

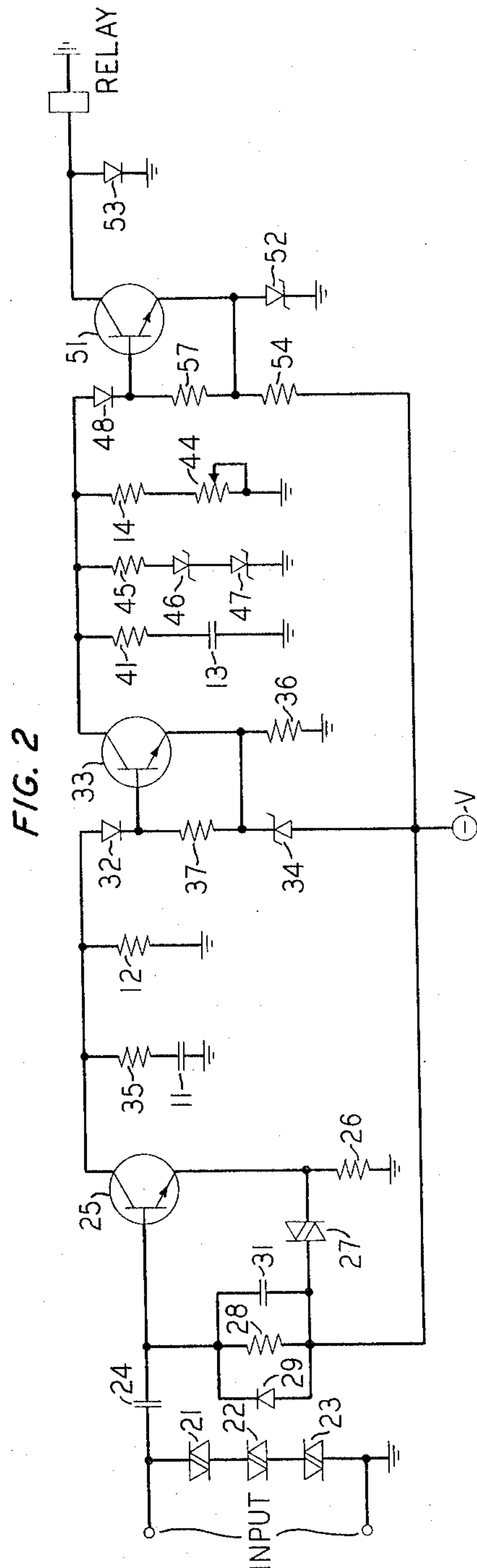
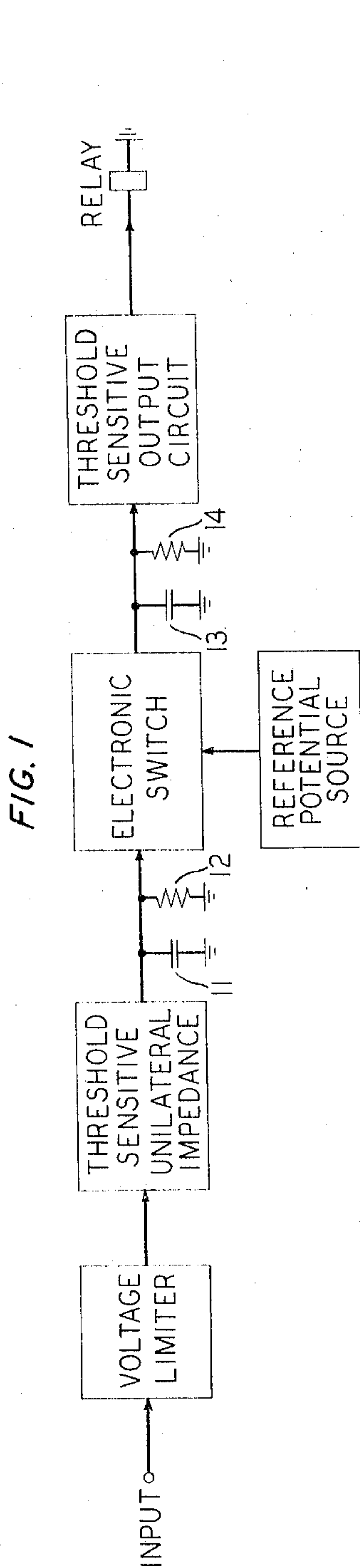
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NOISE INDICATOR CIRCUIT

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NOISE INDICATOR CIRCUIT

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This invention relates to apparatus for indicating the presence of noise on a speech transmission circuit, and more particularly for detecting the presence of a sustained noise even though its magnitude may be less than speech signals normally found on the circuit.

