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(54) **HEARING AID WITH IMPROVED PERCENTILE ESTIMATOR**

HÖRGERÄT MIT VERBESSERTEM PERZENTILGENERATOR

PROTHESE AUDITIVE AVEC ESTIMATEUR AMELIORE DE PERCENTILES

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(73) Proprietor: **TOPHOLM & WESTERMANN APS**
DK-3500 Vaerloese (DK)

(72) Inventor: **BAEKGAARD, Lars**
DK-3520 Farum (DK)

(74) Representative: **Böhmer, Hans Erich, Dipl.-Ing.**
Keplerstrasse 23
71134 Aidlingen (DE)

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EP-A- 0 282 335 **WO-A-95/15668**
US-A- 4 204 260 **US-A- 5 027 410**

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Description

Background of the invention

[0001] The invention relates to a hearing aid, preferably to a programmable hearing aid having at least one microphone, at least one signal processor with at least one channel, an output amplifier and an output transducer, at least one of the channels containing a signal processing circuit with at least one percentile estimator for the continuous determination or calculation of at least one percentile value of the input signal from a continuous analysis and evaluation of the frequency and/or amplitude distribution of the input signal, whereby the percentile value(s) serve either directly or indirectly as control signals for controlling the gain and/or the frequency response of the electronic processing circuit, the percentile estimator consisting essentially of a comparator stage with two inputs and two outputs, the first input being directly or indirectly connected to the input of the hearing aid, its two outputs controlling a first control stage the output signals of which control a first integrator, the output of which, directly or indirectly, conveys a control signal to the signal processing circuit and the second input of the comparator stage.

[0002] Percentile estimators which may also be used in hearing aids, are known in principle from US-A 4.204.260.

[0003] Clinical tests have shown, that the use of correctly fitted hearing aids, i.e. hearing aids with constant gain, independent of signal-levels, in noisy as well as quiet surroundings are superior to hearing aids with an automatic gain control, with respect to speech comprehension. However, while linear hearing aids require the user to adjust the volume control dependent on the actual listening environment, hearing aids with automatic gain control adapt themselves to the environment and thereby clearly improve the ease-of-use.

[0004] Based on the clinical tests mentioned above, the percentile estimators have to work very slowly to achieve an almost constant gain for speech signals. This works very well if one stays in an environment where the level of sound is not varying too much, but the long response times of the system will in some cases not adapt fast enough to changes in environment, resulting in phrases not being heard.

[0005] A common problem is the situation where the user of the hearing aid is yelling a message to a distant person. This will increase the percentile estimate and hence reduce the gain in the hearing aid. Since the percentile estimator works slowly, the gain stays reduced for a while, and the hearing aid user will not be able to hear the distant person answering, because the resulting output of the hearing aid will be very low, perhaps even below the users hearing threshold level.

[0006] On the other hand one could let the percentile estimators work fast, which obviously will make the system adapt faster to changes in environment, but the gain can then not be considered constant for the speech signals. The fast gain adjustment of the system will cause "pumping"-effects, which can be very annoying for the user, especially in noisy surroundings, and may result in loss of speech comprehension.

[0007] In an automatic gain control system for hearing aids, percentile estimators, operating on the present signal in one or more channels may be used for controlling the gain of the electronic signal processors. Such a system is f. i. disclosed in WO 95/15668 of applicant.

Summary of the invention

[0008] It is an object of the present invention to create an improved percentile estimator, particularly for use in hearing aids of the kind referred to above, which makes it possible for the hearing aid to adapt fast to changes in the environment, while maintaining a slow response when operating on continuous signals, e.g. speech signals in a steady environment.

[0009] This is achieved in a hearing aid as referred to above in accordance with the present invention with a percentile estimator structure having at least a second control stage connected to the first control stage, and at least one additional integrator controlled by the second control stage, the output of which is connected to a further input of the second control stage as well as to a multiplier stage, interconnected between the first control stage and the first integrator.

[0010] It is of particular importance that the second control stage supplies a rectified and scaled version of the pre-defined parameters of the first control stage, generating a positive control signal for the second integrator and a forward reset signal to said second integrator for establishing a predefined minimum value of said integrator whenever the output signal of the first control stage changes.

[0011] Other characteristics of the invention and advantageous further embodiments thereof are subject of the remaining claims.

Brief description of the drawings

[0012] In the drawings

Fig. 1 shows a schematic circuit diagram of a multichannel hearing aid using percentile estimators;

Fig. 2 shows a schematic diagram of the principle of a percentile estimator;

Fig. 3 shows, schematically, an improved percentile estimator for hearing aids with two levels in accordance with the present invention;

Fig. 4 shows, schematically, an improved percentile estimator for hearing aids with three levels in accordance with the invention and

Fig. 5 shows a diagram of the operation of a traditional percentile estimator in comparison with the operation of the improved percentile estimator on an actual sound example.

