A voice-actuated switching system selectively connects multiple microphones (1, 2, N) to an audio line (36) in accordance with the output signal levels from each of the microphones. Comparison circuitry including an analog multiplexer (25), a nonlinear amplifier (40), an analog demultiplexer (45), a peak detector (50), an analog multiplexer (55), an analog to digital connector (60) and a central processing unit (65) determines the state of each microphone which can exist in one of three states: selected, mixed, or off. The microphone with the greatest output signal level at any given time is considered in the selected state and is selected for connecting to the audio line with no loss. Those microphones in the mixed state have their output signal levels attenuated before being connected to the audio line. And those microphones in the off state have their outputs essentially disconnected from the audio line. The user of a microphone which is in the mixed state can be heard along with the user of a microphone which is in the selected state, but at a lower level. Improved accuracy is obtained in the microphone selection process by comparing the microphone signals to each other and to a reference level that takes into account any offsets induced into the signals by the system. The system can accommodate any number of microphones.
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A VOICE-ACTUATED SWITCHING SYSTEM

Background of the Invention

1. Technical Field

This invention relates to a voice-actuated switching system for selectively connecting speech signals from a plurality of speech circuits to an output line, the system comprising a plurality of speech circuits for generating speech signals.

2. Description of the Prior Art

Major companies are beginning to consider teleconferencing as a cost effective way of communicating among personnel at dispersed locations and thereby reduce the need for business travel. In a teleconferencing arrangement, a number of conferees at a location are placed in communication with a number of conferees at one or more remote locations via a telephone connection. The quality of the transmission between the separated groups of conferees is generally dependent upon the position of each conferee with respect to a microphone and loudspeaking device at each location. With a single microphone and loudspeaking device in the conference location room, the transmission is subject to degradation because some of the conferees are generally at a greater than optimum distance from the microphone and loudspeaking device.

It is well known to use a plurality of microphones appropriately spaced at each conferee location such as a conference room to improve the quality of the conference system. The microphone outputs are summed and the summed output is applied to the communication links between locations. In such an arrangement, each conferee can be within an acceptable distance from one of the microphones, whereby speech pickup is of relatively good quality. With all microphones turned on at one time, however, several undesirable effects occur. The total noise pickup is much greater than for a single microphone.
The artificial reverberation effects occasioned by the delayed signal pickup from the more remote microphones severely lower the quality of the conference transmission. Further, electroacoustic instability can easily result from the plurality of the always turned on microphones. It is therefore desirable and known in the art to provide a switching arrangement which permits only that microphone closest to the talking conferee to be active so that reverberation and noise pickup are minimized.

Such an arrangement is commonly known as a "voting circuit." In the "voting circuit" arrangement, the loudest talker can capture control and lock out the other conferees at his location. This automatic switching between microphones responsive to the highest speech level microphones, however, may also result in transmission interruptions which adversely affect intelligibility and can result in unwanted interference occasioned by transient room noise. For example, a loud noise at one of the conference locations may completely turn off the controlling microphone. Further, since only one microphone is operative at a time, transfer of control from one microphone to another such as occasioned by the talking conferee moving from one position to another in a room location can result in speech transmission of varying quality, interruptions in transmission, and reverberation effects which vary with the talking conferee's position.

Various teleconferencing arrangements have been proposed and used heretofore for selecting a single microphone of a plurality of conferee microphones and for transmitting the signal from only the selected microphone. An example of such an arrangement is seen in U. S. Patent No. 3,730,995. In this arrangement, each of a plurality of microphones is associated with a speech detector and a relay. In response to voice signals from one of the microphones, an associated speech detector activates its relay which connects the microphone to an audio line and generates a signal inhibiting the other relays. Another
example is seen in U.S. Patent No. 3,755,625. This patent discloses a multimicrophone-speakerphone arrangement using a comparator in combination with logic circuitry for selecting a microphone with the greatest output and connecting it to the speakerphone input while simultaneously disconnecting the other microphones. While these arrangements have been satisfactory in minimizing the degradation of the speech signals due to reverberation and noise pickup, it is nevertheless a problem that the microphone selection technique does not appear to occur in as normal a manner as possible. And it is a further problem of syllabic clipping that occurs when a microphone turns on from the full off condition.