In a "4-wire" telephone system in which a plurality of remotely located subscribers are connected together via a 4-wire bridge for a conference setup, any noise which is generated on one of the remote subscriber's transmitting lines is distributed equally to all of the remaining subscriber's, thereby tending to impair the intelligibility of the speech transmission on all subscriber lines. Such a noise may result in serious harm in the transmission of telephone messages from a central subscriber to a plurality of geographically spaced subscribers on an occasion when time is of the extreme essence. Accordingly, it is desirable to have circuits which are capable of detecting and indicating an objectionable noise level in the presence of speech as a continuous procedure, thereby enabling an immediate substitution of an alternate route for the noisy route. In this way a high level of intelligibility is maintained on the conference network at all times.

The type of noise that is most damaging to intelligibility is a sustained noise. Although other noises may be equally annoying to a subscriber, such as key clicks which appear only once or at large intervals between occurrences, they do not substantially impair the intelligibility of a signal with as much redundancy as speech. Accordingly, it is usually only the presence of sustained noises which must be detected in order to maintain a high level of intelligibility. The detection circuit must, of course, be able to distinguish between a sustained noise and speech even where the speech signals are greater in magnitude than the magnitude of sustained noise which is determined to be objectionable.

A distinctive feature of speech which has been utilized in prior art noise circuits to distinguish it from sustained noise is the fact that pauses occur in speech at frequent intervals during which the signal level falls to zero. These pauses occur between syllables, between words, and at longer intervals during the period of time when a speaker pauses to take a breath. It has been experimentally determined that the maximum interval between pauses for the average speaker does not exceed three seconds. Even under the most severe speech and talker conditions, the maximum interval has not been found to exceed five seconds.

A novel circuit which utilizes the fact that pauses occur in speech, to thereby distinguish between speech and sustained noise, is disclosed in the copending application of W. G. Feger, Serial No. 161,647, filed December 22, 1961. The Feger circuit produces an output signal in response to an intolerable sustained noise at its input, but produces no output signal in response to speech. The same is accomplished by passing the input signal through a voltage limiter and multivibrator type trigger circuits so as to produce a sharp-edged envelope of the input signal which is in turn differentiated to produce spikes at those moments in time when, and if, pauses occurred. These spikes in turn operate a further trigger circuit which recycles an output circuit that is set to produce an output indication if no spikes appear within a predetermined interval of time of about five seconds.

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The circuit of the Feger application although fully capable of performing the job mentioned hereinabove with relation to a 4-wire conferencing arrangement, does require a large number of transistors (a total of 10) and associated circuit components.

A distinctive feature of speech which has been experimentally observed is that the intersyllabic pauses in speech are of a duration in the order of fifty milliseconds or more. Hence, the duration of time for which such a pause occurs is quite long relative to the time per cycle for the frequencies of speech and noise involved (200 to 3500 c.p.s.). This distinctive characteristic of speech does not appear to have been heretofore utilized in the prior art for distinguishing speech from sustained noise.

It is accordingly a primary object of the present invention to utilize this additional distinctive characteristic of speech to produce a novel apparatus for the detection of a sustained noise in the presence of speech.

It is a further object of the invention to significantly reduce the cost and complexity of circuitry which detects the presence of a sustained noise in the presence of speech.

A still further object of the invention is to provide a circuit which will detect a sustained noise in the presence of speech and which does not require a differentiator circuit with its attendant disadvantages and additional specialized circuits, such as multivibrators, to over-emphasize the sharpness of the pauses in speech in order to obtain sharp spikes at the instants pauses occur.