Detailed description of a preferred embodiment of the invention

[0013] Fig. 1 shows a principle circuit diagram of a multi-channel hearing aid with one microphone 1 and preamplifier 2, a band split filter 3 for splitting the signals into a number of channels (here 3 is shown), each having a signal processing circuit 4 consisting of a signal processor 5 and a percentile estimator 6, a register 7 for storing parameters related to the basic hearing aid performance, a summing circuit 8, an output amplifier 9 and a receiver 10.

[0014] Fig. 2 shows the principle of a traditional percentile estimator 6. Such percentile estimators are known from US-A 4.204.260.

[0015] The input signal for the specific channel is led into a detector stage 11, which is not essential for the operation of the percentile estimator, but is preferably used. It could include a rectification for determining the envelope of the input signal, and also a logarithmic conversion to obtain the envelope on a dB-scale, which is commonly used in hearing aids. The output signal from the detector 11 is supplied to a comparator 12 with its two inputs connected to the output from the detector 11 and an integrator 14.

[0016] The result of the comparison is supplied to the control stage 13, which in case of the output of the integrator 14 being greater than the output of the detector 11 holds a predefined negative value at its output, causing a decrease of the value stored in the integrator 14, and in the opposite case holds a predefined positive value at its output, causing an increase of the integrator value.

[0017] In this way the value present at the output of the integrator 14 will be a percentile estimate of the input signal of the detector 11 and the signal processor 5, the percentile value being dependent on the actual predefined values of the control stage 13.

[0018] The output of the percentile estimator 6 is used for controlling the signal processor 5. Clearly, it is possible to include more than one percentile estimator 6 in each channel and let the signal processor be controlled by all of these in combination. In that case, a combination and control logic may be used to combine the output signals of the different percentile estimators.

[0019] Fig. 3 shows the principle of an improved percentile estimator in accordance with the invention.

[0020] The traditional percentile estimator is modified with a multiplier 15, with its output supplying the integrator 14 and its inputs connected to the output of the control stage 13 and the output of an integrator 17. The integrator 17 is controlled by a control stage 16 which includes a rectifier 21 and a gain block 22 for rectifying and scaling the predefined parameters of the control stage 13 and thereby modifying the timing of the increase and decrease of the integrator 14 and thus the response time of the percentile estimator.

[0021] The control stage includes a zero-cross detector 23 which provides a reset pulse for the integrator, which then resets to a predefined minimum value whenever the output from the control stage 13 changes, hence whenever the input sound crosses the percentile estimator level.

[0022] The control stage 16 further may include a comparator 24 for checking if the output of the integrator 17 is less than a predefined maximum allowable value 25, in which case the transmission control 26 passes the output of the gain block 22 on to the integrator 17, and in the opposite case passes a value of zero or less on to the integrator 17 in order to prevent further increase of the integrator output.

[0023] The effect is an "accelerating" percentile estimator. The short term percentile estimator response time is long, dependent on the minimum value of the integrator 17 and will be dominant when the environment is characterized by a relatively constant sound level, where the input sound level crosses the percentile estimate frequently. The long term response time is relatively short because of the acceleration, and this effect will be of use in cases where the sound level changes, e.g. when communicating with a distant person, as mentioned earlier.

[0024] Fig. 4 shows an expansion of the improved percentile estimator by another level by adding a multiplier 18 with its output supplying the integrator 17 and its inputs connected to the output of the control stage 16 and the output of an integrator 20, which again is controlled by a control stage 19 similar to control stage 16.

[0025] Clearly it is possible to expand the number of levels in the improved percentile estimator even more than the three levels shown.

[0026] For the traditional percentile estimator of Fig. 2 a percentile level of p percent is obtained by the following formula:

$$p = 100 \cdot u / (u - d)$$

where

u is the upward integration value (positive)

d is the downward integration value (negative)

[0027] Both u and d in the formula above are defined by the predefined values of the control stage 13.

[0028] In the improved percentile estimator, the integration speeds are time dependent. The upward integration speed is determined by

$$u_{\text{result}} = u \cdot \int_0^{t_u} k_{16} \cdot |u| \cdot \int_0^{t_u} k_{19} \cdot |u| \, dt \dots dt$$

and the downward integration speed is

$$d_{\text{result}} = d \cdot \int_0^{t_d} k_{16} \cdot |d| \cdot \int_0^{t_d} k_{19} \cdot |d| \, dt \dots dt$$

where k_{16} and k_{19} are the scaling factors in the control stages 16 and 19.

[0029] In a "stationary" sound environment, i.e. when the percentile estimate is stable, we have

$$|u| \cdot t_u = |d| \cdot t_d = \text{constant}$$

where t_u and t_d are the collective time intervals over this stable time period in which the integrator integrates upwards and downwards, respectively.