The problems are solved in accordance with this invention in a voice-actuated switching system in which the system further comprises comparison circuitry automatically operative in response to the signals from the speech circuits for selecting that one of the signals having the greatest magnitude, a control unit for connecting the selected one of the signals to the output line at an unattenuated level and for connected unselected signals to the output line at an attenuated level, and the comparison circuitry determines the signal with the greatest magnitude by comparing the signals both with reference to each other and with reference to a ground potential.

Summary of the Invention

In accordance with the present invention, in a teleconferencing system a voice-actuated switching arrangement provides for the selection of multiple microphones in accordance with the output signal levels from each of the microphones. The outputs of the microphones are combined and applied via a voice gate and bridge circuit to a telephone line. The state of each microphone is determined by its use and each can exist in one of three states: selected, mixed, or off. The microphone with the greatest output at any given time is considered in the selected state and is selected by the
switching arrangement for connecting to the voice gate and bridge circuit with no loss. Those microphones whose outputs have exceeded a certain predetermined threshold level at least once during the conference, though not necessarily to the extent of having been in the selected state, are considered to be in the mixed state and have their outputs attenuated before being connected to the voice gate and bridge circuit. Once in the mixed state these microphones will only change between the mixed and selected states for the duration of the conference.

The off state is applicable to those microphones whose outputs have not exceeded the predetermined threshold level at least once during the conference and have their outputs essentially disconnected from the voice gate and bridge circuit. This state serves to avoid the additional noise from those microphones that would be present were they initially in the mixed state. Speaking into a microphone while in this state will cause the microphone to change either to the mixed or selected state depending upon the conferee's speaking level. Once activated it will also vary about these two states and not return to the off state. In addition to allowing other speaking conferees to be heard, the tri-state arrangement of the microphones avoid the syllabic clipping that would be apparent if the microphones were to change only between the selected and off states.

In accordance with the invention, another aspect thereof is directed to the voice-actuated switching arrangement for detecting the state of each of the multiple microphones. The arrangement simplifies and reduces the amount of circuitry used for "microphone voting" yet maintains a high level of accuracy in microphone selection. In achieving this, the arrangement incorporates a first and a second analog multiplexer and an analog demultiplexer for processing the speech signals from each of the multiple microphones. The first multiplexer not only samples at a moderately high frequency rate the signal on the
microphones but also samples the signal "ground" level for reference purposes. These signals are coupled via a single nonlinear amplifier onto the demultiplexer which is synchronized with the first multiplexer and is used for decoding the sampled speech signals. Multiple peak detectors are used to store the signals provided by the demultiplexer. The second multiplexer samples each of the peak detectors at a rate slower than the rate of the first multiplexer and the demultiplexer but sufficiently high enough to avoid syllabic clipping. Hence, accuracy in the microphone selection is enhanced by having these multiplexers and the demultiplexer provide interfacing through a common nonlinear amplifier for multiple peak detectors that contain both the signal envelope from each of the microphones and the ground reference level. And in providing this reference level along with the signals, the requirement of having a stable ground reference is avoided since temperature and component changes are accommodated and any offsets induced in the signals are compensated.

Brief Description of the Drawing

The invention and its mode of operation will be more clearly understood from the following detailed description when read with the appended drawing in which:

FIG. 1 is a block diagram of the voice-actuated switching system showing the major functional circuit components of the system and their general interconnection with each other in accordance with the present invention;

FIGS 2 and 3 present a schematic diagram showing the detailed circuitry of an embodiment of the voice-actuated switching system; and

FIG. 4 shows a modified embodiment of the voice-actuated switching system of FIG. 1 in accordance with the present invention.

Detailed Description

Referring now to FIG. 1 of the drawing, there is shown a functional block representation of a voice-actuated switching system operative in accordance with the
principles of the invention. As shown, the switching system comprises multiple microphones 1, 2, and N that are each respectively connected via an associated preamplifier to lead 1, lead 2, and lead N. These leads connect the multiple microphones with a microphone control unit 20 and comparison circuitry including an analog multiplexer 20, a nonlinear amplifier 40, an analog demultiplexer 45, a peak detector 50, an analog multiplexer 55, an analog to digital converter 60 and a central processing unit 65. The microphone control unit 20 couples the microphone signals to a summing amplifier 30 where the signals are further amplified. From the amplifier 30 the signals are coupled to a voice gate and bridge circuit 35 which switches between a receive state wherein it couples incoming signals from the central office onto the room speakers and a transmit state wherein the microphone signals are coupled to a telephone line 36 for transmission to the central office. The voice gate and bridge circuit 35 continually compares the output signal of the summing amplifier 30 with the signal received from a remote location and determines which of the two is the larger. The larger signal is coupled through the voice gate and bridge circuit 35, and the smaller signal is further attenuated by this circuit to reduce speaker-to-microphone echoes.

