

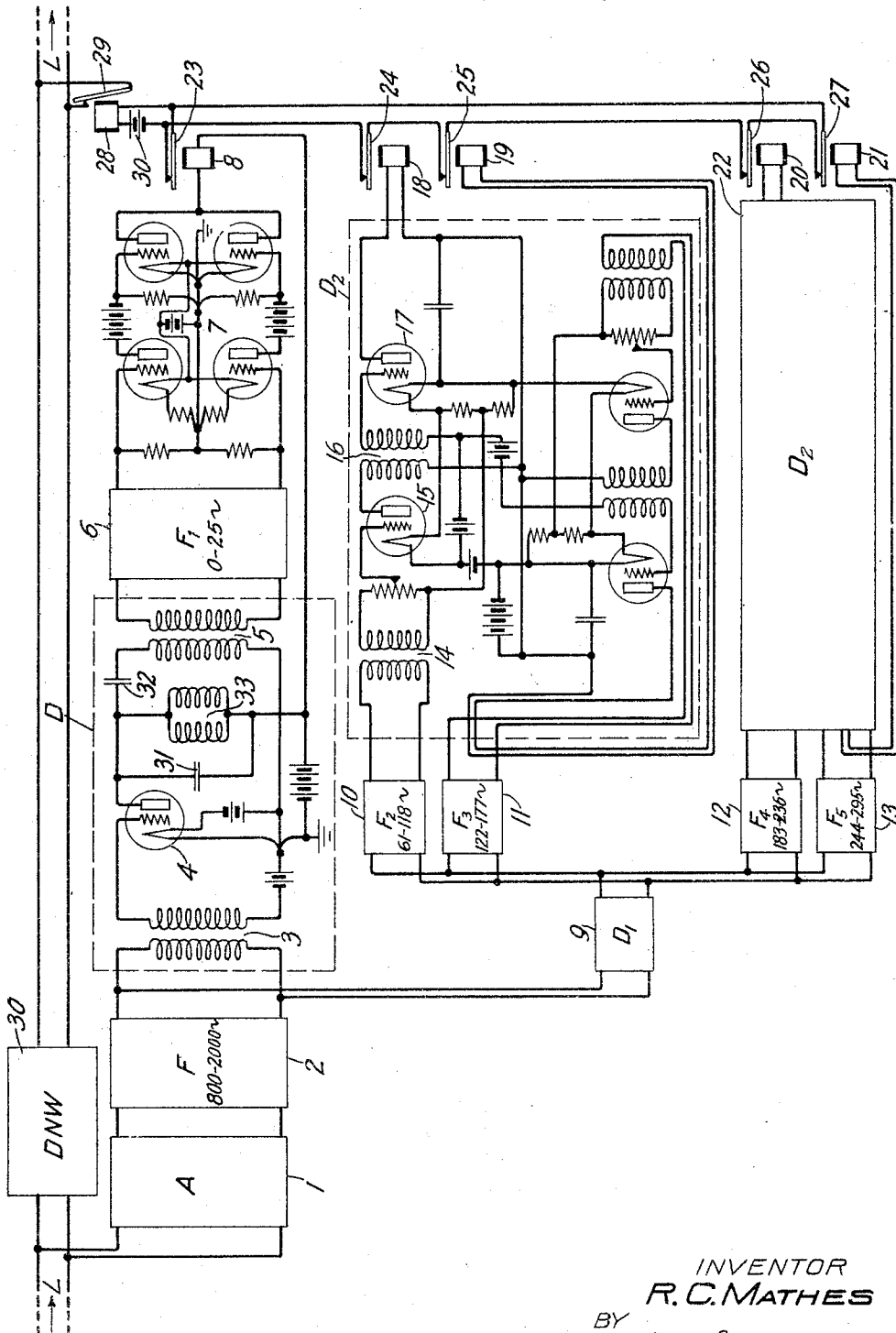
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VOICE OPERATED CIRCUIT

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VOICE OPERATED CIRCUIT

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

5 One of the difficulties encountered in the proper operation 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 limita-
10 tion 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 con-
15 nected to the echo suppressor at any given time although for the greater number of other connections a greater sensitivity would be possible.

