Oct. 27, 1942. A. W. HORTON, JR 2,299,821

SIGNALING SYSTEM

Filed April 5, 1940

FIG. 1

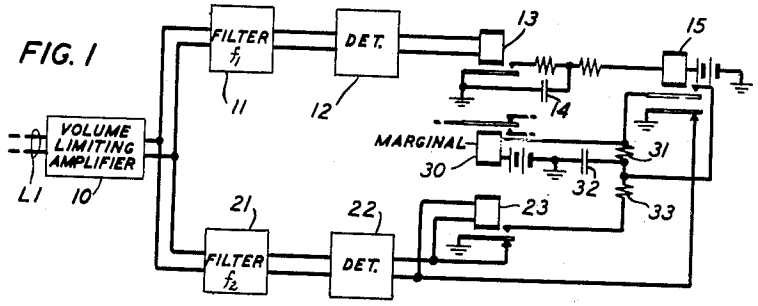


FIG. 2

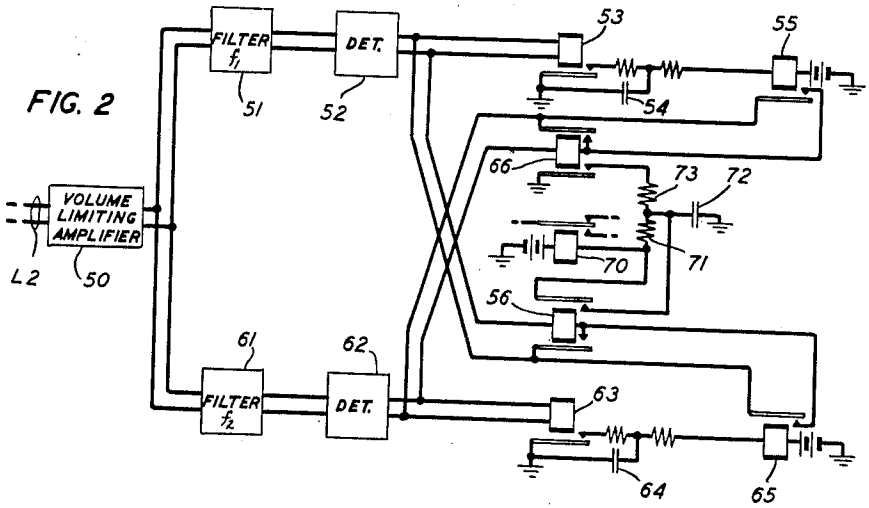
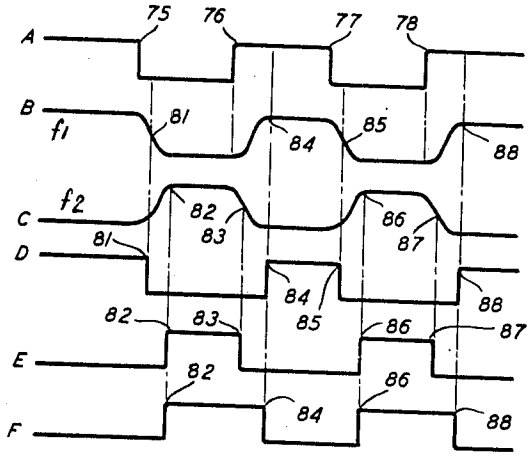


FIG. 3



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SIGNALING SYSTEM

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11 Claims. (Cl. 179—84)

This invention relates to signaling systems and particularly to telephone systems in which voice frequency currents are used for signaling.

Objects of the invention are an increase in the efficiency and reliability of voice frequency signaling systems and a reduction in the probability of false operation of the signal receiving means in such systems in response to voice currents or to other, disturbing currents of the same frequencies as are used for signaling.

This invention is a voice frequency signal receiver responsive to signals, each of which consists of current of one of two signaling frequency characteristics for a short interval of time followed by current of the other frequency characteristic, the receiver being arranged to prevent distortion of the time characteristic of a signal or successive signals. According to a feature of the invention, distortion is prevented by designing the filters, which are provided for selectively passing current of each of the two signaling frequency characteristics, to have the same current delay characteristics.

A further feature of the invention is a signal receiver of the above-described character in which the operation of a first signaling relay in response to current of one of two voice frequency characteristics constitutes the beginning of a signal and the operation of a second signaling relay in response to current of the other frequency characteristic constitutes the end of the signal, the filters through which current of the two frequency characteristics is selectively directed to each of two relays being designed to have substantially the same current delay characteristics.