These and other objects are attained in accordance with the present invention wherein a capacitor is charged by voltage peaks of the input noise and speech signals which exceed a predetermined threshold and is discharged through a resistance path whose discharge time with relation to the capacitor is somewhat less than the length of the shortest pause. If the voltage peaks which exceed the threshold are caused by sustained noise, the capacitor will be retained at a substantially constant voltage since the aforementioned discharge time is very much longer than the time per cycle of even the lowest frequency found in the incoming signal. A normally ON electronic switch is caused to remain in its OFF state by the substantially constant voltage retained across the capacitor, thereby allowing an output circuit to produce an indication a predetermined interval of time after the switch has been operated to, and maintained in, its OFF state. If, however, the voltage peaks which exceed the threshold are caused by speech, an output indication will not be provided since the electronic switch will not be maintained in its OFF state for the predetermined interval of time but will be permitted to return to its ON state when an inevitable intersyllabic pause in speech occurs.

It is a feature of the present invention that both of the above-noted distinctive features of speech (i.e., the duration of intersyllabic pauses and the maximum interval between pauses for the average speaker) are utilized to distinguish the same from sustained noise.

Other objects and many of the attendant advantages of the invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings in which:

FIG. 1 is an overall block diagram of apparatus in accordance with the present invention; and

FIG. 2 is a schematic circuit diagram of a specific embodiment of the present invention.

Referring now to FIG. 1, the input signals from a speech transmission circuit are passed through a voltage limiter to a threshold sensitive unilateral impedance. The purpose of the voltage limiter is to restrict the magnitude of the largest peaks so as to prevent damaging the device which is used as the unilateral impedance. Input signals

of sufficient magnitude to be limited by the voltage limiter are still of sufficient magnitude to exceed the threshold of the unilateral impedance. The peaks of this limited signal, of given polarity, are passed by the unilateral impedance to capacitor 11 thereby changing the charge thereon. Capacitor 11 is provided with a resistance discharge path 12, through which the charge on the capacitor can return to its original value; the discharge time associated with the resistance path and the capacitor is less than the length or period of the shortest intersyllabic pause in speech. As indicated heretofore, this discharge time however is much longer than the time per cycle of the lowest frequency (e.g., 200 c.p.s.) of the input signals. Consequently, a series of charging peaks produced by the input signals will maintain a substantially constant voltage across capacitor 11 since the discharge path is ineffective in discharging the capacitor in the short period of time available between peaks. If, however, the input signal which has exceeded the threshold of the unilateral impedance does not contain a sustained noise but is made up of speech, an inevitable intersyllabic pause in the speech will occur, thereby allowing capacitor 11 to discharge through resistive path 12 back toward its original voltage.

The electronic switch, connected to capacitor 11, is arranged to be in its ON state when the voltage on the capacitor is substantially equal to its initial or no signal voltage, and it is immediately turned OFF when the voltage on the capacitor is changed by a peak of the incoming signal which exceeds the threshold of the unilateral impedance. When the electronic switch is ON, capacitor 13 is maintained at a constant charged potential by being connected through the switch to the reference potential source. When the switch is turned OFF, this connection is interrupted and capacitor 13 is permitted to discharge through resistance path 14. The threshold sensitive output circuit is biased so as to operate the relay only when the voltage on capacitor 13 discharges below a given magnitude. Consequently, the relay will not be operated until capacitor 13 has discharged from its initial reference potential through resistance 14 for a predetermined interval of time. As will be clear hereinafter, this predetermined interval of time should be greater than that interval in which a speech pause is certain to occur in incoming speech.

Summarizing the FIG. 1 operation, if the input signal is not of a sufficient magnitude to exceed the threshold of the unilateral impedance, the entire circuit remains inoperative. If, however, the input signal does exceed the threshold of the unilateral impedance, the input peaks thereof are permitted to charge capacitor 11 thereby causing a change in its voltage, which in turn causes the electronic switch to be switched to its OFF state. Capacitor 13 is thereby disconnected from the power supply and permitted to discharge through resistive path 14. If a succession of peaks continue to exceed the threshold level of the unilateral impedance, capacitor 11 will effectively remain in its charged state and the electronic switch will remain in its OFF state. A predetermined interval of time after capacitor 13 has started its discharge, the threshold sensitive output circuit will operate and thus indicate that a sustained noise is present at the input. If, however, the input signal which is temporarily exceeding the input threshold is not a sustained noise but is made up of speech, one of the inevitable pauses in the same will occur before the threshold sensitive output circuit is able to operate. Since the pause interval is greater than the discharge time of the capacitor, capacitor 11 will have sufficient time to discharge through resistance path 12 to thereby allow the electronic switch to return to its ON state and recharge capacitor 13.