20 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
25 the same order of magnitude as compared to the noise currents.

Related objects of the invention are to provide a voice operated relay circuit which is rendered operative by the syllable frequen-
30 cies and in which all frequencies above the syllable frequencies are suppressed, whether these frequencies are voice frequencies or noise frequencies, that is, by rendering the circuit operative only by such frequencies as
35 are included in the syllable frequency range; and to provide a voice operated relay circuit which will eliminate 60 cycle noise and its harmonics and divide the energy of noise having a uniform spectrum into several
40 parts, thereby increasing the sensitivity at which a voice operated circuit, such as an echo suppressor, can be worked over a system in which the noise energy has not been divided into several parts.

45 The invention is applicable to any type of voice operated systems but has especial application to those types where interference from external noises is troublesome.

A feature of the invention is that two dif-
50 ferent systems, each superior to the other as

far as certain types of noises are concerned are connected in parallel in such a manner that both must function before the voice operated device will function to open or short
55 circuit the transmission line. In this manner, assuming that there are certain types of noises which can be protected against by one system to a greater degree than by another, a parallel connection will give more
60 noise protection than either system independently.

In the specific embodiment of the invention herein shown and described, the two
65 separate control systems are connected in parallel in a manner such that both must operate before the auxiliary relay whose function is to open or short circuit the transmission line operates. A delay circuit is employed to retard the voice currents so that
70 they do not reach the line until after the voice operated circuit has functioned.

One of the systems herein shown and described employs two detector tubes in tan-
dem. Between the two detector tubes a band-
75 pass filter having cut-offs at or near the minimum and maximum syllable frequencies is employed. This may consist of a low-pass filter and an output circuit in the preceding
80 detector which acts as a simple high-pass filter. A relay is connected to the output of the second detector which will control the operation of another relay whose function is to open or short circuit the transmission line.

The other of said systems herein shown and
85 described employs a series of filters connected in parallel to the output of a single detector. These filters are designed so as to exclude 60 cycle interference from power lines and the harmonics of this 60 cycle interference. Connected to the output of each of the filters
90 is an individual detector and a relay. The contacts of all the relays are arranged in series so that the opening of any of them will cause the operation of another relay, the function of which is to open or short circuit
95 the transmission circuit.

The invention will be better understood by referring to the following description and accompanying drawing.

Referring to the drawing, L represents a 100

normally disabled transmission path such as a one-way path of a repeater, or the one-way line of a four-wire circuit. In the operation of such circuits it is desirable, in order to prevent singing, that apparatus shall be operated to put the path in condition for transmission only during the time when voice currents are being transmitted in the direction indicated. In the case of echo suppressors the control relay would be bridged across the opposite half of the four-wire circuit and would short circuit it whenever speech passed on the first side for a period long enough to avoid echoes, as shown, for example, in U. S. Patent No. 1,536,907 to J. Mills, May 5, 1925.

The voice operated equipment is bridged across the path L ahead of the delay network 30 and amplifier 1 is preferably placed in the input circuit of the voice operated equipment. The amplifier 1 preferably has a high impedance, so that the loss in transmission due to the voice operated equipment being shunted across the transmission path L will be small. A band-pass filter 2 is connected to the output of amplifier 1. This filter 2 is designed to pass only frequencies within the voice range in which the speech energy is large as compared to the noise energy. A range of frequencies between 800 and 2000 cycles has been found satisfactory for the 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.

The two different types of noise protection circuits referred to above are connected to the output of filter 2. The one shown at the upper part of the drawing is connected to the output filter 2 through a transformer 3 to a detector tube 4. The output of detector tube 4 is connected through a transformer 5 to a low-pass filter 6.

