May 17, 1932. B. G. BJÖRNSON 1,859,019

VOICE OPERATED RELAY CIRCUITS

Filed Sept. 12, 1930 3 Sheets-Sheet 1

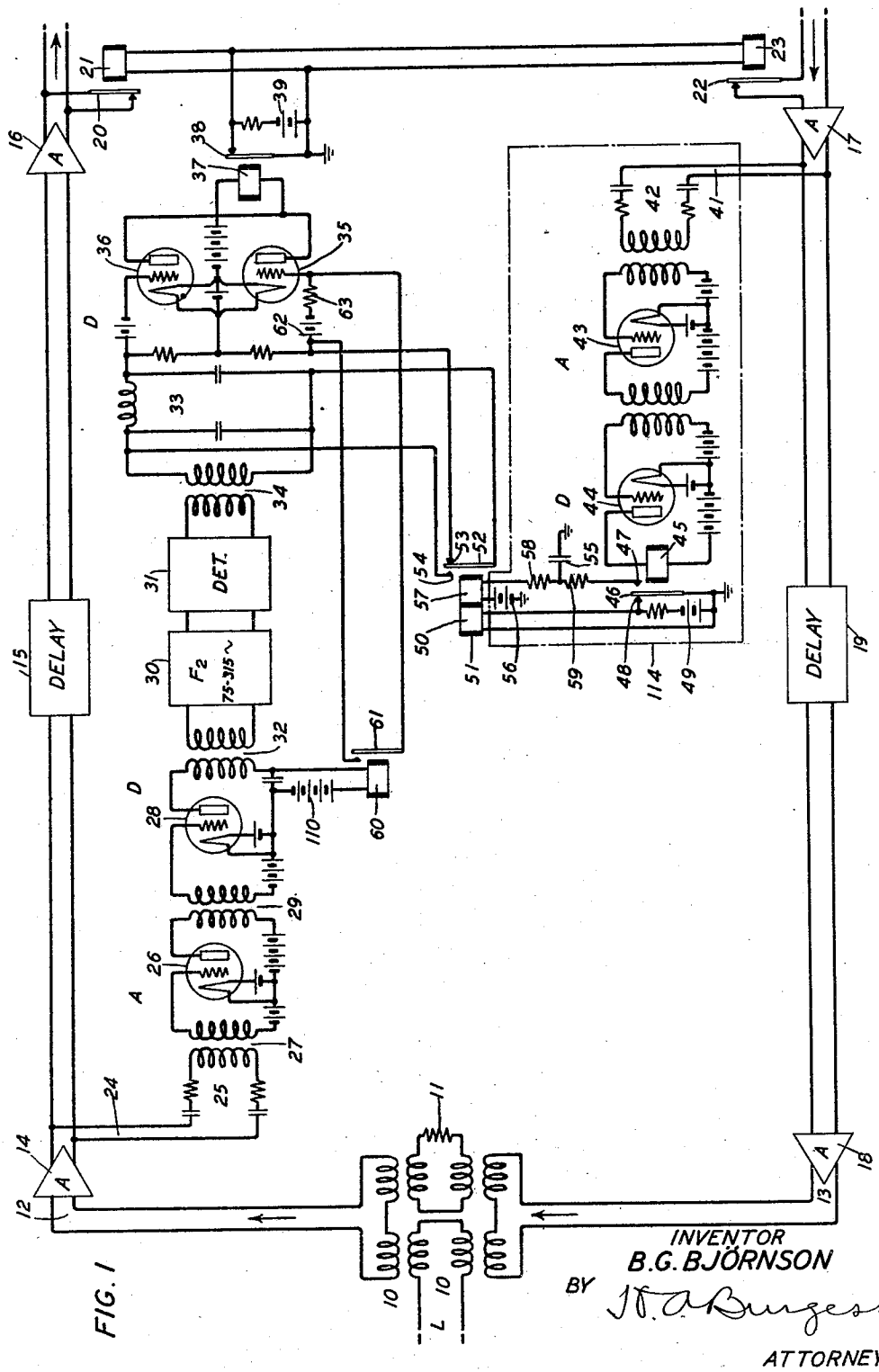

FIG. 1