Referring now to FIG. 2, a schematic diagram of a three-transistor circuit constructed in accordance with the present invention is shown. The voltage of the input signal is limited in magnitude by the series circuit con-

nected across the input, comprising three varistors 21, 22, and 23. The action of varistors is well known in the art and may be summarized by saying that they provide a substantially high impedance to signals of a low magnitude but provide a very low impedance to signals which exceed their so-called threshold level. Consequently, the input signals are only allowed to attain a maximum voltage equal in magnitude to the sum of the threshold voltages of varistors 21, 22, and 23. The voltage limited signals are passed through the coupling capacitor 24 to the base of transistor 25. Transistor 25 is connected in a common emitter configuration and is normally biased beyond cutoff by a current which flows from ground through resistance 26 and varistor 27 to the negative potential source V. This back bias, equal in magnitude to the threshold voltage which appears across varistor 27, is transmitted through resistance 28 to the base. The input signals which are coupled to the base through coupling capacitor 24 appear across resistance 28; only those positive peaks of the voltage limited input signal which are in excess of the back bias produced by varistor 27 will be sufficient to forward bias the base-emitter junction of transistor 25. Diode 29 is connected across resistance 28 in order to bypass the negative peaks of the input signal thereby preventing excessive negative peaks from damaging transistor 25. Capacitor 31 is also connected across resistance 28 to filter out high frequency noise generated by the circuit itself during normal operation. This noise might otherwise add to the input noise and cause false indications even though the input noise is below the objectionable level. Transistor 25 is thus a threshold sensitive unilateral impedance which passes positive peaks of the input signal and only those positive peaks which are sufficient in magnitude to exceed the back bias on the base-emitter junction.

Capacitor 11, connected in the collector circuit of transistor 25, is normally maintained at a negative potential with respect to ground by current which flows from ground through resistance 12, the forward biased diode 32, the forward biased base-emitter junction of transistor 33, and back biased Zener diode 34 to the negative potential source V. This potential is normally maintained on capacitor 11, and transistor 33 is thus maintained in its ON state as long as the input signals delivered to transistor 25 do not exceed the threshold level established by varistor 27. If, however, transistor 25 is turned on by an input signal which exceeds the threshold, capacitor 11 will be rapidly charged to a much higher negative potential by the negative potential source V acting through varistor 27, transistor 25, and resistance 35. Since resistance 35 is a very small value, placed in the circuit only to protect transistor 25 during the initial warmup period when the charge on capacitors 11 and 31 is zero, the change in charge of capacitance 11 will occur very rapidly. This larger negative potential on capacitance 11 back biases diode 32 and the base-emitter junction of transistor 33, thereby transferring transistor 33 to the OFF state. Through this transition the emitter of transistor 33 remains at substantially the same voltage, established by the current which flows from ground through resistance 36 through back biased Zener diode 34 to the negative potential source V. The purpose served by diode 32 and resistance 37 is to protect transistor 33 during this back-bias condition; if the base of transistor 33 were connected directly to the collector of transistor 25, the entire back-bias potential would appear across the base-emitter junction of transistor 33 thereby possibly causing damage to the same. Instead, diode 32 absorbs a substantial part of the back-bias potential.

Capacitor 11 is provided with a discharge path through resistance 12. The discharge (i.e., time to discharge to a predetermined point at which transistor 33 goes ON) associated with this path, however, is much longer than the time interval between the pulses which are supplied by signals within the frequency range of interest (200 to

3500 c.p.s). Consequently, capacitor 11 will remain at substantially the same high negative potential during the entire period that a signal is presented to the base of transistor 25 which exceeds the threshold potential. The discharge time is, however, less than the shortest inter-syllabic pause which can be expected to occur in speech. Accordingly, if the signal which has exceeded the threshold of transistor 25 does not contain a sustained noise but rather is made up of speech, one of the inevitable pauses therein will occur and allow capacitor 11 to discharge through resistance 12 toward the potential which the capacitor maintains under no input signal conditions. This change in potential across capacitance 11 will allow the base-emitter junction of transistor 33 to be eventually forward biased thereby causing transistor 33 to return to the ON state. Hence, transistor 33 is an electronic switch, under the control of the potential across capacitance 11, and is normally ON under no signal conditions and during the pauses that occur in speech.