Condensers 31 and 32 and coils 33 are preferably employed in the output circuit of detector tube 4 so that the output circuit will preferably resonate at a frequency of the order of $2\frac{1}{2}$ to 5 cycles and so that the lower cut-off is at or near the minimum syllable frequency, which is approximately 2 cycles. The filter 6 is preferably of the low-pass type having a cut-off at or near the maximum syllable frequency which is in the neighborhood of 25 cycles. The detector circuit D and filter 6 will therefore pass only frequencies between 2 and 25 cycles.

The output of low-pass filter 6 is connected to a second amplifier-detector 7. Preferably the amplifier-detector 7 is of the balanced type well known in the art. A relay 8 is connected to the output of the amplifier-detector circuit 7.

The noise protection circuit shown at the bottom of the drawing is also connected across the output of the band-pass filter 2

through a detector circuit 9. The detector circuit 9 is similar to circuit D except that the condensers 31 and 32 and coils 33 have been omitted so that it will not resonate at a low frequency.

A series of band-pass filters 10, 11, 12 and 13 are connected in parallel to the output of detector circuit 9. These filters are designed to exclude 60 cycle interference from power lines and the harmonics of the 60 cycle interference. In the particular noise protection circuit illustrated the filters were designed to pass the following frequencies and to substantially exclude other frequencies: filter No. 10, 61 to 118 cycles; filter No. 11, 122 to 177 cycles; filter No. 12, 183 to 236 cycles; filter No. 13, 244 to 295 cycles. These filters 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, January, 1925, vol. 1, No. 1, entitled "Mutual inductance in wave filters with an introduction on filter design" by K. S. Johnson and T. E. Shea.

Connected to the output of each of the filters 10, 11, 12 and 13 is a second amplifier-detector circuit, two only of which are shown in detail on the drawing. To the output of filter 10 the primary winding of transformer 14 is connected. The input circuit of the vacuum tube amplifier 15 is connected to the secondary winding of the transformer 14. The output circuit of the amplifier 15 is connected through transformer 16 to the input circuit of vacuum tube detector 17. A relay 18 is connected to the output circuit of vacuum tube detector 17.

In a similar manner relay 19 is connected through its individual amplifier-detector circuit to filter 11. Relays 20 and 21 are connected through amplifier-detector circuits 22 to filters 12 and 13 respectively. The amplifier-detector circuits 22 are preferably the same as the amplifier-detector circuits D, which connect relays 18 and 19 to filters 10 and 11 respectively.

Relay 8 actuates switch 23 which is normally in the circuit closing position. Relays 18, 19, 20 and 21 actuate switches 24, 25, 26 and 27 which are connected in series and are normally in the circuit closing position.

Relay 28 which actuates switch 29 is energized by current from the battery 30 through switch 23 and/or through switches 24, 25, 26 and 27 in series. Since switches 23, 24, 25, 26 and 27 are normally in the circuit closing position relay 28 is normally operated, which holds switch 29 in the circuit closing position maintaining a short-circuit across the line L.

The operation of the system is as follows: (it being understood that speech arriving from the left over line L is to open up a path for itself by opening switch 29, while noise

currents on the line will be prevented from opening switch 29) part of the voice currents over the line L in the direction indicated pass through the delay network 30 and part of them are shunted from the line L, before reaching the delay network 30, through the amplifier 1 to filter 2. Since the filter 2 preferably passes only frequencies from 800 to 2000 cycles (a frequency band in which the speech energy is large with respect to the noise energy) voice currents in this frequency band pass from filter 2 to detector tube 4 through transformer 3 and to the detector circuit 9.

The currents which pass through transformer 3 are detected by the detector tube 4 and the detected current is impressed on the band-pass filter 6 by means of transformer 5.