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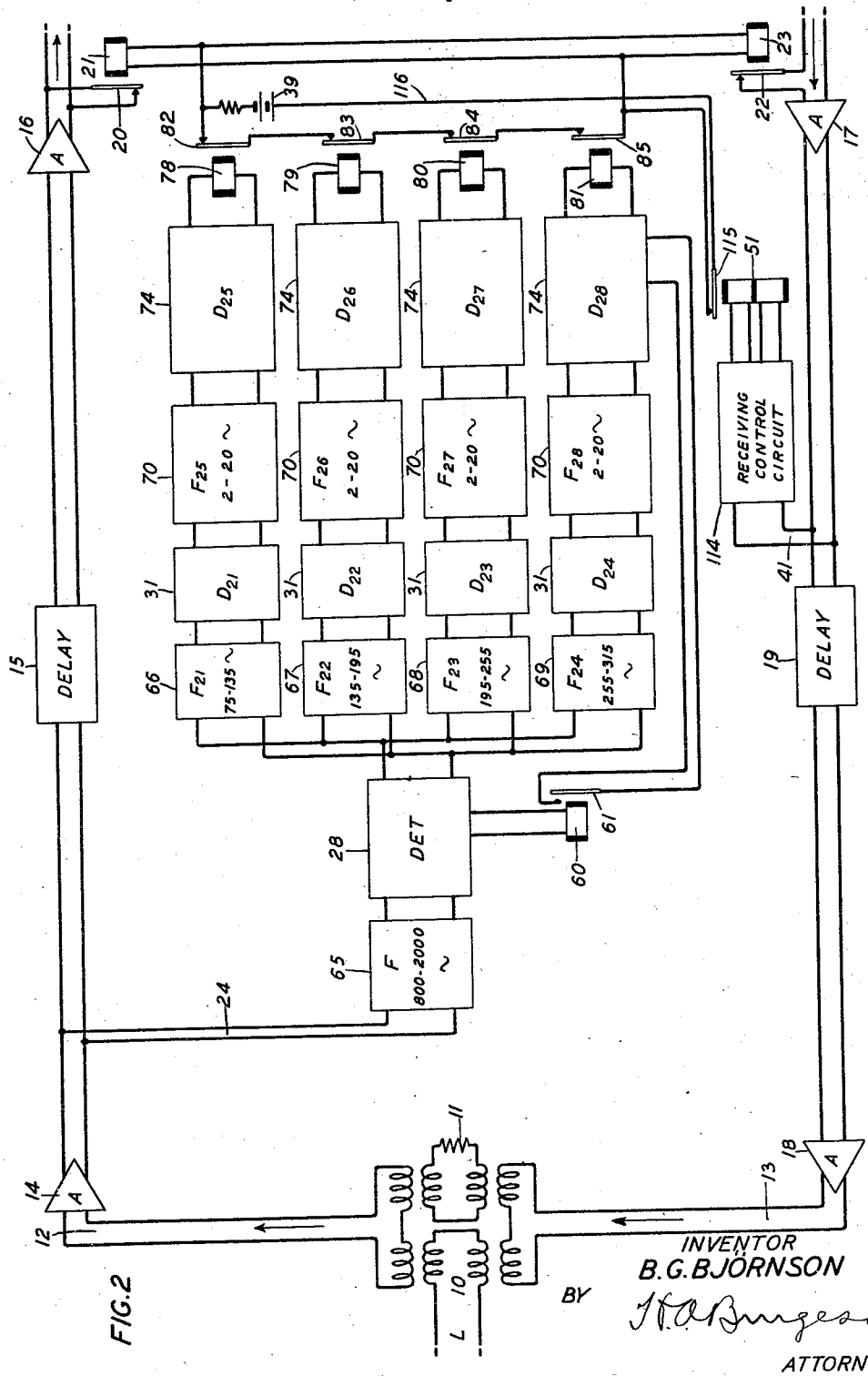

FIG. 2

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Filed Sept. 12, 1930 3 Sheets-Sheet 3

