FORM 1

SPRUSON & FERGUSON

APPLICATION ACCEPTED AND AMENDMENTS ALLOWED 13-2-90

COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952

596333

APPLICATION FOR A STANDARD PATENT

American Telephone and Telegraph Company, incorporated in New York, of 550 Madison Avenue, New York, New York, 10022, UNITED STATES OF AMERICA, hereby apply for the grant of a standard patent for an invention entitled:

Technique for Improved Subjective Performance in a Communication System Using Attenuated Noise-Fill

which is described in the accompanying complete specification.

Details of basic application(s):-

Basic Applic. No:	Country:	Application Date:
209,458	US	20 June 1988

The address for service is:-

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31 Market Street
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DATED this THIRTY FIRST day of MAY 1989

American Telephone and Telegraph Company

By: J. Spruson

Registered Patent Attorney

TO: THE COMMISSIONER OF PATENTS
OUR REF: 97466
S&F CODE: 63845

S007872 01/06/89

5845/2

FORM 8

COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952-69

DECLARATION IN SUPPORT OF A CONVENTION APPLICATION FOR A PATENT

In support of the Convention application made for a patent for an invention entitled: TECHNIQUE FOR IMPROVED SUBJECTIVE PERFORMANCE IN A COMMUNICATION SYSTEM USING ATTENUATED NOISE-FILL.
I, Christopher Simon Thirsk Buckley of 37 The Albany, Sunset Avenue, Woodford Green, Essex IG8 0TJ, England

do solemnly and sincerely declare as follows:

1. I am authorized by American Telephone and Telegraph Company, the applicant for the patent to make this declaration on ~~their~~ its behalf.

2. The basic application(~~s~~) as defined by Section 141 of the Act was made in the United States of America on the 20th day of June 1988 by ROBERT C. ASHENFELTER, MARCO J. BONOMI AND DUANE O. BOWKER.

3. ROBERT C. ASHENFELTER of E4 Hillside Court, Highlands, New Jersey 07732, United States of America, MARCO J. BONOMI of 38 Spruce Drive, Fair Haven, New Jersey 07704, United States of America and DUANE O. BOWKER of 20 Third Avenue, Neptune City, New Jersey 07753, United States of America.

are the actual inventor(s) of the invention and the fact upon which American Telephone and Telegraph Company is entitled to make the application is as follows:

The said Company is the assignee of the actual inventor(s).

4. The basic application referred to in paragraph 2 of this declaration was the first application made in a Convention country in respect of the invention the subject of the application.

Declared at LONDON

this 19th day of May 1989

C A Buckley

Declarant

To: The Commissioner of Patents.

(12) PATENT ABRIDGMENT (11) Document No. AU-B-35969/89
(19) AUSTRALIAN PATENT OFFICE (10) Acceptance No. 596333

(54) Title
TECHNIQUE FOR IMPROVED SUBJECTIVE PERFORMANCE IN A COMMUNICATION SYSTEM USING ATTENUATED NOISE-FILL

International Patent Classification(s)
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209458 20.06.88 US UNITED STATES OF AMERICA

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AMERICAN TELEPHONE AND TELEGRAPH COMPANY

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(74) Attorney or Agent
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(56) Prior Art Documents
AU 562044 41026/85 H04B 15/00
AU 558636 22223/83 H04B 7/005
EP 112108 H04B 7/005

(57) Claim

1. A method of providing noise matching to a destined end user in a communication system during gaps in active signal transmission to the end user, the method comprising the steps of

(a) detecting periods of active and inactive signal transmissions destined for the end user,

(b) concurrent with step (a), measuring the background noise level at the input of a transmitter providing the signal transmission destined for the end user during either one or both of the active and inactive signal transmission periods,

(c) during the detected period of each active signal transmission in step (a), directing the active signal transmission to the end user, and

(d) during the detected period of each inactive signal transmission in step (a), generating a noise fill signal for transmission to the end user, the noise fill signal provided to the

end user comprising a level that is attenuated by a predetermined amount from the background noise level measured at the input of the transmitter in step (b) for providing improved subjective performance.