It has been determined experimentally, by measuring the time between zero amplitudes of electrical currents produced from English syllables, that a frequency range of 2 to 25 cycles per second will satisfactorily transmit syllable frequency impulses.

The detector circuit D and low-pass filter 6 therefore produce syllable frequency currents having frequencies from 2 to 25 cycles.

Currents from the output of filter 6 are impressed on the amplifier-detector circuit 7, the output current of which operates relay 8. Relay 8 opens switch 23. The operation of relay 8 alone has no effect on the operation of relay 28 as the switches 24, 25, 26 and 27 are also closed and maintain the circuit through relay 28.

If, however, the noise protection circuit shown at the bottom of the drawing is omitted switch 23 will, when opened by relay 8, open the circuit through relay 28 causing switch 29 to open and remove the short circuit across line L. This will allow the speech currents which pass through the delay network 30 to pass over the line L.

The amplifier-detector circuit 7 is preferably of the balanced type shown. It is, however, possible to operate a circuit with an unbalanced amplifier-detector provided there is sufficient hold-over in the relay 8 for each syllable. There will be initially a single impulse of relay current. Depending on the amplitude of the syllable and the sensitivity of the second detector, relays 8 will be given an impulse of some definite duration. If the syllable persists at the suppression point beyond the hang-over time there will be "clipping." A second and more favorable effect arises from the fact that there is a second impulse of relay current after the end of each syllable because of the discharge of the output circuit of the first detector 4 and low-pass filter 6. This also tends to operate relay 8 so that the line will be held in operative condition for the next syllable if it follows soon enough. There may, therefore, be no initial clipping of weak

syllables following closely upon strong ones. The action of the balanced detector permits both the initial and final impulses to be used for operating relay 8 and allows the use of shorter hang-over without the danger of final clipping.

Certain line noises will, however, fall within this frequency band, 2 to 25 cycles per second. The commonly accepted value of probable variation of 60 cycle sources along the lines is $\pm \frac{1}{4}$ cycle. Difference frequencies of harmonics of the order n will then appear as frequencies of orders 0 to

$$\frac{n}{2},$$

some of which will fall in the 2 to 25 cycle band. It is to be expected that difference frequencies of other noises on which but little data is available may also fall within this region. Random noises and so-called steady noises that change in amplitude more than once a second will affect the noise margin. The relation of these noises to the voice currents which actuate the relays must be determined on the individual lines. The noise protection circuit shown at the bottom of the drawing will provide additional protection against the noises having difference frequencies within the 2 to 25 cycle band.

The currents which pass through filter 2 are also impressed on the detector circuit 9 and are there detected. The detected currents pass to filters 10, 11, 12 and 13. The current from the output of filter circuit 10 passes through transformer 14 to the amplifier tube 15, through transformer 16 to the detector tube 17. The detected currents pass to relay 18. Relay 18 operates switch 24 which, when the switch 23 has been opened by relay 8 as described above, will release relay 28.

Currents through each of the other filters 11, 12 and 13 pass through similar amplifier detectors and operate relays 19, 20 and 21 respectively. It is only necessary that one of the relays 18, 19, 20 or 21 be operated, together with relay 8, at a given instant to put the line L in operative condition.

Since the voice frequencies lying in the region from 61 to 295 cycles, consist chiefly of the fundamental frequencies, these frequencies will at any instant be concentrated in a narrow band and will operate one of the four detectors. If this band should shift during a word or sentence, it will shift in such a way as to cause the operation of another one of the four detectors.

This arrangement eliminates 60 cycles and three harmonics of 60 cycles from the band of frequencies and results in substantially complete freedom from interference of this sort. Also since the energy of noise having a uniform spectrum is divided in four parts each of the four detectors can be operated with more sensitivity than if a single detector

were substituted for them. It is possible, therefore, to obtain as good operation with this circuit by the voice currents as would be obtained if a single second detector circuit containing an harmonic elimination filter were employed and at the same time to obtain a reduction in the effect of noise other than the harmonics of 60 cycles.