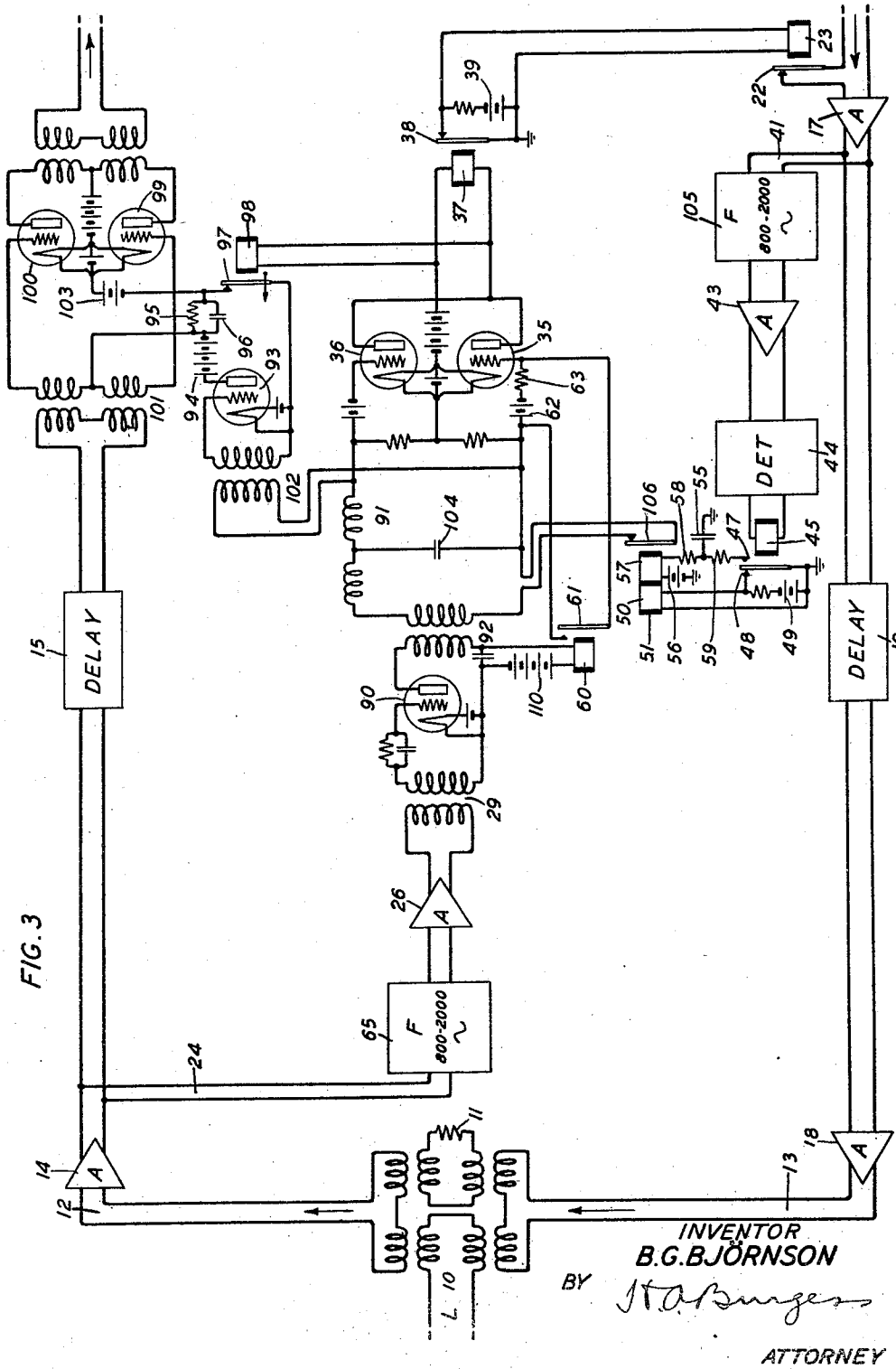

FIG. 3

Patented May 17, 1932 1,859,019

UNITED STATES PATENT OFFICE

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VOICE-OPERATED RELAY CIRCUITS

Application filed September 12, 1930. Serial No. 481,363.

This invention relates to voice-operated relay circuits of the type used in echo suppressing equipment, voice-operated repeater circuits and the like.

One of the difficulties encountered in the proper operations of such circuits is that steady alternating currents such as those set up in the telephone circuits by induction from power lines and other adjacent circuits and other random noises are a serious limitation on the sensitivity at which a voice-operated circuit, such as an echo suppressor, can be worked. This difficulty is a serious one since the sensitivity of an echo suppressor is limited by the noisiest circuit which may be connected to the echo suppressor at any given time although for the greater number of other connections a greater sensitivity would be possible.

A general object of this invention is to provide a voice-operated relay circuit which will be substantially non-responsive to noise currents but which will be quite sensitive to voice currents even though the voice currents be of the same order of magnitude as compared to the noise currents.

In the patent application of Robert C. Mathes, Serial No. 356,136, filed April 18, 1929, a voice-operated relay circuit is disclosed which is rendered operative by the syllable frequencies and in which all frequencies above the syllable frequencies are suppressed, whether these frequencies are voice frequencies or noise frequencies; that is, the circuit is rendered operative only by such frequencies as are included in the syllable frequency range.

Another object of the invention is to provide means for maintaining the device operated on sustained syllables.

A feature of the invention is the use of an auxiliary relay in the plate circuit of the first detector which auxiliary relay operates when a sustained syllable of high amplitude is transmitted through the device, which when operated, removes a part of the grid bias of the second detector to maintain the device operated.

Another object of the invention is to provide means for operating the system on the initial part of the speech wave, when the slope of the wave is small, and, at the same time, permitting the system to release in a relatively short time after the cessation of the speech wave.

Another feature of the invention is the use of two syllabic detectors, an operating detector which operates quickly to avoid initial clipping and a less sensitive or follow-up detector which operates sometime during the decay of the syllable, and which has a shorter time of release.