5. A receiver for use in a communication system, comprising means for receiving from a remote transmitter active signal transmissions interspersed with inactive signal transmission periods which are destined for a predetermined end user of the receiver, and generating and directing means responsive to (1) a first control signal indicating each period of active signal transmission for directing the received active signal transmission to the end user, and (2) both a second control signal indicating each period of inactive signal transmission, and a third control signal indicating a background noise level measured at the input of the remote transmitter for generating a noise fill signal comprising a level that is attenuated by a predetermined amount from the background noise level measured at the input of the remote transmitter and directing the attenuated noise fill signal to the end user during each inactive signal transmission period for providing improved subjective performance.

S & F Ref: 97466

FORM 10

COMMONWEALTH OF AUSTRALIA

PATENTS ACT 1952

COMPLETE SPECIFICATION

596333

(ORIGINAL)

FOR OFFICE USE:

Class Int Class

Complete Specification Lodged:
Accepted:
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Related Art:

Name and Address of Applicant: American Telephone and Telegraph Company
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Complete Specification for the invention entitled:

Technique for Improved Subjective Performance in a Communication System Using Attenuated Noise-Fill

The following statement is a full description of this invention, including the best method of performing it known to me/us

METHOD OF PROVIDING NOISE MATCHING IN A COMMUNICATION SYSTEM AND RECEIVER FOR USE THEREIN

This invention relates to methods of providing noise matching in a communication system and to receivers for use therein.

In certain communication systems it has been found advantageous to insert noise when a speech or data signal is not present. More particularly, in, for example, a packet communication system, an access interface (AI) generates voice packets only when its speech detector determines that there is activity present on a trunk. When gaps are encountered in the packet stream, the receiving AI inserts noise at a level corresponding to the continuous real-time estimates of the background noise present in the incoming trunk. These estimates can, for example, be made at the trasmitting AI and sent to the receiving AI in the packet headers or preambles. Noise insertion is performed to prevent degradations in voice quality that could result from obvious discontinuities in the background noise level as the speech transmission is switched on and off. The term "noise pumping" is frequently used to describe the sudden changes in noise associated with inadequate background noise matching.

An exemplary communication system that uses a noise-matching technique is described, for example, in (1) the article "TASI-E Communication System" by R.L. Easton et al. in IEEE Transactions On Communications, Vol. COM-30, No. 4, April 1982, at pages 803-807, and in particular at pages 804 and 805, and (2) in U.S. patent 4,408,324 issued to D.H.A. Black et al. on October 4, 1983. In such communication system, a channel-checking arrangement is used to periodically measure, inter alia, the noise on the channels of the system, the measured channel noise then being used along with the measured background noise on the incoming trunk in a noise-matching operation during silent periods on the channel. In other words, when a trunk is not connected to a channel, such

communication system inserts noise at the transmitting or receiving end of that channel to make the total noise at the channel output equal to the same value as when the trunk is connected to the channel and a signal is being transmitted over the channel, thereby avoiding various effects such as noise-pumping.

Similar techniques are also used in digital conferencing arrangements as described, for example, in U.S. patent 4,482,998 issued to M.A. Marouf et al. on November 13, 1984. There, when no one is momentarily speaking during a conference connection, which is formed from a plurality of ports on a bridge connection, a minimum number of selected ports are maintained in a holdover state to provide background noise on the bridge. This ensures that each conferee receives some minimum background noise to eliminate the feeling that the conferee is cut off from the conference.

The problem remaining in the prior art is to provide a technique which can further improve, if possible, the subjective performance of a communication system, which includes speech interpolation and may or may not include noise-matching.