The analog multiplexer 25 sequentially samples at a moderately high frequency rate all of the microphone signals and serially couples these signals to the nonlinear amplifier 40 which compresses somewhat the peak amplitude of the signals. Moreover, as part of the sampling routine the analog multiplexer 25 also samples the signal ground reference level and couples this signal to the nonlinear amplifier 40. Thus, through use of a single nonlinear amplifier, its parameters are made common both to the microphone signals and the ground reference level, and the resolution of the system is increased thereby. The required circuitry for the system is also minimized.
Coupled to the output of the nonlinear amplifier 40 is the analog demultiplexer 45 which operates in synchronism with multiplexer 25, and has the same number of outputs as multiplexer 25 has inputs. Demultiplexer 45 changes the serial data stream containing amplitudes of the sampled microphone signals and the signal ground reference level once again into a parallel data stream. These signals are all applied to the peak detector circuit 50 wherein the signal envelope for each microphone is stored. The multiple outputs of the peak detector 50 are sampled by the analog multiplexer 55 which combines the parallel data signals into a serial data signal for application to the analog-to-digital converter 60.

Operation of the analog multiplexer 55 is at a rate 100 times slower than the multiplexer 25 and demultiplexer 45. The advantage derived by this arrangement is that multiplexer 25 and demultiplexer 45 allow for a sufficiently rapid sampling rate to detect any fast changes in signal level upon the microphones while multiplexer 55 with its slower sampling rate allows for a reduced processing time in which to make any changes in the system dictated by the signal level changes on the microphones.

The analog-to-digital converter 60 couples the microphone signals and the signal ground reference level to the central processing unit (CPU 65). CPUs are commercially available. The voice switching system described in this invention uses approximately 50% of the processing capability of the CPU. The signals from the analog-to-digital converter 60 are compared both to each other and to the ground reference level in the CPU 65 to determine which signal is of the greatest magnitude. In that the ground reference level compared is that which is provided as an input to the multiplexer 25, the assurance of accuracy in the comparing of the signals is provided since any offsets or other circuit-induced or temperature-induced errors in the signals will also be present in the...
reference level. Thus the difference between the speech
signal levels and the reference level yields a direct
measure of the speech signal levels during the comparison
process in the CPU 65.

In operation, a control signal is provided from
the CPU 65 to the microphone control unit 20. This control
signal allows the microphones to exist in one of three
states: selected, mixed, or off. The microphone having
the greatest sampled signal level on peak detector 50 is
considered in the selected state and is selected by the
microphone control unit 20 for connecting to the voice gate
and bridge circuit 35 with no loss in its circuit path.
Those microphones having signals that have exceeded a
certain predetermined amplitude level on peak detector 50
at least once after the initiation of the conference are
considered to be in the mixed state and have their output
circuit paths attenuated before being connected to the
voice-switched bridge 35. Those microphones that have not
had a signal exceed the predetermined amplitude level at
least once during the conference are essentially
disconnected from the voice-switched bridge by the
microphone control unit 20. Speaking into a microphone
while in this state causes the microphone to change either
to the mixed or selected state depending upon the
conferee's speaking level into the microphone. For a
different microphone to become selected, it must exceed the
level of the presently selected microphone by 50%. Once
activated, a microphone will only change between the mixed
and selected state and not return to the off state during
the conference.

Referring now to FIG. 2, there is shown a
schematic diagram of part of the detailed circuitry of the
voice-actuated switching system of FIG. 1. For
illustration purposes, microphones 101 through 112 and
their respectively associated preamplifiers 121 through 132
are shown in this embodiment. It will become obvious to
those skilled in the art that any number of microphones
other than twelve can be utilized in practicing this invention. Hence it is not intended nor should the invention be construed as being limited to any particular number of microphones by this illustration.

Preamplifiers 121 through 132 are identical in design and thus for simplicity only preamplifier 121 is shown and described in specific detail.