Another object of the invention is to provide a voice operated circuit involving noise protection, based on speech frequency discrimination, fundamental pitch frequency discribination, and syllabic frequency discrimination.

Another feature of the invention is the use of a filter, or filters, which will pass currents in the pitch frequency range, i. e. the fundamental frequency of the voice, to the exclusion of other frequencies and a pitch detector between the speech detector and the filter which passes only syllabic frequencies.

The invention is applicable to any kind of voice-operated systems, but has special application to those types where interference from external noises is troublesome.

Another object of the invention is to provide means in a two-way communication system for disabling the voice-operated syllabic relay device when signals are being received from the other direction.

Another object of the invention is to employ a vacuum tube as a relay to block the transmission path.

The invention will be better understood by referring to the following description and accompanying drawings in which Fig. 1 is a circuit diagram of a terminal of a 4-wire voice controlled circuit showing one embodiment of the invention; and Figs. 2 and 3 are similar showings of modified forms of the invention.

Referring to Fig. 1, the line L is shown terminating in a hybrid coil schematically indicated at 10, and having a balancing impedance 11. An eastward transmitting branch 12 and a westward transmitting branch 13

are associated with the hybrid coil 10. Amplifiers 14 and 16 and a delay network 15 are preferably associated with the eastward transmitting branch 12. Amplifiers 17 and 18 and a delay network 19 are preferably associated with the westward transmitting or receiving branch 13.

The eastward or transmitting branch 12 is normally disabled by the normally closed switch 20. The switch 20 is controlled by the relay 21. The westward or receiving branch 13 is normally in an operative condition. This branch is arranged to be disabled by the opening of the normally closed switch 22 under control of the relay 23.

The input circuit 24 of a voice operated equipment is bridged across the eastward or transmitting branch 12 between the amplifier 14 and the delay network 15. The voice operated equipment comprises the circuit 25, which is tuned to a frequency of approximately 1200 cycles per second, an amplifier 26 which is coupled to the tuned circuit 25 by means of a transformer 27, a speech detector 28 which is coupled to the amplifier 26 by means of a transformer 29, a 75–315 cycle band-pass filter 30 which is coupled to the speech detector 28 by means of a transformer 32, a pitch detector 31 associated with the filter 30, a low pass filter 33 which is coupled to the pitch detector 31 by means of a transformer 34, a syllabic operate detector 35 and a syllabic follow-up detector 36 which are connected to the low-pass filter 33, and a relay 37.

The filter 30 may be of the type well known in the art, for example, as disclosed in U. S. Patent to Campbell Nos. 1,227,113 and 1,227,114, granted May 22, 1917.

The pitch detector 31 may be of the type well known in the art, for example, it may be similar to the speech detector 28. Preferably however the pitch detector 31 with the associated transformer 34 is of the type disclosed in the patent application of R. C. Mathes, Serial No. 356,136, referred to above, and shown on D of the Mathes drawing, to provide for a cut-off at approximately two cycles.

The filter 33 is of the low-pass type having preferably a cut-off at or near the maximum syllable frequency which is in the neighborhood of twenty-five cycles.

An auxiliary relay 60 has its winding connected in the plate circuit of the detector 28. It is preferably connected between the plate battery 110 and the primary winding of the transformer 32, as shown, so as to serve as a choke coil in addition to its function as a relay. A switch 61 is closed by the operation of relay 60, and when closed, it short-circuits the battery 62 and resistance 63 which are connected in the grid circuit of the syllabic operate detector 35.

A voice operated echo suppressor circuit has its input circuit 41 bridged across the westward or receiving branch 13 between the amplifier 17 and the delay network 19. The echo suppressor circuit comprises a tuned circuit 42, an amplifier 43, a detector 44, a relay 45, the winding of which is in the plate circuit of the detector tube 44 and a relay 51, the operation of which prevents the voice operated equipment connected to the eastward branch 12 from disabling the westward or receiving branch 13. The relay 51 is provided with a winding 57 which is associated with a battery 56, resistances 58 and 59 and condenser 55 to provide a time lag in the release of the relay 51.

The operation of the circuit is as follows: (It being understood that speech arriving from the line L is to open up a path for itself by opening the switch 20, while noise current on the line will be prevented from opening the switch 20.) Part of the voice currents over the eastward or transmitting branch 12, in the direction indicated, pass through the delay network 15 and amplifier 16 and part of them are shunted from the eastward or transmitting branch 12 to the input circuit 24 of the tuned circuit 25. As this tuned circuit 25 is tuned to a frequency of approximately 1200 cycles it will pass only frequencies in this neighborhood (a frequency band in which the speech energy is large with respect to the noise energy). Voice current in this frequency band will pass from the tuned circuit 25 through the transformer 27 to the amplifier 26 and through the transformer 29 to the speech detector 28.