According to one aspect of this invention there is provided a method of providing noise matching to a destined end user in a communication system during gaps in active signal transmission to the end user, the method comprising the steps of (a) detecting periods of active and inactive signal transmissions destined for the end user, (b) concurrent with step (a), measuring the background noise level at the input of a transmitter providing the signal transmission destined for the end user during either one or both of the active and inactive signal transmission periods, (c) during the detected period of each active signal transmission in step (a), directing the active signal transmission to the end user, and (d) during the detected period of each inactive signal transmission in step (a), generating a noise fill signal for transmission to the end user, the noise fill signal provided to the end user comprising a level that is attenuated by a predetermined amount from the background noise level measured at the input of the transmitter in step (b) for providing improved subjective performance.

According to another aspect of this invention there is provided a receiver for use in a commication system, comprising means for receiving from a remote transmitter active signal transmissions interspersed with inactive signal transmission periods which are destined for a predetermined end user of the receiver, and generating and directing means responsive to (1) a first control signal indicating each period of active signal transmission for directing the received active signal transmission to the end user, and (2) both a second control signal indicating each period of inactive signal transmission, and a third control signal indicating a background noise level measured at the input of the remote transmitter for generating a noise fill signal comprising a level that is attenuated by a predetermined amount from the background noise level measured at the input of the remote transmitter and directing the attenuated noise fill signal to the end user during each inactive signal transmission period for providing improved subjective performance.

Thus in a communication system such as, for example, a Wideband Packet Technology (WPT) Access Interface (AI) with speech interpolation, a noise measurement at the transmitter end, or the reproduced noise-fill at the receiver end, is attenuated or reduced by a predetermined amount from the average monitored level of noise normally received over a channel when communication is taking place before being provided to an end user during non-information transmission periods.

The invention will now be described by way of example with reference to the accompanying drawings, in which:

FIG. 1 is a block diagram of pertinent parts of an exemplary communication system employing a noise matching method in accordance with and a receiver embodying the present invention;

FIG. 2 depicts an exemplary arrangement for a combination of a speech detector, noise measuring means and attenuator in the transmitter of FIG. 1; and

FIG. 3 is a graph representing an exemplary result of providing improved subjective performance of speech transmission by reducing the amount of noise fill provided during gaps in the speech transmission below the point (0 dB) where the matched noise level is exactly equal to the input noise level.

FIG. 1 shows only pertinent parts of a transmitter 10 and a receiver 20 within a communication system for practicing the present noise-matching technique, where information signal detection and noise measurements are performed at transmitter 10 and used at both the transmitter 10 and the associated receiver 20. For purposes of explanation hereinafter, it will be assumed that the information signal used as an input to transmitter 10 is a speech signal, but it should be understood that the information signal could comprise any other information signal such as a music signal, that a person associated with a remote receiver might be listening to. Additionally, it should be understood that any form of information signal transmission can be used for practicing the present invention of noise matching, as, for example, analog, digital or packet trasmission with a wideband or narrow band spectrum, since the form of transmission is arbitrary.

More particularly, during a connection between two end users in voice communication, the input speech signal from a first end user at input 11 is directed to each of (a) a first input terminal 13 of a switching means 12, (b) a speech detector 16, and (c) a noise measuring arrangement 17. Another input signal, such as data signals, that might be sent over the same communication channel 18 between transmitter 10 and receiver 20 is provided as an input to a second input terminal 14 of switching means 12. Speech detector 16 monitors input 11 to determine whether a speech signal is active (present) or inactive (not present) and provides an output control signal which is representative of the speech activity and is received by both switching means 12 in transmitter 10 and remote receiver 20 via communication channel 18. The control signal from speech detector 16 causes switching means 12 in transmitter 10 to (a) connect input terminal 13 to output terminal 15 when a speech signal is being detected at input 11 in order to transmit the detected speech signal to receiver 20 over communication channel 18, and (b) to connect input terminal 14 to output terminal 15 when a

speech signal at input 11 is not detected in order to transmit the other input signal, when present, arriving at second input terminal 14 of switching means 12 to receiver 20 over communication channel 18. The other input signal on input 14 of switching means 12 can be, for example, a packet signal which has its packets stored in a memory (not shown) for transmission by a gating means (not shown) which is responsive to the same speech detector output control signal that causes switching means 12 to connect its input 14 with its output 15. In this manner other signals can be transmitted on communication channel 18 when it is not being used for the speech signal transmission and thereby provide a Speech Interpolation technique.