Another feature of the invention is a signal receiver of the above-described character in which selective filters have the same current-time characteristics and in which volume limiting means is provided for limiting the total input to the signal responsive relays to a value which is insufficient to operate either of the relays unless substantially all of the current is of the one or the other of the two signaling frequency characteristics.

A clear and complete understanding of the invention will be facilitated by considering specific circuit arrangements in which the invention is embodied, two such arrangements being shown schmatically in the drawing which forms a part of this specification. The invention is not limited in its application to the particular system and arrangement shown in the drawing but is applicable to any voice frequency signaling system in which signals consist of currents of two frequencies in sequence.

Referring to the drawing:

Fig. 1 shows in schematic form a line L1, and signal receiving means comprising a volume limiting amplifier 10, filters 11 and 21, detectors 12 and 22, and relays 13, 15, 23 and 30;

Fig. 2 shows a line L2 and signal receiving means comprising a volume limiting amplifier 50, filters 51 and 61, detectors 52 and 62, and relays 53, 55, 56, 63, 65, 66 and 70; and

Fig. 3 shows a set of curves A, B, C, D, E and F illustrating the time-amplitude character of the signaling currents, the effect of the selective filters, the separate response to each frequency, and the combined response to both frequencies.

Each of the signal receiving devices shown in Figs. 1 and 2 is particularly adapted to respond to dial impulses incoming over the line to which it is connected. The dial and other signal transmitting apparatus at the distant end of the line is not shown but may be so arranged that a source of current of one of two signaling frequencies is connected to the line upon movement of the dial out of normal position and so that this source is disconnected and a source of the other of the two signaling frequencies is connected to line in response to each opening of the impulse contacts of the dial.

The current in the lines L1 and L2, signaling current, voice current and noise or other interference current, is amplified by a volume limiting amplifier, 10 or 50, which may be similar to those disclosed in the patent to G. T. Lorance, No. 1,654,085, granted December 27, 1927, or to 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; and the output of the amplifier 50 is limited to a value which is slightly in excess of that required for operating each of the signal receiving relays 53 and 63.

The output circuit of the amplifier 10 is connected to the input side of two filters 11 and 21 and the output circuit of the amplifier 50 is connected to the input circuit of two filters 51 and 61. Each of the filters 11 and 51 is designed to pass currents of one of the two frequencies used for transmitting dial impulses and each of the filters 21 and 61 is designed to pass currents of the other of the two frequencies used for transmitting dial impulses. Each of the filters 11 and 21 is designed to pass a narrow and equal band

of frequencies and to have substantially the same current build-up and decay characteristics, the build-up time being substantially equal to the decay time. Thus the delay introduced by the filter 11 in building up the current of one of the signaling frequencies to the level required for effecting a signal response is the same as the delay introduced by the filler 21 in building up the current of the other of the signaling frequencies to the level required for effecting a signal response. The filters 51 and 61 are also designed to pass a narrow and equal band of frequencies and to have the same build-up and decay characteristics. The filters 11, 21, 51 and 61 may be similar in design to the filter shown in Fig. 3, page 10 of an article entitled "Transient oscillations in electric wave-filters" by John R. Carson and Otto J. Zobel, published in the Bell System Technical Journal, July 1923. The manner of designing such filters so as to have desired build-up and decay time characteristics is described beginning on page 17 of this article, the formula for determining the delay time of a band-pass filter being given at the top of page 20.

The detectors 12 and 22 of Fig. 1 and 52 and 62 of Fig. 2 which connect the filters 11 and 21 and 51 and 61 to the signal relays 13 and 23 and 53 and 63 may be of any well-known type, for instance, thermionic or copper-oxide detectors.