The detected current is impressed on the filter 30 by means of a transformer 32. The filter 30 passes to the detector 31 only currents in the frequency band between 75 and 315 cycles. It has been determined experimentally that the pitch frequency (or the fundamental frequency) of the voice lies within the frequency band from 75 to 315 cycles. The pitch frequency currents are detected by the detector 31.

The detected currents are transmitted to the filter 33 by means of the transformer 34. The filter 33 preferably passes only currents below 25 cycles and the transformer 34 preferably has a lower cut-off at approximately 2 cycles. Currents within the frequency band from 2 to 25 cycles are impressed on the input circuit of the syllabic detectors 35 and 36. The output currents from the syllabic detectors 35 and 36 operate the relay 37.

The operation of relay 37 opens the switch 38 allowing sufficient current from the source of potential 39 to flow through the windings of relays 21 and 23 and operate the corresponding associated switches 20 and 22. The opening of switch 20 removes the short-circuit from across the eastward or transmitting branch 12, allowing the voice currents from the line L to be transmitted over the eastward or transmitting branch. The opening of

switch 22 disables the westward or receiving branch, thereby preventing voice currents from the westward or receiving branch from being transmitted to the line L.

Preferably the syllabic detectors 35 and 36 are adjusted so that the operate detector 35 operates quickly to avoid initial clipping of the speech syllables and the follow-up detector 36 is less sensitive than the operate detector 35, since it has only to operate sometime during the decay of a syllable. This adjustment is preferably made by regulating the negative grid bias on the detectors 35 and 36. With the syllabic detectors 35 and 36 biased in this manner it has been found possible to obtain a much shorter releasing time after the end of a syllable, for the relay 37, than when the detectors 35 and 36 are of equal sensitivity.

The auxiliary relay 60 which is connected in the plate circuit of the speech detector 28 is adjusted to operate and close the switch 61 when the current level through the speech detector 28 is high usually near the overloading point of the speech detector. As long as the switch 61 is maintained in a closed position by the auxiliary relay 60, sufficient current will flow in the plate circuit of the operate syllabic detector 35 through the relay 37 to maintain the relay 37 operated. In this manner the relay 37 is maintained operated on high level steady impulses.

Speech currents arriving from the east over receiving branch 13 through the amplifier 17 are transmitted in part through the delay network 19, amplifier 18 to the line L, and in part over the path 41 through the tuned circuit 42, amplifier 43 and detector 44, thereby operating the relay 45. When the relay 45 operates the switch 46 removes the ground from the contact 48 and puts a ground on the contact 47. When ground is removed from the contact 48 sufficient current flows from the source of potential 49 through the winding 50 on relay 51 to operate the relay 51. When the relay 51 operates it disconnects the switch 52 from the contact 53 and connects the switch 52 with the contact 54, thereby placing a short-circuit across the secondary winding of the transformer 34 and opening the circuit between the transformer 34 and the grid potential battery 62 of the syllabic operate detector 35. This prevents either noise or voice currents from the eastward or transmitting branch from causing the operation of relay 37, which relay if operated would open the switch 38 and cause the westward or receiving branch to be disabled.

The blocking of the transmitting control circuit at the output of the low pass filter 33, by the opening of the contact 53, will allow the use of a delay circuit 19 having shorter delay characteristics than those employed in the prior art, and in some cases will allow the omission of the delay circuit 19, since the time delay in the low pass filter 33 will prevent echo currents from the receiving branch from operating the relay 37 before the relay 51 of the receiving control circuit has operated.

The shorting of the input side of the filter 33 by the closing of contact 53 prevents the storage of an excessive amount of energy in the filter 33. If the echo currents were permitted to store up an excessive amount of energy in the filter 33 it would be necessary to provide a large hangover in the receiving branch control circuit to avoid false operation of relay 37 by the energy stored up in the filter 33 after the relay 51 releases.

At the cessation of the speech impulses from the westward or receiving branch 13 the relay 45 will release, causing the switch 46 to disconnect from the contact 47 and connect with the contact 48. When the switch 46 makes connection with the contact 48, the condenser 55, which has previously discharged through the resistance 59, contact 47 and switch 46, is charged by the battery 56, through the winding 57 and resistance 58. (The discharge of the condenser 55 through the resistance 59, contact 47 and switch 46 to ground took place when the relay 45 was in its operated position.) The charging of condenser 55 as described holds the relay 51 operated while the condenser 55 is being charged and prevents either voice or noise currents on the eastward or transmitting branch 12 from disabling the westward or receiving branch 13 immediately after the relay 45 has released upon the cessation of a syllable, thereby maintaining the westward or receiving branch operated for the succeeding syllable.

