operation of relay 53 or relay 63 unless substantially all of this current is of the one or the other of the two signaling frequencies. The coil 51 and condenser 52 constitute a filter which offers substantially infinite impedance to current of signaling frequency f_1, so that current of this frequency in the output of tube A2 is rectified by rectifier R1 to energize the winding of relay 53. The coil 61 and condenser 62 constitute a filter which offers substantially infinite impedance to current of signaling frequency f_2, so that current of this frequency in the output of tube A2 is rectified by rectifier R2 to energize the winding of relay 63.

To condition the signal receiver for operation, key K1 is operated, thereby connecting the filament current source B1 and the plate current source B2 to the tubes A1 and A2. The source B2 is also connected to conductor 70, thereby effecting the energization of the right, biasing windings of each of relays 53, 54, 57, 63, 64 and 67. The bias of relays 53, 54, 63 and 64 is such as to make these relays quickly responsive to current in their operating windings. The bias normally introduced by the energization of the right windings of relays 57 and 67 is sufficient to prevent their operation when relays 53 and 63 operate in response to voice or other interfering currents of frequencies f_1 and f_2 respectively.

Assume, first, transmission of a signal through line L3 consisting of current of frequency f_1 followed by current of frequency f_2. The operation of relay 53 in response to the current of fre-

quency f_1 closes circuits for energizing the left windings of relays **54** and **57**. Relay **54** operates but the energization of the left winding of relay **57** is not sufficient to overcome the biasing winding and, therefore, relay **57** does not operate. Relay **54** opens the circuit through resistor **69**, thereby decreasing the current in the biasing winding of relay **67**. When the current of frequency f_1 ceases, relay **53** releases, opening the circuit for energizing the left windings of relays **54** and **57**. Relay **54** does not release immediately, being held operated for a predetermined interval of time by the current charging condenser **55**. The current of frequency f_2, following the current of frequency f_1 before relay **54** releases, causes the operation of relay **63** and relay **63** closes circuits for energizing the left windings of relays **64** and **67**. Relay **64** operates and, since relay **54** has not released, the energization of the biasing winding of relay **67** is not sufficient to prevent the operation of relay **67** and, therefore, relay **67** also operates. Relay **67** connects ground to conductor **6**, thereby effecting operation of signaling means not shown in the drawings. Relay **67** prevents an increase in the energization of its biasing winding when relay **54** releases. The release of relay **63**, when current of frequency f_2 ends, causes the release of relays **64** and **67**. Relay **64** is held operated, for a predetermined interval of time after relay **63** releases, while condenser **65** is being charged. When relay **67** releases, the signal responsive circuit through conductor **6** is opened.

If a signal is transmitted through line L3 consisting of current of frequency f_2 followed by current of frequency f_1, relay **63** is operated by the current of frequency f_2. Relay **63** closes circuits for energizing the left windings of relays **64** and **67**. Relay **64** operates but relay **67** does not, due to the energization of its biasing winding. Relay **64** opens the circuit through resistor **59**, thereby decreasing the current through the biasing winding of relay **57**. When the current of frequency f_2 ceases, relay **63** releases. Relay **64** remains operated, for a predetermined interval of time after relay **63** releases, while condenser **65** is being charged. The current of frequency f_1, following the current of frequency f_2, now causes the operaiton of relay **53**. Relay **53** closes the circuits for energizing the left windings of relays **54** and **57**; and, since relay **64** has not yet released, both of relays **54** and **57** are operated. Relay **57** connects ground to conductor **5**, thereby effecting operation of signaling means not shown in the drawings. Relay **57** prevents an increase of the energization of its biasing winding when relay **64** releases. The release of relay **53**, when current of frequency f_1 ends, causes the release of relay **54** and **57**, relay **54** remaining operated until condenser **55** is charged.

In each of the arrangements shown in Figs. 1, 2 and 3 the operation of only one of the two signal responsive relays, **13** and **23**, **33** and **43**, and **53** and **63**, is possible at a time because the current output of the volume limiting amplifier is insufficient to effect the operation of any one of these signal relays unless substantially all of the output consists of one only of the two signaling frequencies. Thus the output volume may exceed the minimum operating value by only 3 or 4 decibels. The closer this limiting volume approaches the minimum operating value, the less chance there is of false operation by voice or interference currents. Furthermore, a signal response cannot be effected unless the current of the second frequency follows the current of the first frequency within a short and predetermined interval of time, which interval is measured by the charging of a condenser in each of the arrangements shown although any other known method of timing this interval may be employed.