Noise measuring arrangement 17 is used to determine the level of the background noise in the speech signal at input 11 and to generate a background noise level control signal for transmission either directly to receiver 20 over communication channel 18 or indirectly to receiver 20 via optional attenuator arrangement 19. Where attenuator arrangement 19 is present in transmitter 10, it functions to reduce the value of the determined background noise level by a predetermined amount before being transmitted to receiver 20 over channel 18. It is to be understood that attenuator arrangement 19 is an optional element and (a) is, therefore, shown by dashed lines, and (b) when present in transmitter 10 can form a part of noise measuring arrangement 17. Alternatively, attenuator arrangement 19 can be disposed in receiver 20 as an optional attenuator arrangement 22 as will be described hereinafter. It is to be understood that the concurrent information, active/inactive, and noise value signals transmitted on communication channel 18 are transmitted as separate portions of an overall communication signal and, therefore, can be concurrently transmitted in any suitable manner such as, for example, on separate leads or in a composite signal in, for example, the header and information portions of a packet or in different frequency subbands of the composite signal. It is to be understood that speech detector 16 and noise measuring arrangement 17 may actually be formed as part of one circuit as will be shown hereinafter in FIG. 2, but is described here as separate elements for ease of description.

At receiver 20, (a) the active/inactive control signal portion is received by each of a first and a second switching means 23 and 27 in order to control the path through these switching means; (b) the information signal portion is received at an input terminal 28 of second switching means 27; and (c) the noise value control signal portion is received by a noise generator 21. Noise generator 21 is responsive to the background noise level control signal transmitted by noise measuring arrangement 17 in transmitter 10 for generating a level of noise which corresponds to the level of background noise indicated by the received background noise level control signal. The background noise signal produced by noise generator 21 is provided to the input terminal 24 of first switching means 23 either (a) directly when the noise value signal from noise measuring arrangement 17 has been previously attenuated by the predetermined amount in attenuator 19, or (b) indirectly via attenuator 22 when the noise value signal from noise measuring arrangement 17 has not been previously attenuated before being transmitted. It is to be understood that optional attenuator 22 can be a separate circuit, disposed before or after noise generator 21, or form a part of noise generator 21. Regardless of which attenuator 19 or 22 is used, the resultant noise signal provided to input terminal 24 of first switching means 24 is a signal which has been attenuated or reduced in level by a predetermined amount from the background noise level which was determined for the signal at input 11 of transmitter 10.

In operation, when speech detector 16 at transmitter 10 detects the presence of a speech signal, including background noise, at input 11, it generates a control signal having first value which is transmitted to receiver 20 while simultaneously causing switching means 12 to connect input terminal 13 to output terminal 15 and thereby transmit the speech signal, and included background noise, to receiver 20. Noise measuring arrangement 17, which has been continuously determining the background noise level received at input 11, transmits a noise value, which either has been attenuated (when attenuator 19 is present) or has not been attenuated (when attenuator 19 is not present) to receiver 20. At receiver 20, the received first value control signal from speech detector 16 causes first switching means 23 to close the path between input terminal 24

and output terminal 25 to divert any noise signal from noise generator 21 away from a first output path 31 of receiver 20, while simultaneously causing second switching means 27 to close the path between input terminal 28 and output terminal 30 to direct the received speech signal, and included background noise, to first output path 31.