When desirable the filter 30, which passes a band of frequencies between 75 and 315 cycles, and the pitch detector 31 may be omitted, in which case the speech detector 28 would be coupled to the low-pass filter 33 by means of a transformer, such as the transformer 34.

Fig. 2 illustrates a voice operated terminal circuit similar to that shown in Fig. 1. A band-pass filter 65 is connected to the eastward or transmitting branch 12 through the path 24. This filter 65 is designed to pass only frequencies within the voice range in which speech energy is large as compared to the noise energy. A range of frequencies between 800 and 2000 cycles has been found satisfactory for this filter. The filter may be of the type well known in the art, for example, as disclosed in U. S. patents to Campbell Nos. 1,227,113 and 1,227,114 granted May 22, 1917. If desired the tuned circuit 25 shown in Fig. 1 may be used instead of the band-pass filter 65.

For the sake of simplicity the amplifier 26 has been omitted from the circuit of Fig. 2

and the detector 28 coupled directly to the band-pass filter 65.

A series of band-pass filters 66, 67, 68 and 69 are connected in parallel to the output of the speech detector 28. These filters are designed to divide the detected speech currents into four equal frequency bands. In the particular noise protection circuit illustrated the filters were designed to pass the following frequencies and to substantially exclude other frequencies:

Filter No. 66—75 to 135 cycles;
Filter No. 67—135 to 195 cycles;
Filter No. 68—195 to 255 cycles;
Filter No. 69—255 to 315 cycles.

These filters may be of the type well known in the art for example, they may be designed in accordance with the disclosure published in the Bell System Technical Journal, January 1925, vol. 4, No. 1, entitled "Mutual inductance in wave filters with an introduction on filter design" by K. S. Johnson and T. E. Shea.

Individual pitch detectors 31 are connected to the output of each of the filters 66, 67, 68 and 69.

Individual filters 70 are connected to the output of each of the pitch detectors 31. These filters are preferably designed to pass frequencies between 2 and 20 cycles. They may be of any type well known in the art. For example, they may be designed in accordance with the disclosure published in the Bell System Technical Journal referred to above.

Individual syllabic detectors 74 are connected to the output of the filters 70. These syllabic detectors are preferably of the type shown in Fig. 1 comprising the detectors 35 and 36. Individual relays 78, 79, 80 and 81 are connected to the output circuit of the syllabic detectors 74. Normally closed switches 82, 83, 84 and 85 are associated with the relays 78, 79, 80 and 81 respectively. The operation of the relays 78 to 81 inclusive opens the respective switches 82 to 85 inclusive.

The switch 61, which is actuated by the relay 60, is shown connected to the syllabic detector 74, which is associated with band-pass filter 69, although it might as well be associated with any of the other three syllabic detectors 74. A receiving control circuit 114, the same as the control circuit 114 shown in Fig. 1 is connected to the receiving branch 13 to control the operation of relay 51. A normally closed switch 115, which is associated with the relay 51 is connected in battery supply lead 116 of the battery 39.

The operation of this system is as follows: The voice frequency currents passing through the band-pass filter 65 are detected by the detector 28. The detected currents from the detector 28 pass through the filters 66, 67, 68 and 69. Currents within the frequency bands from 75 to 135 cycles will pass through the filter 66, be detected by the pitch detector 31 associated therewith, and the detected currents in the frequency band from 2 to 20 cycles will pass through the filter 70, be detected by the syllabic detector 74 and actuate the relay 78.

Similarly currents from the output of detector 28 within the frequency band from 135 to 195 cycles will cause the operation of relay 79, currents within the band from 195 to 255 cycles will cause the operation of relay 80, and currents within the band from 255 to 315 cycles will cause the operation of relay 81.

The operation of any one of the relays 78 to 81 inclusive will open the corresponding associated switches 82 to 85 inclusive. Since the switches 82 to 85 inclusive are connected in series the opening of any one of them will remove the short circuit from the source of potential 39 and its associated resistance and allow sufficient current to flow through the relays 21 and 23 to open the switches 20 and 22.

Since the pitch frequencies of the voice vary from about 90 cycles to about 300 cycles and since the fundamental pitch will vary but little during the utterance of a syllable, most of the energy of individual syllables in the output of the speech detector 28 will be located in a unique narrow frequency band somewhere between 90 and 300 cycles, and as the frequency band from 75 to 315 cycles has been divided into four parts by means of the filters 66 to 69 inclusive, noise energy having a uniform spectrum is divided into four parts, thereby decreasing the sensitivity of the circuit for noise currents. This is due to the fact that, at a given instant of time, most of the speech energy will reach one of the relays 78 to 81 inclusive, while only one-fourth of the noise energy having a uniform spectrum will reach that same relay, and the operation of any one of these relays will cause the operation of relays 21 and 23.