[0030] This simplifies the integration in the formulas above, and yields the following expressions for the integration speeds of the improved percentile estimator:

$$u_{\text{result}} = u \cdot k_{16} \cdot |u| \cdot k_{19} \cdot |u| \cdot t_u \dots t_u$$

$$= u \cdot k_{16} \cdot k_{19} \dots \text{constant}$$

$$d_{\text{result}} = d \cdot k_{16} \cdot |d| \cdot k_{19} \cdot |d| \cdot t_d \dots t_d$$

$$= d \cdot k_{16} \cdot k_{19} \dots \text{constant}$$

[0031] Hence, for stationary environments, even though the integration speeds are time dependent, the percentile

level can be obtained by the same formula as for the traditional percentile estimator, since a constant multiplied to the integration speeds u and d does not change this formula.

[0032] Fig. 5 shows the function of a 2-level improved 90% percentile estimator with an increase from a minimum odB/sec growing 207.36 dB/sec^2 to a maximum of 57.6 dB/sec and a decrease from a minimum odB/sec growing $2,56 \text{ dB/sec}^2$ to a maximum of 6.4 dB/sec .

[0033] This is achieved by using a digital implementation with:

- a 32 kHz sampling frequency
- an upward integration step of $u = 5e - 4$ in the control stage 13
- a downward integration step of $d = -5e - 5$ in the control stage 13
- a scaling factor of $k_{16} = 1$ in the control stage 16
- a predefined minimum value of 0 of the integrator 17
- a predefined maximum allowable value of 4 of the integrator 17

[0034] The function is compared with a traditional 90% percentile estimator with an increase of 14.4 dB/sec and a decrease of 1.6 dB/sec .

[0035] The comparison is performed on an actual sound example with a duration of 32 secs. The sound level is stepped down 20 dB after approximately 7 secs to simulate a change of sound environment.

[0036] Note that the improved percentile estimator, because of the increasing integration speed, adapts much faster to change in environment than the traditional one, with respect to sound level increases (see the first 2 seconds) as well as sound level decreases (see the signal behaviour around 7 seconds).

[0037] Still, the improved percentile estimator behaves similar to the traditional one in the time range where the percentile estimation in both cases has become "stationary", i.e. from approximately 20secs to 32secs. This is due to the signal crossing the output of the improved percentile estimator, which generates a frequent reset of the integrator speed, and hereby keeps the response time of the percentile estimator long for this signal.

[0038] Finally, it may be pointed out that all the parameters of control stages 13 and the scaling factors of control stages 16 and 19 may be preset, may be programmable or may even be program controlled.

[0039] The steady progress in the design of very highly integrated circuits may lead to an extremely compact design of hearing aids, incorporating not only the improved percentile estimators for one or several channels but also the microprocessor and storage means for the necessary operational tools, such as algorithms.

[0040] Furthermore it is to be understood that the register 7 in Fig. 1 should comprise all necessary control parameters for the control of the transfer characteristic of the hearing aid, possibly also for various different programmed or programmable environmental listening situations.

Claims

1. A hearing aid having at least one microphone (1) for providing an input signal, at least one signal processing channel (4) receiving and processing at least a portion of said input signal to produce at least one output signal, an output amplifier (9) for amplifying said at least one output signal, and an output transducer (10) responsive to the amplified output signal, said at least one channel including a signal processing circuit (5) for processing said input signal portion in accordance with an output, signal from a percentile estimator (6), said percentile estimator including a comparator stage (12) for comparing said input signal portion to an integrated value, a control stage (13) being responsive to an output signal from said comparator stage (12) for providing an integrator control signal representing a value anti a direction of integration in accordance with said comparison, and an integrator (14) responsive to said integrator control signal, providing said integrated value to said comparator stage (12), and, as said output signal to said signal processing circuit (5), characterized by a multiplier stage (15) interconnected between the output of said first mentioned control stage (13) and the input of said integrator (14) for modifying said value of the integrator control signal of said first control stage (13), and by a second control stage (16) responsive to the integrator control signal of said first control stage (13) for controlling a second integrator (17) for providing a modification signal to the multiplier stage (15).
2. Hearing aid in accordance with claim 1, characterized in that the output of the second integrator (17) provides an integrated value signal to a further input of the second control stage (16).
3. Hearing aid in accordance with claim 1, characterized in that the second control stage (16) supplies a rectified and scaled version of predefined control parameters of the first control stage (13), generating a positive control signal for the second integrator (17) and a forward reset signal to said second integrator (17) for establishing a predefined

minimum value of said integrator (17) whenever the output signal of the first control stage (13) changes.