When speech detector 16 does not detect a speech signal at input 11 of transmitter 10, it generates a control signal having a second value which is transmitted to receiver 20 over communication channel 18 while simultaneously causing switching means 12 to connect input terminal 14 to output terminal 15 and thereby transmit other input signals to receiver 20. At receiver 20, Noise Generator 21 generates a noise signal at a level specified by the current measured background noise level of the signal at input 11, or by a prior measured background noise level value measured during a last period when speech signal was not detected, this noise level being determined in transmitter 10 by noise measuring arrangement 17 with or without optional attenuator 19. The received second value control signal from speech detector 16 causes first switching means 23 to close the path between input terminal 24 and output terminal 26 to direct the attenuated noise fill signal obtained from noise generator 21 and optional attenuator 22 (when present) onto first output path 31 from receiver 20, while simultaneously causing second switching means 27 to close the path between input terminal 28 and output terminal 29 to direct the received other information signals onto a second output path 32 from receiver 20.

By the above technique, when a speech signal, including background noise, is detected at input 11 of transmitter 10, the speech plus background noise signal is transmitted to receiver 20 via switching means 12 and communication channel 18, and directed onto first output path 31 from receiver 20 by second switching means 27. No additional attenuated noise fill signal is provided to first output path 31 from first switching means 23 because the path between input terminal 24 and output terminal 26 is not closed. When no speech signal is detected at input 11 of transmitter 10, then another input signal is transmitted via switching means 12 and communication channel 18 to receiver 20 in place of the normally

transmitted speech signal, where this other information signal is directed by second switching means 27 onto second output path 32 while only an attenuated noise fill signal is transmitted over first output path 31 to the listening, or possibly speaking, end user. It is to be understood that first and second switching means 23 and 27 at receiver 20 can have any suitable arrangement to realize comparable interconnections.

In an exemplary wideband packet technology transmitter 10, which is also known as an access interface (AI), with digital speech interpolation, an exemplary arrangement for providing noise matching in transmitter 10 is shown in FIG. 2. In the arrangement of FIG. 2, it will be seen that speech detector 16, noise measuring arrangement 17 and optional attenuator 19 of FIG. 1 can all be formed as part of speech detector 16. Noise matching involves two functions, noise level estimation and noise generation. Noise level estimation is performed as part of the speech detection function in speech detector 16 by the following exemplary digital circuits. The speech signal at input 11 is high-pass filtered in HP filter 40 to reduce hum and remove any DC component. The resultant signal is full-wave rectified in rectifier 41 and then low-pass filtered in LP filter 42. The resulting envelope signal is monitored in peak monitor circuit 43 for the peaks and minima levels. These peak and minima levels are taken to be measures of the speech level and the background noise level, respectively, and are used by speech detector 16 in setting its speech threshold. When the noise value to be transmitted to receiver 20 is to be attenuated before transmission to receiver 20, optional attenuator 19 would be used with a noise level translator 44 to provide a digital noise value which is at the predetermined reduced or attenuated value. It is to be understood that attenuator 19 can be either before or after or a part of noise level translator 44.

In operation, the noise level measure from speech detector 16 can be made available as, for example, an 8-bit quantity for transmission to noise level translator 44 and/or attenuator 19. The range of noise levels this represents could be divided into 16 exemplary parts and translated to a 4-bit noise level value by noise level translator 44. This 4-bit noise level value would be

transmitted in, for example, the header of each speech packet during the period when the end user associated with input 11 is active and providing a speech signal. When the end user associated with input 11 becomes inactive and, therefore, packets are no longer sent, the noise level value transmitted in the last packet, and received at receiver 20, is used to generate an appropriate random noise signal by noise generator 21, which noise signal is inserted in the speech gap at output 31 by switching means 23. In an exemplary arrangement of noise generator 21, for each of the 16 noise levels, noise generator 21 can produce a random or pseudorandom sequence of Pulse Code Multiplex (PCM) samples with the desired noise powers.