If desirable, the frequency bands of the filters 66 to 69 inclusive can be made to overlap slightly so as to provide better transmission for the fundamental voice frequencies falling near the filter cut-offs.

The receiving control circuit 114 functions in a similar manner to the control circuit shown in Fig. 1, except that the switch 115 opens the battery supply lead 116, thereby preventing the operation of relays 21 and 23 when relay 51 is operated.

The system shown in Fig. 3 is similar in general to that shown in Fig. 1. A band-pass filter 65, the same as the filter 65 shown in Fig. 2 is employed in place of the tuned circuit 25 of Fig. 1. A detector 90 is coupled to the amplifier 26 by means of the transformer 29. The detector circuit illustrated is of the grid-condenser-resistance or grid

current type instead of the plate circuit type illustrated in Fig. 1.

The grid current type of detector has two advantages over the plate circuit type of detector. It is more efficient than the plate circuit type and by the proper adjustment of the operating characteristics and selection of the operating range its variation of output level will be more nearly linear, with changes in the input level, than the plate circuit type of detector, in which the output level of the difference frequency changes by twice the amount of the change in the input level, due to its parabolic plate circuit characteristic. With a plate circuit type of detector it is necessary to employ a low-pass filter such as the filter 33 in Fig. 1, which has attenuation characteristics twice as great as when the attenuation for the difference frequency is only half of that for the input frequencies. The grid current detector therefore permits the use of a more simple filter circuit with the consequent saving in operating time. A low-pass filter 91 is of the mid-series type and is coupled to the detector 90 by means of the transformer 92 instead of the low-pass filter 33 of Fig. 1 of the mid shunt type.

The primary winding of a transformer 102 is shunted across the output of the low-pass filter 91. The input circuit of the vacuum tube 93 is connected to the secondary winding of the transformer 102. A source of potential 94, a resistance 95, shunted by a condenser 96, and a switch 97 are connected in series in the output circuit of the vacuum tube 93. The switch 97, which is normally closed, is opened by the operation of a relay 98, the winding of which is connected in shunt to the winding of the relay 37.

The amplifier 16 of Fig. 1 has been replaced by a push-pull amplifier employing tubes 99 and 100, the input circuits of which are associated with the output circuit of the delay network 15 by means of a transformer 101. The source of potential 103 and the resistance 95, in shunt with the condenser 96, are connected in series in the input circuit of the vacuum tubes 99 and 100 to provide grid biasing potential therefor.

The auxiliary relay 60, which actuates the switch 61, has its winding connected in the plate circuit of the detector 90 in a similar manner to that shown in Fig. 1 in connection with the detector 28.

The operation of the system is as follows: Speech currents coming from the line L are amplified by the amplifier 14 and part of them are shunted to the input of the filter 65. The currents between the frequencies of 800 and 2000 cycles pass from the filter 65 through the amplifier 26 to the input of the detector 90. The detected currents are transmitted through the transformer 92 to the low-pass filter 91, which has a cut-off at approximately 25 cycles. These currents are detected by the syllabic detectors 35 and 36. The detected currents from the output of detectors 35 and 36 actuate the relays 37 and 98. Part of the currents from the output of the filter 91 are transmitted through the transformer 102 to the input circuit of the vacuum tube 93.

The currents impressed on the input circuit of the vacuum tube 93 reduce the amount of plate current flowing in the output circuit of the vacuum tube 93. A reduction in the plate current flowing through the resistance 95 reduces the amount of negative bias on the tubes 99 and 100 thereby putting the tubes 99 and 100 in an operative condition. After the plate current through the tube 93 has been reduced sufficiently to render the amplifier tubes 99 and 100 operative, the relay 98 operates and opens the switch 97. This insures that the amplifier tubes 99 and 100 will remain in an operated condition as long as the relay 98 remains operated.

At the cessation of the signal currents through the filter 91 and the syllabic detectors 35 and 36 the relay 98 will release, causing the switch 97 to close. This allows normal plate current to again flow in the tube 93, thereby rendering the amplifier tubes 99 and 100 inoperative.

Relays 37 and 23 function in the same manner as the corresponding relays in Fig. 1, thereby rendering the eastward or receiving branch 13 operative and inoperative.

The switch 61, which is actuated by the auxiliary relay 60, functions in the same manner as described above in connection with the circuit shown in Fig. 1, to maintain the relays 37 and 98 operated when the current level through the speech detector 90 is high.

The echo suppressor circuit comprising the path 41, filter 105, amplifier 43, detector 44, and relays 45 and 51 function in the same manner as the echo suppressor circuit shown in Fig. 1 except that the relay 51 opens a normally closed switch 106 which disables the voice operated circuit connected to the eastward branch 12 by opening the circuit between the transformer 92 and the condenser 104 of the filter 91.