Assume now that the line L1 is siezed at its distant end and that a source of current of frequency f_1, for instance 1100 cycles, is connected to line L1 preparatory to the transmission of dial impulses. The resulting current of frequency f_1 in line L1 is amplified in the volume limiting amplifier 10. The amplified current is passed through filter 11, is rectified by detector 12; and, there being no current of other frequencies in line L1 at that time, the amplified current is of sufficient amplitude to effect the operation of relay 13. Relay 13 closes a circuit for operating relay 15. Relay 15 opens the normally closed short circuit across the winding of relay 23 to enable the operation of relay 23 in response to current of frequency f_2 when the first dial impulse is transmitted. The transmission of each impulse of a train of dial impulses is effected by disconnection of the source of current of frequency f_1 from line L1 and the connection of a source of current of frequency f_2, for instance 1750 cycles, to line L1 followed by the disconnection of the source of current of frequency f_2 and reconnection of the source of current of frequency f_1 to the line L1. When the source of current of frequency f_1 is disconnected from line L1 to begin the transmission of a dial impulse, the current of frequency f_1 passing through filter 11 drops below the level required for holding relay 13 operated; and relay 13 releases. When relay 13 releases, condenser 14 is charged in series with the winding of relay 15 so that relay 15 remains operated for a predetermined and desired interval of time during which resistor 31 is short-circuited. The source of current of frequency f_2 having been connected to line L1, current of this frequency begins to build up in the filter 21, is rectified by detector 22 and, when it reaches the required amplitude, causes the operation of relay 23. Since the transmission of current of frequency f_2 as part of a dial impulse causes the operation of relay 23 within the aforementioned predetermined interval during which relay 15 is held operated, the operation of relay 23 causes the operation of relay 30. In operating, relay 23 prevents closure of the short circuit across its winding when relay 15 releases, so that relay 23 remains operated as long as the current of frequency f_2 is being received over line L1. At the end of the impulse the decay of current of frequency f_2 causes the release of relay 23; and the build-up of current of frequency f_1 causes the reoperation of relays 13 and 15. The release of relay 23 opens the operating circuit of relay 30, but relay 30 is held operated for a desired and predetermined interval of time while condenser 32 is being charged in series with the winding of relay 30 and resistor 31. When relay 15 reoperates, resistor 31 is short-circuited, thereby effecting the immediate completion of the charging of condenser 32 to cause the release of relay 30. Each succeeding dial impulse transmitted over line L1 effects a like cycle of operations, relay 30 being operated at the beginning of each impulse responsive to the build-up of current of frequency f_2, and being released at the end of each impulse responsive to the build-up of current of frequency f_1. Each operation and release of relay 30 actuates its armature and contacts to control an impulse register or a selector circuit, as the case may be.

If speech currents or other interfering tones effect the operation of relays 13 and 15, a current of frequency f_2 will not follow the current of frequency f_1 before relay 15 releases, as is the case if dial impulses are being transmitted; therefore relay 23 cannot be operated and relay 30 will not be falsely operated. If the current in line L1 includes both signaling frequencies at the same time or includes the frequency f_1 and also other noise or speech frequencies in any considerable amount, the false operation of relay 13 is prevented because a part of the current in the output of the volume limiting amplifier 10 will be of frequencies other than the frequency f_1 and the current of frequency f_1 passed through filter 11 will not be sufficient to cause the operation of this relay. If, after relays 13 and 15 have been operated, current of frequency f_2 is transmitted over line L1 together with a considerable volume of noise or other speech frequencies, the part of the current in the output of amplifier 10 which is of the frequency f_2 will be insufficient to effect the operation of relay 23.

Referring now to the arrangement shown in Fig. 2, the application of current of frequency f_1 to the line L1 preparatory to the transmission of dial impulses effects the operation of relay 53. Relay 53 closes a circuit for operating relay 55. When relay 53 releases at the beginning of the first dial impulse, relay 55 is held operated for a desired and predetermined interval of time by the current which charges condenser 54. The build-up of current of frequency f_2 to the effective level, before relay 55 releases, causes the operation of relays 63 and 66. Relay 63 closes a circuit for operating relay 65. Relay 66 closes a circuit through resistors 71 and 73 for operating relay 70; and closes a circuit for holding itself operated after relay 56 releases, until the end of the impulse; at which time the decay of the current of frequency f_2 causes the release of relays 63 and 66. The release of relay 66 opens the operating circuit of relay 70 but relay 70 is held operated by current charging condenser 72. Relay 65 is held operated for a desired and predetermined interval of time, after relay 63 releases, by the current which charges condenser 64. The build-up of current of frequency f_1 at the end of the first dial impulse and before relay 65 releases, effects the reoperation of relay 53 and the operation of relay 56. Relay 53 again closes the

circuit for operating relay **55** and relay **56** closes a circuit for holding itself operated after relay **65** releases as long as current of frequency f_1 is being transmitted. The operation of relay **56** short-circuits resistor **71** to effect an immediate completion of the charging of condenser **72** and the immediate release of relay **70**. Thus relay **70** is operated due to the operation of relay **66** by current of frequency f_2 at the beginning of each dial impulse and is released due to the operation of relay **56** by current of frequency f_1 at the end of each dial impulse. The decay of current of frequency f_2 at the end of the last impulse of a train effects the release of relays **63** and **66** and the relays **65** and **70** both release after condensers **64** and **72** have been charged, the reoperation of relays **53** and **56** not being needed to effect release of relay **70** after the last impulse. The volume limiting amplifier **50** prevents the operation of relay **53** alone, or the operation of both of relays **53** and **56**, by current of frequency f_1 in case the current in line L2 includes a substantial volume of other frequencies and also prevents the operation of relay **63** alone, or the operation of both of relays **63** and **66**, by current of frequency f_2 if the current in line L2 includes a substantial volume of other frequencies.