The noise fill signal to be provided during gaps in the output speech signal at output 31 of receiver 20 to provide improved subjective performance of speech signals was found to occur when the noise signal reduced below the 0 dB noise match value. More particularly, in an illustrative example shown in FIG. 3, the subjective performance of speech transmission is found to be improved as the noise fill signal is reduced below the 0 dB noise match value. From the graph of FIG. 3, it can be seen that the subjective performance was found to increasingly improve as the background noise fill is decreased from the 0 dB noise match value until it reaches a maximum between the -3 and -6 dB noise match value depending on the actual noise level at input 11. The subjective performance was found to decrease at noise match values below -3 dB. Therefore, it is shown that the end users find the subjective performance of speech transmission better when the noise match level is reduced below the 0 dB level with the best subjective performance occurring between the -3 and -6 dB noise match levels.

The claims defining the invention are as follows:

1. A method of providing noise matching to a destined end user in a communication system during gaps in active signal transmission to the end user, the method comprising the steps of

(a) detecting periods of active and inactive signal transmissions destined for the end user,

(b) concurrent with step (a), measuring the background noise level at the input of a transmitter providing the signal transmission destined for the end user during either one or both of the active and inactive signal transmission periods,

(c) during the detected period of each active signal transmission in step (a), directing the active signal transmission to the end user, and

(d) during the detected period of each inactive signal transmission in step (a), generating a noise fill signal for transmission to the end user, the noise fill signal provided to the end user comprising a level that is attenuated by a predetermined amount from the background noise level measured at the input of the transmitter in step (b) for providing improved subjective performance.

2. A method as claimed in claim 1 wherein in step (d) the attenuated noise fill signal is at a level between -1dB and -6dB of the background noise level measured in step (b).

3. A method as claimed in claim 1 or 2 wherein the detected active and inactive signal transmission periods in step (a) are used for generating a first and a second control signal, respectively, for causing the implementing of respective steps (c) and (d).

4. A method as claimed in claim 3 comprising the further step of

(e) causing a different active signal transmission to be transmitted to another end user over a channel normally used for the active signal transmissions to the destined end user when the second control signal is generated.

5. A receiver for use in a communication system, comprising means for receiving from a remote transmitter active signal

transmissions interspersed with inactive signal transmission periods which are destined for a predetermined end user of the receiver, and generating and directing means responsive to (1) a first control signal indicating each period of active signal transmission for directing the received active signal transmission to the end user, and (2) both a second control signal indicating each period of inactive signal transmission, and a third control signal indicating a background noise level measured at the input of the remote transmitter for generating a noise fill signal comprising a level that is attenuated by a predetermined amount from the background noise level measured at the input of the remote transmitter and directing the attenuated noise fill signal to the end user during each inactive signal transmission period for providing improved subjective performance.

6. A receiver as claimed in claim 5 wherein the generating and directing means is adapted to generate and direct a noise fill signal to the end user which is at a level between -1dB and -6dB of the background noise level measured at the input of the remote transmitter.

7. A receiver as claimed in claim 5 or 6 wherein the generating and directing means comprises switching means responsive to the second control signal for directing a different active signal transmission destined for another end user of the receiver which is received from the remote transmitter over a same channel to the other end user, while concurrently directing the attenuated noise fill signal to the predetermined end user.

8. A method of providing noise matching to a destined end user in a communication system during gaps in active signal transmission to the end user, substantially as hereinbefore described with reference to the drawings.