The output of microphone channel 101 is connected to the first of two operational amplifiers comprising preamplifier 121. The first amplifier 135, provides a balanced input for microphone 101 through resistors 136 and 137. And capacitors 138 and 139 are connected across this input and voltage level +V in order to suppress radio frequency demodulation in this first stage. The first amplifier 135, having associated components, resistors 140, 141, 142, and capacitor 143, amplify the output of microphone channel 101 and couple this signal to the second operational amplifier via resistor 144 and capacitor 145. This second operational amplifier 146, having associated components, resistor 147 and feedback resistor 148, further amplifies the output of microphone 101.

The output of the first preamplifier 121 is fed to a select section 201 and a mixer section 202 in the microphone control unit 20 and also on line 150 to the analog multiplexer 25 (shown in FIG. 3) to be later discussed. Under the control of the CPU 65, the microphone control unit 20 controls the selected, mixed and off states of the twelve microphones. Select section 201 and mixer section 202 are used for determining the selected and mixed states, respectively, of the first four microphones. For example, as earlier indicated, the output of preamplifier 121 on line 151 goes both to one of the four inputs of select section 201 and one of the four inputs of mixer section 202. When the microphone is considered in the off state, neither switch 211 in select section 201 nor switch 215 in mixer section 202 are closed.
As the microphone output exceeds a predetermined amplitude threshold, the CPU 65 provides an activation signal that closes switch 215 in mixer section 202. This then places microphone 101 in the mixed state since the output of preamplifier 121 is coupled through switch 215 in mixer section 202 and then through resistor 225 in resistor network 205 and onto capacitor 301 in mixer amplifier 30. As the amplitude of microphone 101 increases to the point where it has the largest speech signal input, the CPU 65 then provides a control signal to select section 201 and causes switch 211 to close and switch 215 in mixer section 202 to open. In this state, microphone 101 is the selected channel and its output is coupled through switch 211 of select section 201, resistor 221 of resistor network 204 and onto capacitor 301 of mixer amplifier 30.

Control signals are provided by the CPU 65 on the bus to the microphone control unit 20 such that only one microphone channel can be in the selected state, the remainder being either in the off or mixed state. Thus, in the foregoing example and with reference to the illustrative embodiment showing the control unit switches 211 through 218 for the four microphones, while microphone 101 is in the selected state, microphone channels 102, 103, and 104 are necessarily in either the off or mixed state. Select and mixer sections 203 for microphones 105 through 112 and accompanying resistor network 206 perform in the same manner for these channels, as do select section 201 and mixer section 202 and their respective resistor networks 204 and 205 for microphones 101 through 104. In extending the foregoing example, microphones 105 through 112 are also necessarily in either the off or mixed state. It is seen, therefore, that the control unit 20 directs the output of each microphone through two different paths to the common input of the summing amplifier 30. One path provides zero decibel of gain to the signal and the other 6 decibels of gain to the signal to the summing amplifier 30. This
amplifier, which comprises operational amplifier 302 and associated components, resistors 303, 304, and capacitor 305, applies the output signal onto line 160 for coupling to the voice gate and bridge circuit 35 shown in FIG. 1.

Referring now to FIG. 3, there is shown a schematic diagram of the remainder of the detailed circuitry of the voice-actuated switching system of FIG. 1. The output of each one of the microphone preamplifiers 121 through 132 (shown in FIG. 2) is coupled over line 150 to the input of analog multiplexer 25. This multiplexer serves as a microphone scanner and sequentially couples the output of each preamplifier to the input of a nonlinear amplifier 40. The scanning interval is set at 100 microseconds allowing 6.25 microseconds for each microphone channel. In addition to the twelve amplifier inputs provided to this multiplexer, another four inputs at signal ground reference level are provided.

The nonlinear amplifier 40 is shared commonly between the microphone channels and the inputs for signal ground reference level. This amplifier comprises operational amplifier 400, resistors 401 through 407, and capacitor 408. Diode 409 is also included for attenuation of the larger amplitude signals. The signals are also provided with a dc offset by diode 410 to compensate for a voltage drop caused by diodes in the peak detectors that are later described. The signal from the nonlinear amplifier 40 is provided to the analog demultiplexer 45 which changes the signal from a serial to a parallel form for applying to the peak detectors.