Supposing that each of the noise protection systems operates satisfactorily for voice currents but that for a certain percentage of the time they will be falsely operated by noise, the chances that a given noise will operate both systems of discrimination simultaneously are considerably smaller than that it will operate either one alone. Therefore, whenever either noise protection system in itself should prove to give insufficient protection against noise, further protection may be obtained by making the final operation dependent on the operation of both devices as shown in the drawing. This is due to the fact that, as explained above, the two different noise detection schemes operate at different frequencies and both devices must operate before the short circuit is removed from across the line L.

While a single embodiment of the invention has 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 embodiment described since numerous modifications thereof may be made by persons skilled in the art 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 second detector, and means associated with the first detector for rendering said second detector selectively responsive to currents confined to a frequency range from about 25 cycles per second downwards.

2. In a voice operated relay circuit, a path over which voice frequency currents and relatively sustained alternating currents may be transmitted, means for deriving syllable frequency currents from said voice frequency currents, a detector associated with said path, a relay controlled by said detector and means to substantially prevent the effects of currents other than currents of frequencies of the order of two to twenty-five cycles per second from being transmitted to said detector.

3. 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, other detectors connected to said last mentioned means, and relays controlled by said other detectors, said relays having their contacts connected in series.

4. In a voice operated relay circuit, a circuit over which speech waves and relatively sustained alternating currents may be transmitted, a plurality of parallel paths connected to said circuit, a detector for each path, filters having mutually exclusive pass ranges connected one to the output of each of said detectors, one such filter passing only frequencies of the order of twenty-five cycles per second and lower, another of said filters passing only frequencies higher than this range but lower than the upper speech frequencies, and switching means responsive to the combined effect of the currents transmitted through said paths.

5. In a voice operated relay circuit, a path over which fluctuating voice currents and random noise currents may be transmitted, parallel paths connected in said first mentioned path, means in said parallel paths for rendering them less responsive to noise currents, said means in one of said parallel paths being less responsive to certain types of noise currents than said means in the others of said parallel paths, response means in each of said parallel paths responsive to the transmitted speech energy currents, and means responsive to the combined response of said response means in said parallel paths.

6. In a signal operated relay circuit having a path including several parallel branches over which signal currents and random noise currents may be transmitted, the method of discriminating against noise currents which comprises transmitting part of said signal and noise currents over one branch selectively non-responsive to certain types of noise and transmitting part of said signal and noise currents over another branch selectively non-responsive to other types of noise, detecting the currents transmitted through the several branches, controlling a response element by each of the several detectors, and controlling said signal operated relay circuit by the simultaneous operation of the several response elements.

7. 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, means for attenuating the frequency transmitted over power lines adjacent to said path and the harmonics of said frequencies, a plurality of means for detecting the unattenuated frequencies transmitted from the output of said first detector, and response elements controlled by said last mentioned means.

8. A signal receiver subject to combined waves including signal waves having a dis-

crete frequency spectrum and interfering waves which over a definite frequency range have a substantially continuous energy spectrum, comprising a plurality of wave-controlled devices each responsive to a given amount of wave energy and irresponsive to a lesser amount of energy, and means for supplying to each of said devices a different frequency band of said combined waves within said definite frequency range, each band having such a width that the amount of energy therein due to said interfering waves is less than said given amount.

9. A signal receiver subject to combined waves including speech waves and interfering noise waves which over a definite frequency range have a substantially continuous energy spectrum, comprising a plurality of wave-controlled devices each responsive to the amount of energy contained in a discrete frequency of said speech waves, and irresponsive to a lesser amount of energy below a certain value, and means for supplying to each of said devices a different frequency band of the combined waves within said definite frequency range, and having a width such that the amount of energy therein due to said noise waves is less than said certain value.