9. A receiver for use in a communication system, substantially as hereinbefore described with reference to the drawings.

DATED this TWENTY-THIRD day of NOVEMBER 1989

American Telephone and Telegraph Company

Patent Attorneys for the Applicant
SPRUSON & FERGUSON

FIG.1

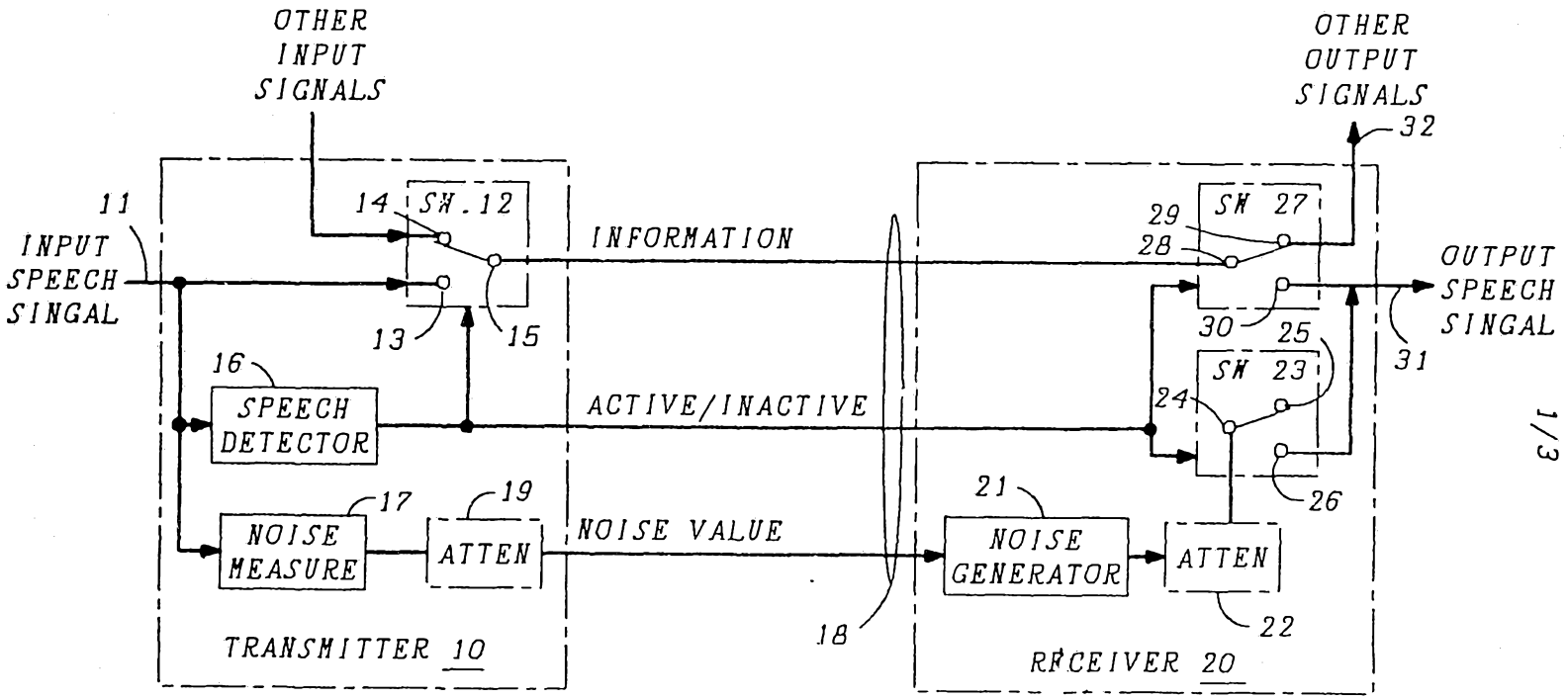

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FIG.2

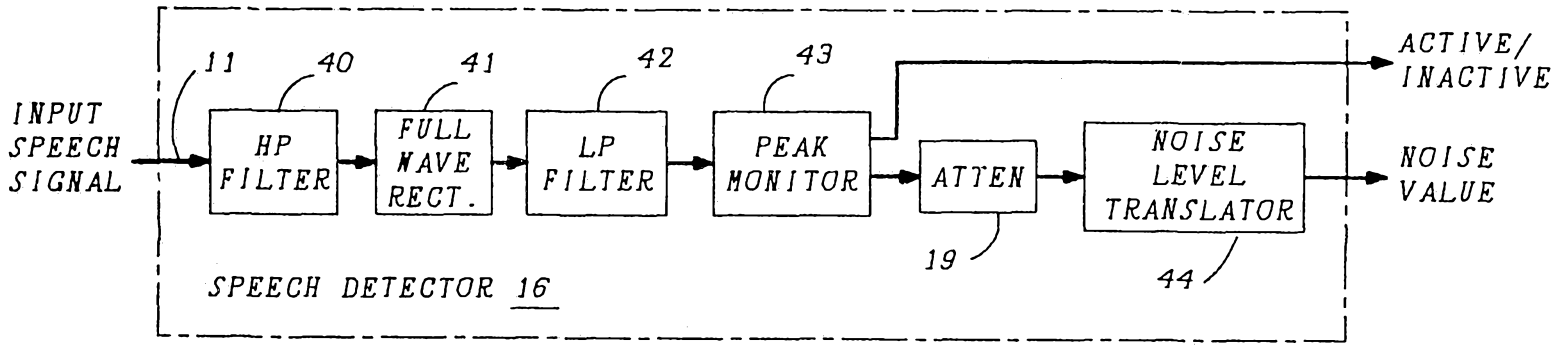