What is claimed is:

1. In a telephone system, a line, a signal receiver connected to said line for responding to signals each of which consists of a current of a first predetermined frequency characteristic in said line followed by a current of a second predetermined frequency characteristic, said receiver comprising two relays, one for operation in response to that part of a signal which consists of current of said first characteristic, the other for operation in response to that part of a signal which consists of current of said second characteristic, a filter for selectively passing from said line to said one of said relays current of said first characteristic, a filter for selectively passing from said line to said other relay current of said second characteristic, and means for limiting the total current input to said relays to a value sufficient for operating only one of said relays at a time.

2. In a telephone system, a line, a signal receiver connected to said line for responding to signals consisting of current of a first predetermined frequency characteristic in said line followed by current of a second predetermined frequency characteristic, said receiver comprising relays for operation by said signaling currents, filters for selectively passing to each of said relays current of a different one of said frequency characteristics, one of said relays connected for operation in response to that part of a signal which consists of current of said first characteristic and another of said relays connected for operation in response to that part of a signal which consists of current of said second characteristic, and means for limiting the input to said filters to a value sufficient for effecting the operation of a relay only if substantially all of said input is of the frequency characteristic passed to said relay.

3. In a telephone system, a line, a signal receiver connected to said line for responding to signals consisting of current of a first predetermined frequency characteristic in said line followed by current of a second predetermined frequency characteristic, and for responding to signals consisting of current of said second frequency characteristic followed by current of said first frequency characteristic, said receiver comprising relays for operation by said signaling currents and filters for selectively passing to each of said relays current of a different one of said frequency characteristics, one of said relays connected for operation in response to that part of a signal which consists of current of said first characteristic and another of said relays connected for operation in response to that part of a signal which consists of current of said second characteristic, and means for limiting the input to said filters to a value sufficient for effecting the operation of a relay only if substantially all of said input is of the frequency characteristic passed to said relay.

4. A signal device adapted to respond to signals consisting of current of a first voice frequency characteristic followed, within a predetermined interval of time after this current ends, by current of a second voice frequency characteristic, said device comprising two signal receiving relays, one for operation responsive to

current of said first characteristic and the other for operation responsive to current of said second characteristic, filters for selectively passing from said line to each of said relays current of a different one of said characteristics, means for limiting the total input to said filters to an amount sufficient for operating only one of said relays at a time, a signal circuit, and auxiliary relays controlling said circuit, one of said auxiliary relays being operative in response to the operation of one of said receiving relays followed within a predetermined interval of time after the release of said one of the receiving relays by the operation of the other of said receiving relays, the other of said auxiliary relays being operative in response to the operation of said other of the receiving relays followed within a predetermined interval of time after the release of said other receiving relay by the operation of said one of the receiving relays.

5. In a signaling system, a line, a signal receiver connected to said line for responding to signals each of which consists of a current in said line of a first predetermined frequency characteristic followed within a predetermined interval of time by a current of a second predetermined frequency characteristic, said receiver comprising a volume limiting amplifier the input side of which is connected to said line, two tuned circuits connected in series in the output circuit of said amplifier, one of said tuned circuits constituting a high impedance to signaling current of said first characteristic, the other of said tuned circuits constituting a high impedance to signaling current of said second characteristic, a first relay, a second relay, a rectifier connecting said first relay to said first tuned circuits for operation in response to that part of a signal which consists of current of said first characteristic and a rectifier connecting said second relay to said second tuned circuit for operation in response to that part of a signal which consists of current of said second characteristic, the output of said amplifier being only sufficient to effect the operation of one of said relays at a time.

6. A signal receiver for response to signals consisting of current of a first frequency characteristic followed within a definite interval of time by current of a second frequency characteristic, said receiver comprising relays for operation by said signaling currents, filters for passing to each of said relays current of a different one of said characteristics, a first relay means, said first means responsive to the operation of one of said relays by current of the first characteristic, a second relay means, said second means responsive to the operation of the other of said relays by current of said second characteristic, means including said first relay means for preventing the operation of said second relay means unless the operation of said other relay occurs within a predetermined interval of time after the release of said one relay, and means for limiting the input to said filters to a value sufficient for effecting the operation of one of said relays only if substantially all of the input is of the one or the other of said characteristics.

7. In a signal receiver, according to claim 6, means comprising a condenser fixing said predetermined interval of time.

8. In a telephone system, a line, a signal receiver connected to said line, said receiver arranged for response to signals consisting of current of a first frequency characteristic followed within a definite interval of time by current of a second frequency characteristic, said receiver comprising signal relays for operation by said signaling currents, filters for passing to each of said relays current of a different one of said characteristics, means comprising an amplifier for amplifying all current in said line, the output of said amplifier being limited to prevent the operation of any of said signal relays unless substantially all of the current in said line is of the one or the other of said characteristics, auxiliary relays, a first auxiliary relay operatively responsive to the operation of one of said signal relays, a second auxiliary relay operatively responsive to the operation of the other of said signal relays, means for holding operated said first auxiliary relay for a predetermined interval of time after said one of the signal relay releases, and relay means responsive to signaling current of said other characteristic only if it occurs before said first auxiliary relay releases.