Each of the twelve microphone signals and the four ground reference signals are used for charging the peak detector capacitors 501 through 516. In the charging of peak detector capacitor 501, for example, a positive input from the non-linear amplifier 40 charges this capacitor through resistor 407 and diode 521. As earlier indicated, diode 410 provides a dc offset necessary to
compensate for the diode drop that has to be overcome in each peak detector. This is due to diodes 521 through 536. These diodes are inserted to limit the charging current flow to one direction in the peak detectors. The charging time constant for the peak detectors is 10 microseconds and the discharge time constant is 500 milliseconds. This discharge time constant is determined by resistor 540 and each capacitor in the peak detectors as they are sequentially connected by the analog multiplexer 55 to resistor 540 and a buffer amplifier 550.

The scanning interval of analog multiplexer 55 is set to scan all sixteen peak detectors every 10 milliseconds. This scanning interval is also set to recognize syllabic speech, i.e., catch the leading edge of the voice. Thus a decision as to whether a microphone is on or off is available to the system within 10 milliseconds. And since the average person can barely detect a clip in syllabic speech within 20 milliseconds, this sampling interval is sufficiently fast to avoid such detection.

Operation of the peak detecting and multiplexing part of the system might be better appreciated when considered in conjunction with the following example. If a person is talking with an energy content in his or her voice at around 500 Hertz with a 2 millisecond time period, and if a voter circuit performed sampling in real time, it is very possible the sampling could take place in the null of this person speaking. In the arrangement of this invention, the peak detectors are utilized to conveniently store speech signals obtained at a high sampling rate while the multiplexer 55 needs only to sample the envelope of the speech at a rate exceeding the detectable clipping rate.

Analog multiplexer 25 and analog demultiplexer 45 are synchronized through use of a system clock 70. An output of the system clock is used to drive a four-bit binary counter 710 which has its output coupled to both multiplexer 25 and demultiplexer 45 on lines 711 through
714 for providing the synchronous four-bit binary count required. Also provided to the multiplexer 25 and the demultiplexer 45 is an enable signal from the system clock on line 701 and a timing signal to the CPU 65 on line 702. The clock 70 also provides an enable signal on line 703 to the analog multiplexer 55, an analog-to-digital converter 60, a tri-state latch 655 and a tri-state buffer 660. The scanning interval of analog multiplexer 55 is determined by a four-bit binary signal that is provided from the CPU 65 over data bus 670 to the tri-state latch 655 where it is stored and then applied to the count input of multiplexer 55 over lines 656 through 659.

The eight-bit analog-to-digital converter 60 receives the sixteen different output signals from the peak detectors and couples these signals onto the data bus 670 and to the CPU 65 via the buffer 660. The CPU 65 uses this signal to select the appropriate microphone channel to be in the selected state and the appropriate microphone channels to be in the mixed state, as well as the microphone channels that are left in the off state.

By providing the reference level along with the signals for processing by the CPU 65, the requirement for having a stable reference is avoided. This is possible since any drifts in the reference level will be compensated for in the CPU 65. For example, the reference level can drift because of diodes in the circuit paths having coefficients that vary with temperature. The ground reference level that accompanies the microphone signals, however, compensates for any unaccounted for offsets of the signals going through the system by including the offsets in determining a reference for absolute zero. This new reference level is then subtracted in the CPU 65 from all of the readings and a true measure of the talking levels is obtained.

In providing an eight-bit signal to the CPU 65, the analog-to-digital converter 60 provides 256 discrete signal levels. These signal levels are used as follows by
the CPU 65. The lower threshold level below which signals are ignored is defined to be a signal level of 3 above the digitized value of the reference level, the reference level being the level of any or all of the sampled ground inputs and is considered to be at absolute zero by the CPU 65.

And the upper threshold is defined dynamically as a level 50% above the microphone channel presently in the selected state. In order for a microphone to reach the mixed state, the microphone channel must exceed a signal level of 16 above the reference level at least once after the room is placed in a conference mode.

The process for making this selection can be set forth generally as follows:

1. An upper threshold is defined above the level of the present selected microphone channel.
2. The loudest talker is determined.
3. If the loudest talker's level is less than a lower threshold (set slightly above ambient noise), then disregard it.
4. If the loudest talker's level is greater than the upper threshold, then consider this the new selected microphone channel and couple this channel to an audio line unattenuated.
5. All other activated microphone channels are coupled to the audio line attenuated.