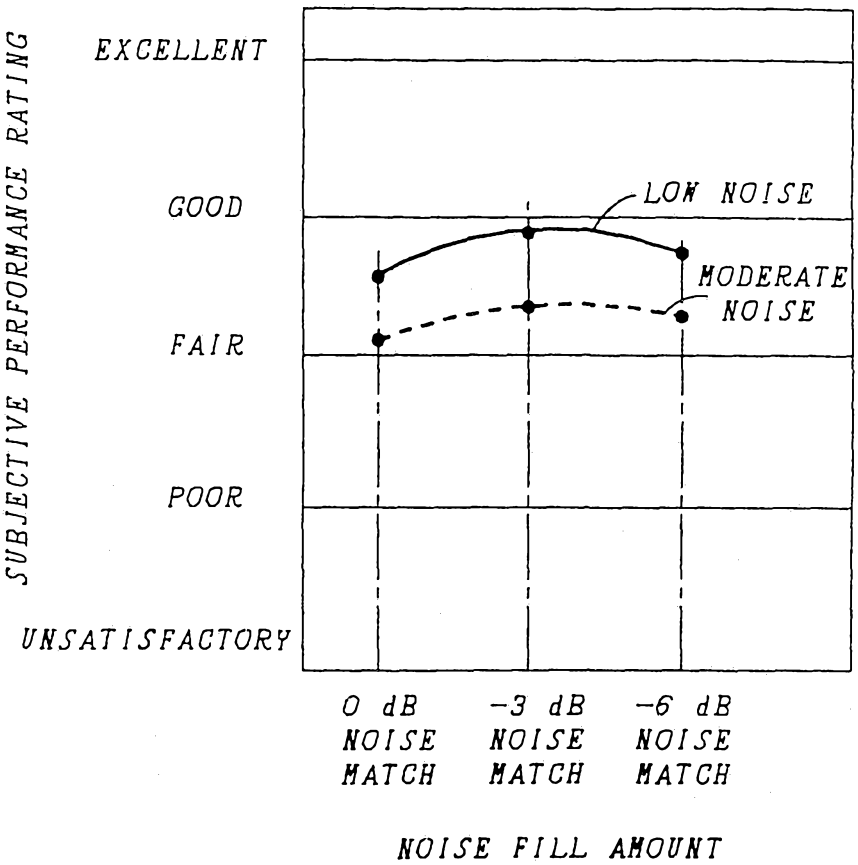

11
40
41
42
43
INPUT SPEECH SIGNAL
HP FILTER
FULL WAVE RECT.
LP FILTER
PEAK MONITOR
ATTEN
19
NOISE LEVEL TRANSLATOR
44
ACTIVE/ INACTIVE
NOISE VALUE
SPEECH DETECTOR 16

FIG.3


SUBJECTIVE PERFORMANCE RATING
EXCELLENT
GOOD
FAIR
POOR
UNSATISFACTORY
LOW NOISE
MODERATE NOISE
0 dB NOISE MATCH
-3 dB NOISE MATCH
-6 dB NOISE MATCH
NOISE FILL AMOUNT