Referring now to Fig. 3, the line A represents the spacing of dial impulses, the interval **75—76** representing the first impulse of a train and the interval **77—78** representing the second impulse of a train. The curve B represents current of frequency f_1 transmitted preceding the first impulse of a train, between impulses of a train, and also after the last impulse of a train if so desired. At points **81** and **85** the current of frequency f_1 has dropped to a value insufficient to hold the signal relay, such as **13**, operated and at points **84** and **88** the current of this frequency has built up to the level required for operating the signal relay. The curve C represents current of frequency f_2 transmitted during each impulse interval. At points **82** and **86** the current of frequency f_2 reaches the level required for operating the signal relay, such as **23**, and at points **83** and **87** the current of this frequency has dropped to a value insufficient to hold the signal relay operated. The line D represents the dial impulses as indicated by the interval during which relay **13** is released and the line E represents the dial impulses as indicated by the interval during which relay **23** is operated. The line F represents the dial impulses as indicated by the operations of relay **30** and it is apparent that these operations produce circuit closures of the same duration and frequency as the originating dial impulses. While there is a delay in the response of relay **30** to the dial impulses, the delay being dependent upon the margin by which the current for operating relays **13** and **23** exceeds that which is barely sufficient to effect operation, there is no distortion of the impulse train. In these curves it is assumed that the envelopes of the build-up and decay of the currents in the selective filters is the same and that the incoming signaling currents of the two frequencies are of the same amplitude.

Although in each of the above-described arrangements a sequence of currents of frequencies f_1, f_2, f_1 is required for transmission of each impulse without distortion, the application of current of frequency f_1 after the last impulse is not required if distortion of the last impulse is not objectionable.

Although the signal receivers in Figs. 1 and 2 are arranged so that operation of a relay in response to current of one signaling frequency characteristic is recognized as the beginning of a signal and operation of a second relay in response to current of another signaling frequency characteristic is recognized as the end of a signal if the operation of the second relay occurs within a predetermined interval after the first relay releases, the invention is also applicable to an arrangement in which the release of a relay at the end of current of one frequency characteristic is recognized as the beginning of a signal and the release of a second relay at the end of current of another frequency characteristic is recognized as the end of a signal if the operation of the second relay occurs within a predetermined time after the release of the first relay. It is further to be noted that current of each of the two signaling frequency characteristics may consist of a single frequency or of a particular combination of frequencies. The filters for selectively passing current of the two signaling frequency characteristics are tuned circuits which if connected in parallel with the input circuit of the associated detector constitute a very high impedance to current of the signaling characteristic and which if connected in series with the input circuit of the associated detector constitute a very high impedance to all currents except those of the signaling characteristic.

What is claimed is:

1. A signal receiver to respond to a signal consisting of current of a first frequency characteristic followed within a short and predetermined interval of time after this current ends by a current of a second frequency characteristic, said receiver comprising selective filters, one filter tuned to pass current of only said first frequency characteristic, the other filter tuned to pass current of only said second frequency characteristic, said filters having similar current build-up time characteristics so as not to distort the time characteristic of the signal response.

2. In a telephone system, a line, a signal receiver connected to said line and adapted to respond to signals consisting of a current of one of two particular frequencies in said line followed by a current of the other frequency, said receiver comprising two relays, one for operation in response to current of one of said frequencies and the other for operation in response to current of the other frequency, a filter for passing from said line to one of said relays current of only said one frequency, a filter for passing from said line to the other of said relays current of only said other frequency, said filters having the same current build-up time characteristics, and signal means actuated only in response to the operation of said one relay followed immediately by the operation of said other relay.