Various modifications within the scope of this invention are possible. By way of example, a voice-actuated switching system is implemented in a video teleconferencing arrangement using voice-switched cameras.

Like audio teleconferencing, video teleconferencing, since it also saves travel time and cost, is expected to become an important communications method.

In video teleconferencing, a plurality of video cameras are generally used and the field of view of each is restricted to a small number of persons in the group.

Voice voting and switching are used to determine the location of the person in the group who is talking and to
enable the appropriate camera to respond thereto so that the talker will be seen at the remote location. As different people in the group speak, the appropriate cameras covering the same are successfully enabled so that the outgoing video signal matches the audio signal.

Shown in FIG. 4, in accordance with the invention, is a modified embodiment of the switching system of FIG. 1 wherein video cameras are selected according to voice voting. The cameras 801 through 805 are connected to a camera and monitor control unit 80 via respective amplifiers 811 through 815. Also connected to the camera and monitor control unit 80 are monitors 821 through 823 that are set to show either the incoming or outgoing signals as preferred.

With the microphone signal levels and the signal ground reference level provided by the analog-to-digital computer 60, the CPU 65 compares and determines which signal is of the greatest magnitude. The CPU 65 then applies a control signal to the camera and monitor control unit 80 for selecting the camera that includes the speaking conferee in its field of view. Input from the voice gate and bridge circuit 35 is provided to the CPU 65 for determining whether the conference room is in a transmit or receive audio state. Hence, when the room is in a transmit audio state, the camera and monitor control unit 80 is instructed by the CPU 65 to send a video signal to the picture processor 90 for transmission to the remote conference locations. When in the receive audio state, locally generated video signals are shown as desired along with the received video signal from a remote conference location on the monitors 821 through 823. The picture processor 90 arranges the video signal in an analog or digital format necessary for transmission to the one or more remote conference locations.

Various other modifications of this invention are contemplated and may obviously be resorted to by those skilled in the art without departing from the spirit and
scope of the invention as hereinafter defined by the appended claims.
Claims

1. A voice-actuated switching system for selectively connecting speech signals from a plurality of speech circuits to an output line (36), the system comprising:
   a plurality of speech circuits (101) for generating speech signals;
   CHARACTERIZED IN THAT
   the system further comprises:
   comparison circuitry automatically operative in response to the signals from the speech circuits for selecting that one of the signals having the greatest magnitude;
   a control unit (20) for connecting the selected one of the signals to the output line at an unattenuated level and for connected unselected signals to the output line at an attenuated level; and
   the comparison circuitry determines the signal with the greatest magnitude by comparing the signals both with reference to each other and with reference to a ground potential.

2. The system in accordance with claim 1, CHARACTERIZED IN THAT the comparison circuitry includes:
   an analog multiplexer (25) and an analog demultiplexer (45) for sequentially sampling each of the plurality of speech circuits and the ground reference level and providing output signals representative thereof within a first time period.

3. The system in accordance with claim 2, CHARACTERIZED IN THAT the multiplexer (25) and demultiplexer (45) have an amplifier (40) connected therebetween, the amplifier having its input sequentially connected to each of a plurality of inputs of the multiplexer for amplifying the respective signals of the speech circuits thereupon and measuring the ground reference level at the input of the
multiplexer, and its output alternately connected between each of a plurality of outputs of the demultiplexer, the outputs of the demultiplexer corresponding in number to the inputs of the multiplexer.

4. The system in accordance with claim 3, CHARACTERIZED IN THAT the comparison circuitry further comprises: a peak detector (50) comprising a plurality of detecting circuits each detecting circuit being associated with one of the speech circuits or the ground reference level and connected to one of the plurality of outputs of the demultiplexer.

5. The system in accordance with claim 4, CHARACTERIZED IN THAT the comparison circuitry further comprises a second analog multiplexer (55) with a plurality of inputs, each input being connected to one of the plurality of detecting circuits for sequentially sampling within a second time period the voltage level representing each of the speech circuit signals stored thereupon or the ground reference level, the second time period being greater than the first time period.

6. The system in accordance with claim 5, CHARACTERIZED IN THAT the first and second analog multiplexers (25, 55) and the analog demultiplexer (45) in combination provide for the first sampling time period for measuring the signal from the speech circuits and ground reference level, and the second protracted sampling time period for measuring the voltage stored on the peak detectors.