10. A signal receiver subject to combined waves including signal waves having a discrete spectrum and interfering waves which over a definite frequency range have a substantially continuous energy spectrum, comprising a plurality of wave-controlled devices each responsive only to waves of energy above a certain amount corresponding to that contained in a discrete frequency of said signal waves, and means for subdividing the frequency band of the combined waves into a plurality of sub-bands within said definite frequency range and of such small width that the energy due to said interfering waves supplied to any one of said devices is insufficient to cause its operation.

11. A signal receiver subject to combined waves including signal waves having a discrete energy spectrum and interfering waves which over a definite frequency range have a substantially continuous energy spectrum, comprising a plurality of wave-controlled devices each responsive to the amount of energy which would be contained in a single discrete frequency of said signal waves but irresponsive to a smaller amount of energy below a certain value, selective means for supplying a different frequency band of the combined waves to each of said wave-controlled devices, each of said selective means being designed to select a sub-band of said combined waves of such width that the amount of energy therein due to said interfering waves is less than said certain value.

12. A signal receiver for a telephone transmission line and subject to combined waves received thereover including speech waves

and interfering resistance noise waves, comprising a transmission control element, a plurality of wave-controlled devices each irresponsive to an amount of wave energy below a certain value, but responsive to an amount of wave energy of said certain value or a larger value, to independently control said transmission control element, and means for selecting and supplying to each of said devices a different frequency band of the combined waves received over said line such that the total energy therein due to said resistance noise waves is less than said certain value, at least one of said bands containing one or more discrete speech frequencies having a total energy content at least as large as said certain value.

13. In a voice operated circuit for discriminating against continuous noise currents, filter means to select from the voice currents the frequency components of largest energy content and to eliminate lower frequencies, a detector connected to the output of said filter means, a low-pass filter connected to the output of said detector, said detector and low-pass filter producing from said voice currents a succession of impulses of the order of occurrence of speech syllables, said low pass filter passing currents of substantially only the voice syllable frequencies, and means utilizing said impulses to operate a switching relay.

14. In a voice operated circuit for discriminating against continuous noise currents, filter means to select from the voice currents the frequency components of relatively large amplitude and to suppress transmission of the lowest portion of the speech frequency range, a detector connected to the output side of said filter, and a filter connected to the output of said detector for suppressing currents of frequencies higher than about twenty-five cycles per second while transmitting currents of lower frequencies, said detector and last mentioned filter operating to produce a current impulse at the beginning and at the end of each speech impulse of approximately syllable frequency, and switching relay means operated by the impulses so produced.

15. In a voice operated relay circuit for discriminating against continuous noise energy, a filter having a pass range from about 800 cycles to about 2000 cycles for selecting from the speech currents the large energy components, a detector for detecting the waves passed by said filter, a filter having a pass range from near zero frequency to the order of twenty-five cycles connected to the output of said detector, said detector and last mentioned filter producing from the speech waves current impulses of the order of occurrence of two to twenty-five per second, and a switching relay operated by said impulses.

16. The combination recited in claim 15 in

which a second detector is connected between said last mentioned filter and said relay.

17. The combination recited in claim 15 in which a push-pull detector is connected between said last mentioned filter and said relay whereby said impulses, of whichever sign, act similarly on said relay to energize it.

18. In a voice operated circuit, a path over which voice frequency currents and relatively sustained alternating currents may be transmitted, filter means to select from said voice currents the frequency components of largest energy content and to eliminate lower frequencies, a detector connected to the output of said filter means, a low-pass filter connected to the output of said detector, said detector and low-pass filter producing from said voice currents a succession of impulses of the order of occurrence of speech syllables, said low-pass filter passing currents of substantially only the voice syllable frequencies, a path having an operative condition and an inoperative condition, and means utilizing said impulses to control the operative condition of said last mentioned path.

In witness whereof, I hereunto subscribe my name this 13th day of April, 1929.

ROBERT C. MATHES.