3. In a telephone system, a line, a signal receiver connected to said line and adapted to respond to signals consisting of a current of one of two particular frequencies in said line followed by a current of the other frequency, said receiver comprising two relays, one for operation in response to current of one of said frequencies and the other for operation in response to current of the other frequency, filters for selectively passing from said line to one of said relays current of only one of said frequencies and to the other of said relays current of only the other of said frequencies, said filters having the same current time characteristics, means controlled by said relays for repeating a train of signals incoming over said line, and means com-

prising said filters for preventing distortion of the repeated signals.

4. In a signal receiver according to claim 1, a relay connected to the output side of said one filter for operation when the output current builds up to the operating value, and a relay connected to the output side of said other filter for operation when the output current builds up to the operating value.

5. In a signal receiver according to claim 1, a relay connected to the output side of said one filter for operation when the output current builds up to the operating value, and a relay connected to the output side of said other filter for operation when the output current builds up to the operating value, and means for limiting the total input to both of said filters to a value which is only sufficient to operate the one or the other of these relays if said current input is substantially all of the first or substantially all of the second or the two signaling frequency characteristics.

6. In a signal receiver according to claim 1, a relay connected to the output side of said one filter for operation when the output current builds up to the operating value, a relay connected to the output side of said other filter for operation when the output current builds up to the operating value, a third relay, and means for operating said third relay upon operation of said one relay and for releasing said third relay upon operation of said second relay.

7. In a signal receiver according to claim 1, a relay connected to the output side of said one filter for operation when the output current builds up to the operating value, a relay connected to the output side of said other filter for operation when the output current builds up to the operating value, a third relay, means for operating said third relay upon operation of said one relay and for releasing said third relay upon operation of said second relay, and means for limiting the total input to both of said filters to a value which is only sufficient for operating the one or the other of said relays if said input is substantially all of said first or substantially all of said second frequency characteristic.

8. In a telephone system, a line, a signal receiver comprising two relays, a first filter and detector connecting said line to a first one of said relays, a second filter and detector connecting said line to the second of said relays, said first filter tuned to pass current of only a first frequency characteristic, said second filter tuned to pass current of only a second frequency characteristic, said first filter having the same delay effect with respect to current of said first frequency characteristic as said second filter with respect to current of said second frequency characteristic, a first relay means responsive to the operation of said first relay, a second relay means responsive to the operation of said second relay, and a signal relay operated in response to the operation of said second relay means only if the operation of said second relay means occurs within a predetermined interval of time following the release of said first relay.

9. In a signaling system, a line, an amplifier, said line being connected to the input of said amplifier, a first filter, a second filter, said first filter tuned to pass current of a first frequency, said second filter tuned to pass current of a second frequency, the input of each of said filters being connected to the output of said amplifier, a first relay, a detector connecting said first relay to said first filter, a second relay, a detector connecting said second relay to said second filter, means for limiting the output of said amplifier to prevent the operation of both of said relays at the same time, and signal means for operation responsive to signals consisting of an impulse of current of said first frequency followed by an impulse of current of said second frequency, the operation of said first relay being delayed by the build-up of current in said first filter for an interval which is substantially equal to the time that the operation of said second relay is delayed by the build-up of current in said second filter.

10. In a telephone system, a line, a volume limiting amplifier, the input side of said amplifier connected to said line, two relays, a first filter and detector connecting the output of said amplifier to the winding of a first one of said relays, a second filter and detector connecting the output of said amplifier to the winding of the second one of said relays, said first filter tuned to pass current of only a first frequency characteristic, said second filter tuned to pass current of only a second frequency characteristic, said filters having the same current build-up characteristics, a first relay means, said first means responsive to the operation of said first relay, a second relay means, said second means responsive to the operation of said second relay, and means including said first relay means for preventing the operation of said second relay means unless the operation of said second relay occurs within a predetermined interval of time after the release of said first relay.

11. A signal receiver for responding to signals each consisting of the termination of a current of a first frequency characteristic followed within a predetermined interval of time by current of a second frequency characteristic, and the termination of the current of said second characteristic followed within a predetermined interval of time by current of said first characteristic, said receiver comprising a first relay, a tuned circuit for passing to said first relay only current of a first frequency characteristic, a second relay, a tuned circuit for passing to said second relay only current of a second frequency characteristic, means responsive to the operation of said first relay for rendering said second relay operable, a signal relay, a circuit closed by the operation of said second relay for operating said signal relay, means for holding said signal relay operated for an interval of time after said second relay releases, and a circuit closed by the reoperation of said first relay for causing the immediate release of said signal relay, said tuned circuits having like time-current characteristics to prevent distortion of the signal response.

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