9. In a telephone system, a line, a signal receiver connected to said line, said receiver arranged for response to signals consisting of current of a first frequency characteristic followed within a definite interval of time by current of a second frequency characteristic, and to signals consisting of a current of said second frequency characteristic followed within a definite interval of time by current of said first frequency characteristic, said receiver comprising signal relays for operation by said signaling currents, filters for passing to each of said relays current of a different one of said characteristics, means comprising an amplifier for amplifying all current in said line, the output of said amplifier being limited to prevent the operation of any of said signal relays unless substantially all of the current in said line is of the one or the other of said characteristics, auxiliary relays, a first auxiliary relay operatively responsive to the operation of a first one of said signal relays, a second auxiliary relay operatively responsive to the operation of a second one of said signal relays, means for holding operated said first auxiliary relay for a predetermined interval of time after said first signal relay releases, a third one of said signal relays responsive to signaling current of said other characteristic only if it occurs before said first auxiliary relay releases, means for holding operated said second auxiliary relay for a predetermined interval of time after said second signal relay releases, and a fourth one of said signal relays responsive to signaling current of said one characteristic only if it occurs before said second auxiliary relay releases.

10. In a telephone system, a line, a signal receiver arranged to respond to signals consisting of current of a first frequency characteristic in said line followed within a definite interval of time by current of a second frequency characteristic, and to respond to signals consisting of current of said second frequency characteristic followed within a definite interval of time by current of said first frequency characteristic, signal relays for operation by said signaling currents, filters for passing to each of said relays current of a different one of said characteristics, means comprising an amplifier for amplifying all current in said line, the output of said amplifier being limited to prevent the operation of any of said signal relays unless substantially all of the current in said line is of the one or the other of said characteristics, auxiliary relays, a first auxiliary relay operatively responsive to the operation of a first one of said signal relays, a second

auxiliary relay operatively responsive to the operation of a second one of said signal relays, means for holding operated said first auxiliary relay for a predetermined interval of time after said first signal relay releases, means for holding operated said second auxiliary relay for a predetermined interval of time after said second signal relay releases, means comprising said second auxiliary relay for rendering a third one of said signal relays responsive to current of said first frequency characteristic, means comprising said first auxiliary relay for rendering a fourth one of said signal relays responsive to current of said second frequency characteristic, a signal circuit, means responsive to the operation of said third signal relay for closing said signal circuit, and means responsive to the operation of said fourth signal relay for opening said signal circuit.

11. In a telephone system, a line, signal relays, a first filter and detector for passing to the operating winding of a first one of said relays current of a first frequency characteristic, a second filter and detector for passing to the operating winding of a second one of said relays current of a second frequency characteristic, means for amplifying all current in said line, the output of said amplifying means being connected to said filters, means for limiting said output to a value sufficient for operating a signal relay only if substantially all of the current in said line is of the first frequency characteristic or if substantially all of the current in said line is of the second frequency characteristic, auxiliary relays each having an operating winding and a biasing winding, a first auxiliary relay operatively responsive to the operation of said first signal relay, a second auxiliary relay operatively responsive to the operation of said second signal relay, a third auxiliary relay normally biased to prevent its operation responsive to the operation of said first signal relay, a fourth auxiliary relay normally biased to prevent its operation responsive to the operation of said second signal relay, means for holding said first auxiliary relay operated for a predetermined interval of time after said first signal relay releases, means for holding said second auxiliary relay operated for a predetermined interval of time after said second signal relay releases, the operation of said first auxiliary relay being effective to reduce the bias of said fourth auxiliary relay to render it responsive to the operation of said second signal relay, the operation of said second auxiliary relay being effective to reduce the bias of said third auxiliary relay to render it responsive to the operation of said first signal relay, and signal circuits controlled by said third and fourth auxiliary relays.

12. In a signal device according to claim 6, a control relay responsive to the operation of said second relay means.

13. In a telephone system and signal receiver according to claim 9, a control relay responsive to the operation of each of said third and fourth signal relays.

14. In a telephone system according to claim 10, a control relay responsive to the operation of each of said third and fourth signal relays.

15. In a telephone system and signal receiver according to claim 9, a control relay, a circuit closed by the operation of said third signal relay for operating said control relay, and a circuit closed by the operation of said fourth signal relay for operating said control relay.

16. In a telephone system according to claim 10, a control relay, the energization of the winding of said control relay being controlled by a contact of said third signal relay and by a contact of said fourth signal relay, said contacts of said third and fourth signal relays being connected in parallel.

ARTHUR W. HORTON, JR.
ORLANDO J. MURPHY.
HENRY E. VAUGHAN.