When transistor 33 is ON, it connects one plate of capacitance 13 through resistance 41 and back-biased Zener diode 34 to the negative potential source V. Since resistance 41 is very small in value, and is only present to protect transistor 33 during the warmup period when capacitance 13 has no charge thereon, capacitance 13 is charged very rapidly after the turn on of transistor 33. When transistor 33 is turned off, capacitor 13 is permitted to discharge through resistors 14 and 44. Since the discharge of capacitor 13 to a particular voltage which will operate succeeding circuits is used to determine a predetermined time interval, it is desirable to have capacitor 13 start its periodic discharges through resistances 14 and 44 from substantially the same potential. However, the voltage to which capacitor 13 is charged is dependent on variations in the negative potential source V. Accordingly, an alternate discharge path through resistance 45 and back-biased Zener diodes 46 and 47 is provided to rapidly discharge capacitance 13 to a substantially constant potential equal in magnitude to the threshold back-bias levels of Zener diodes 46 and 47 in series. After capacitor 13 has discharged rapidly to this back-bias threshold potential of the Zener diodes, current through this alternate discharge path ceases and capacitor 13 thence discharges slowly through resistors 14 and 44.

When capacitor 13 is at its high negative potential, that is when transistor 33 is ON, diode 48 and the base-emitter junction of transistor Q3 are back-biased. Diode 48 like diode 32 is placed in the circuit for the sole purpose of preventing the entire back-bias potential from appearing across the base-emitter junction of transistor 51 thereby possibly causing damage to the transistor. Throughout the operation, the emitter of transistor 51 remains at a substantially constant potential equal in magnitude to the back-bias threshold potential of Zener diode 52. When capacitor 13 discharges to a potential which is slightly less negative than the potential on the emitter of transistor 51, diode 48 and the base-emitter junction of transistor 51 will be forward biased thereby causing transistor 51 to go into conduction. The interval of time which elapses between the start of the capacitor 13 discharge and the turn on of transistor 51 can be controlled by changing the value of resistance 44.

The winding of the relay to be operated, as an indication that an objectionable sustained poise is present, is connected between the collector of transistor 51 and reference potential. Diode 53 is connected in parallel with the relay winding to protect transistor 51 against the transient which occurs as a result of the inductance of the relay winding when transistor 51 is turned off. Hence, the action of capacitor 13 and its associated discharge paths in combination with transistor 51 and the relay may be described as a timer which provides an output indication a predetermined interval of time after transistor 33 is turned off. This predetermined interval of time

should be greater than that interval in which a speech pause is certain to occur in the incoming speech.

In summary, when a signal appears at the input which does not exceed the predetermined threshold, the entire circuit remains inoperative with transistors 25 and 51 cut off and transistor 33 in conduction. When a signal appears at the input which does exceed the predetermined threshold, transistor 25 is turned on, transistor 33 is turned off, and capacitor 13 begins to discharge through its associated discharge path. If the signal at the input which has exceeded the threshold contains a sustained noise (e.g., three seconds), capacitor 11 will continue to be charged by successive cycles thereof thereby maintaining transistor 33 in an OFF state. Capacitor 13 is thus allowed to discharge for the predetermined interval of time until transistor 51 is turned on and the relay is operated. If, however, the input signal which has exceeded the threshold is composed only of speech, an inevitable pause will occur thereby allowing capacitor 11 to discharge, through its associated discharge path, to a point which allows transistor 33 to turn on and recharge capacitor 13. The moment that the pause ends and the next syllable or the next word in speech is presented, capacitor 13 will again discharge until the next pause occurs, at which time capacitor 13 will again be returned to its high negative potential.

What has been described hereinbefore is a specific illustrative embodiment of the principles of the present invention. It is to be understood that numerous other arrangements of physical parts and different component parts may be utilized with equal advantage. For example, although the discharge paths associated with the capacitors have been provided through resistances connected in parallel with the capacitors, a series arrangement of the capacitors and a charging or discharging path may also be utilized. Although the specific embodiment uses NPN transistors, it should be obvious to those skilled in the art that PNP transistors, with corresponding changes in the polarities of the potentials, can also be advantageously utilized in accordance with the instant invention.