7. The system in accordance with claim 5, CHARACTERIZED IN THAT the comparison circuitry further comprises: an analog-to-digital converter (60) for converting each of the speech circuit signals and the ground reference signal to its respective digital equivalent signal, the analog-to-digital converter having
as its input the output of the second analog multiplexer.

8. The system in accordance with claim 7,
   CHARACTERIZED IN THAT
   the comparison circuitry further comprises:
   a central processing unit (65) connected to
   the output of the digital-to-analog converter, the central
   processing unit comparing each of the digital speech
   circuit signals with each other and with the digital ground
   reference level, and selecting that one of the signals
   having the greatest magnitude above the ground reference
   level.

9. The system in accordance with claim 8,
   CHARACTERIZED IN THAT
   the central processing unit (65) applies a
   first control signal identifying the speech circuit signal
   having the greatest magnitude to the control unit.

10. The system in accordance with claim 9,
    CHARACTERIZED IN THAT
    the central processing unit (65)
    identifies the speech circuits having those signals that
    have exceeded a predetermined magnitude with respect to the
    ground reference level, the central processing unit
    providing a second control signal reflecting this
    occurrence to the control unit (20).

11. The system in accordance with claim 10,
    CHARACTERIZED IN THAT
    the control unit (20) connects the unselected
    signals to the output line at a first and a second
    attenuated level, the first attenuated level having more
    loss inserted than the unattenuated signal level and is
    applied in response to the second control signal, and the
    second attenuated signal level having more loss inserted
    than the first attenuated signal level and is applied by
    the control unit in the absence of a first or a second
    control signal.

12. The system in accordance with claim 11,
    CHARACTERIZED IN THAT
the comparison circuitry provides for the selected signal having the greatest magnitude in a first selection interval to be replaced with another selected signal having the greatest magnitude in a subsequent selection interval, a selection interval being equal to the second time period.
1. (Amended) A voice-actuated switching system for selectively connecting speech signals from a plurality of speech circuits to an output line (36), the system comprising:

- a plurality of speech circuits (101) for generating speech signals;
- the system further comprises: comparison circuitry automatically operative in response to the signals from the speech circuits for selecting that one of the signals having the greatest magnitude;

CHARACTERIZED IN THAT
the system further comprises:
- a control unit (20) for connecting the selected one of the signals to the output line at an unattenuated level and for connected unselected signals to the output line at an attenuated level; and
- the comparison circuitry determines the signal with the greatest magnitude by comparing the signals both with reference to each other and with reference to a ground potential.

2. The system in accordance with claim 1, CHARACTERIZED IN THAT
the comparison circuitry includes:
- an analog multiplexer (25) and an analog demultiplexer (45) for sequentially sampling each of the plurality of speech circuits and the ground reference level and providing output signals representative thereof within a first time period.

3. The system in accordance with claim 2, CHARACTERIZED IN THAT
the multiplexer (25) and demultiplexer (45) have an amplifier (40) connected therebetween, the amplifier having its input sequentially connected to each of a plurality of inputs of the multiplexer for amplifying the respective signals of the speech circuits thereupon and measuring the ground reference level at the input of the
INTERNATIONAL SEARCH REPORT

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)

According to International Patent Classification (IPC) or to both National Classification and IPC

INT. Cl. 2 H04M 3/56
US. 179/ICN, 2TS

II. FIELDS SEARCHED

Minimum Documentation Searched

<table>
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<tr>
<th>Classification System</th>
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<tr>
<td>US</td>
<td>179/ICN, IVC, IHF, 2TS, 2TV, 18BC, 370/62; 358/85</td>
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Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched

III. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of Document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to Claim No.</th>
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<tr>
<td>A</td>
<td>US, A, 3,601,530, (Edson et al.) 24 AUGUST 1971</td>
<td>1-12</td>
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<td>Y</td>
<td>US, A, 3,694,578, (Reid) 26 SEPTEMBER 1972</td>
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<td>Y</td>
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<td>A</td>
<td>US, A, 3,730,995, (Mathews) 01 MAY 1973</td>
<td>1-12</td>
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* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"S" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search: 04 MAY 1983
Date of Mailing of this International Search Report: 13 MAY 1983

International Searching Authority: ISA/US

Signature of Authorized Officer:
W.J. Brady

Form PCT/ISA/370 (second sheet) (October 1991)