While but certain embodiments of the invention have been shown and described in detail it is understood that the invention is generic in character and is not to be considered as limited to the particular embodiments described since numerous modifications thereof may be made without departing from the spirit of applicant's invention, the scope of which is to be determined by the appended claims.

What is claimed is:

1. In a voice-operated relay circuit, a path over which voice frequency currents and relatively sustained alternating currents may be transmitted, tandem detectors associated with said path, a relay controlled by the sec-

ond detector, means rendering said second detector selectively responsive to syllable frequency currents, and means associated with said first detector for rendering said relay operative in response to sustained voice frequency currents having a high level.

2. In a voice-operated relay circuit, a path over which fluctuating voice frequency currents and relatively sustained alternating currents may be transmitted, a detector associated with said path, means associated with said detector for transmitting a selected band of frequencies, other detectors having sensitivity characteristics which differ from each other connected to said last mentioned means, and a relay controlled by said other detectors.

3. In a voice-operated relay circuit, a path over which voice frequency currents and relatively sustained alternating currents may be transmitted, tandem detectors associated with said path, a relay controlled by the second detector, means rendering said second detector selectively responsive to syllable frequency currents, and means for rendering said voice-operated relay circuit inoperative while maintaining said first detector in an operative condition.

4. In a voice-operated relay circuit, a path over which fluctuating voice frequency currents and relatively sustained alterating currents may be transmitted, a detector associated with said path, means associated with said detector for transmitting a selected band of frequencies, other detectors having sensitivity characteristics which differ from each other connected to said last mentioned means, a relay controlled by said other detectors, and means for rendering said voice-operated relay device inoperative while maintaining said first mentioned detector in an operative condition.

5. In a voice-operated relay circuit, a path over which voice frequency currents and relatively sustained alternating currents may be transmitted, tandem detectors associated with said path, a relay controlled by the second detector, means rendering said second detector selectively responsive to syllable frequency currents, and means for rendering said voice-operated relay circuit inoperative, said last mentioned means blocking said circuit between said first detector and said means for rendering said second detector selectively responsive to syllabic frequency currents.

6. In a voice-operated relay circuit, a path over which fluctuating voice frequency currents and relatively sustained alternating currents may be transmitted, a detector associated with said path, means associated with said detector for transmitting a selected band of frequencies, other detectors having sensitivity characteristics which differ from each other connected to said last mentioned means, a relay controlled by said other detectors, and means for rendering said voice operated relay device inoperative while maintaining said first mentioned detector in an operative condition, said last mentioned means blocking said circuit between said first mentioned detector and said means for rendering said other detectors selectively responsive to syllabic frequency currents.

7. In a voice operated relay circuit, a path over which voice frequency currents and relatively sustained alternating currents may be transmitted, means for deriving pitch frequency currents from said voice frequency currents, a detector associated with said last mentioned means, a relay controlled by said detector, and means to substantially prevent the effect of currents other than currents of syllable frequency from being transmitted to said detector.

8. In a voice operated relay circuit, a path over which fluctuating voice currents and relatively sustained alternating currents may be transmitted, a detector associated with said path, a second detector associated with said path, means connected between said first mentioned detector and said second detector to substantially prevent the effect of currents other than currents of pitch frequency from being transmitted from said first mentioned detector to said second detector, a third detector associated with said path, means connecting said second and third detectors to substantially prevent the effect of currents other than currents of syllable frequency from being transmitted to said third detector, and a relay controlled by said third detector.

9. In a voice operated relay circuit, a path over which fluctuating voice currents and relatively sustained alternating currents may be transmitted, a detector associated with said path, a plurality of means associated with said detector for transmitting different frequency bands, all of said different frequency bands being within the fundamental or pitch frequency voice range, other detectors connected to said last mentioned means, means associated with said last mentioned detectors for substantially preventing the effect of currents other than currents of syllable frequency from being transmitted therethrough, other detectors connected to said last mentioned means, and relays controlled by said last mentioned detectors, said relays having their contacts connected in series.

10. In a four-wire voice controlled circuit, a path over which voice frequency currents may be transmitted, means including a low pass filter, a detector and a relay associated with said path for rendering said path operative, said detector having its input circuit connected to the output circuit of said low pass filter, a second path over which voice currents may be transmitted, means including a second detector and a second relay associated with said second path for preventing said

first mentioned relay from rendering said first mentioned path operative and for disconnecting the output of said low pass filter from said first mentioned detector when voice currents are being transmitted over said second mentioned path.

In witness whereof, I hereunto subscribe my name this 5th day of September, 1930.

BJÖRN G. BJÖRNSON.