Accordingly, it is to be understood that the above described arrangement is merely illustrative of the application of the principles of the present invention, and numerous modifications thereof may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. A circuit for indicating the presence of sustained noise on a speech transmission line comprising capacitance means, means operative in response to signals on said transmission line above a predetermined value to rapidly change the charge of said capacitance means in a given direction from a steady state value, impedance means coupled to said capacitance means for permitting the charge thereof to gradually return to said steady state value, switch means coupled to said capacitance means and having a given steady state condition which is altered in response to an aforementioned rapid change in the charge on said capacitance means, said switch means returning to said steady state condition when the charge on said capacitance means reached a predetermined point in said gradual return, and output means connected to said switch means for providing an output indication when said switch means has been maintained out of its steady state for a predetermined interval of time, the time period required for the charge of the capacitance means to change from that to which it was rapidly set to that at which the switch means is returned to its steady state condition is less than the commonly encountered intersyllabic period of speech, yet substantially more than the time period per cycle of the lowest frequency of the incoming signal.

2. A noise indicating circuit as defined in claim 1 wherein the said time period is less than the minimum intersyllabic period of speech.

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3. A noise indicating circuit as defined in claim 1 wherein said output means comprises second capacitance means which is retained in a given state of charge during the steady state condition of said switch means, impedance means coupled to said second capacitance means for permitting the charge thereof to gradually change from said given state when the steady state condition of said switch means is altered as aforesaid, and signaling means coupled to said second capacitance means for providing an indication when the charge on said second capacitance means reaches a predetermined point in said gradual change, the time interval required for the charge of said second capacitance means to change from said given state of charge to said predetermined point being at least equal to that interval in which a speech pause is certain to occur in incoming speech.

4. In combination, capacitance means, means operative in response to input noise and speech signals above a predetermined magnitude to rapidly charge said capacitance means, resistance means coupled to said capacitance means for discharging the same, switch means coupled to said capacitance means and having a given steady state condition which is interrupted in response to said charge of said capacitance means, said switch means returning to said steady state condition at a predetermined point in the discharge of said capacitance means, and output means connected to said switch means for providing an output indication when said switch means has been maintained out of its steady state condition for a predetermined interval of time, the time period required for the capacitance means to discharge from its charged state to said predetermined point being less than the normal intersyllabic period of speech but substantially more than the time period per cycle of the lowest frequency of the incoming signals.

5. The combination defined in claim 4 wherein the said time period is less than the minimum intersyllabic period of speech.

6. The combination defined in claim 4 wherein said output means comprises second capacitance means which is retained in a charged state during the steady state condition of said switch means, resistance means coupled to said second capacitance means for discharging the same when the steady state condition of said switch means is interrupted, and signaling means coupled to said second capacitance means for providing an indication when said second capacitance means has been dis-

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charged to a predetermined point, the time interval required for said second capacitance means to discharge from its charged state to said predetermined point being greater than that interval in which a speech pause is certain to occur in incoming speech.

7. The combination defined in claim 6 wherein said switch means is conductively coupled to the first-mentioned capacitance means.

8. The combination defined in claim 6 wherein a Zener diode means is coupled to said second capacitor means for ensuring that the latter means discharge each time from substantially the same potential.

9. The combination defined in claim 6 wherein the resistance means coupled to said second capacitor means includes a variable resistance for selectively changing the time interval.

10. The combination defined in claim 6 wherein said switch means includes a transistor with its base conductively connected to the first-mentioned capacitance means and its collector connected to the second capacitance means.

11. The combination defined in claim 10 wherein said signaling means includes a second transistor with its base conductively connected to the second capacitor means, and relay means connected to the collector of said second transistor to be operated when said second capacitor has been discharged to the predetermined point.

12. A circuit for indicating the presence of a sustained noise in a speech signal comprising capacitor means, threshold sensitive input means connected to said capacitor means for rapidly changing the charge on said capacitor means in response to a peak of the signal which exceeds a predetermined threshold, resistive means connected to said capacitor means for returning the capacitor means to its original charge, electronic switching means having a control element and a stable state, output means connected to said electronic switching means for providing an output indication when said switching means has been maintained out of its stable state for a predetermined interval of time, and means for conductively connecting the control element of said switching means to said capacitor means.

No references cited.

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