4. Hearing aid in accordance with claims 1 and 2, characterized in that the second control stage (16) contains a zero-cross-detector stage (23) coupled between the input of said control stage (16) and a second input of the second integrator (17), providing the reset signal for said integrator (17) for resetting said integrator to a predefined minimum value, whenever the output of the first control stage (13) changes, hence whenever the input sound of the hearing aid crosses the percentile estimator value.
5. Hearing aid in accordance with claim 1, characterized in that the second control stage (16) additionally comprises a rectifier stage (21), a gain block (22) and a transmission control stage (26) controlling the second integrator (17), for rectifying and scaling the predetermined control parameters of the first control stage (13) for controlling the second integrator (17), the output of which is connected with the input of the second control stage (16) by means of a comparator stage (24) for comparing its output with a predefined maximum allowable value (25) to control the passage of the output of the gain block (22) to the second integrator (17) by means of the transmission control stage (26).
6. Hearing aid in accordance with claim 1, characterized by a third control stage (19) connected to the first control stage (13) for controlling a third integrator (20), and a second multiplier (18) connected between the second control stage (16) and the second integrator (17) and also with the output of the third integrator (20), the output of which is further connected to the third control stage (19) for rectifying and scaling the predetermined control parameters of the first control stage (13), generating a positive control signal for the third integrator (20) and a forward reset signal to said integrator for establishing a predefined minimum value of the integrator (20) whenever the sign of the output signal of the first control stage (13) changes.
7. Hearing aid in accordance with claim 1, characterized in that the values of the predefined parameters and/or the predefined scaling factors of the control stages (13, 16, 19) for the control of the integrators (14, 17, 20) may be preset, programmed or program controlled.
8. Hearing aid in accordance with claim 1 characterized in that the values of the output signals of the control stages (13, 16, 19) may or may not be equal for the positive or negative changes to be effected in the integrators (14, 17, 20).
9. Hearing aid in accordance with claim 1, characterized in that for the purpose of the continuous determination of a signal sequence from the input signal, a detector stage (11) is connected between the input of the hearing aid and the input of the percentile estimator (6) for mathematical processing of the input signal by way of predefined or predefinable algorithms or calculating rules.
10. Hearing aid in accordance with claim 1, characterized in that for the purpose of the continuous determination of the envelope of the input signal, a rectifier is connected between the input of the hearing aid and the input of the percentile estimator (6) as a detector stage (11).
11. Hearing aid in accordance with claim 1 with at least two channels, characterized in that at least two percentile estimators (6) are connected in parallel in at least two parallel channels covering essentially adjacent-frequency bands and in which the outputs of the integrators of these percentile estimators (6) of the respective channels are connected with the inputs of a combination and control logic, said combination and control logic being connected in turn to the signal processor (5) of the respective channel via at least one control line.

Patentansprüche

1. Hörgerät mit mindestens einem Mikrofon (1) zur Abgabe eines Eingangssignals, mit mindestens einem der Signalverarbeitung dienenden Kanal (4) für die Aufnahme und Verarbeitung mindestens eines Teils des Eingangssignals, mit einem Ausgangsverstärker (9) für die Verstärkung des mindestens einen Teils des Eingangssignals, wobei der mindestens eine Kanal (4) eine Signalverarbeitungseinheit (5) zur Verarbeitung des genannten Teils des Eingangssignals gemäß einem Ausgangssignal eines Perzentil-Generators (6), aufweist der eine Vergleichsstufe (12) zum Vergleich des genannten Teils des Eingangssignals mit einem integrierten Wert sowie eine erste Steuerstufe (13) enthält, die in Abhängigkeit von einem von der Vergleichsstufe (12) gelieferten Signal ein einen Wert und eine Richtung einer Integration darstellendes Integrator-Steuersignal abgibt, sowie mit einem durch das

Integrator-Steuersignal betätigbaren Integrator (14) zur Abgabe des integrierten Wertes an die Vergleichsstufe (12), gekennzeichnet durch eine zwischen dem Ausgang der ersten Steuerstufe (13) und dem Eingang des Integrators (14) zur Modifizierung des Wertes des Integrator-Steuersignals der ersten Steuerstufe (13) angeordnete Multiplizierstufe (15), sowie durch eine zweite Steuerstufe (16) zum Ansteuern eines zweiten Integrators (17), der der Abgabe eines Modifizier-Signals an die Multiplizierstufe (15) dient.

2. Hörgerät nach Anspruch 1, dadurch gekennzeichnet, daß vom Ausgang des zweiten Integrators (17) ein einen integrierten Wert darstellenden Signal einem weiteren Eingang der zweiten Steuerstufe (16) zugeführt wird.

3. Hörgerät nach Anspruch 1, dadurch gekennzeichnet, daß die zweite Steuerstufe (16) eine gleichgerichtete und skalierte Version von vorbestimmten Steuerparametern der ersten Steuerstufe (13) abgibt und damit ein positives Steuersignal für den zweiten Integrator (17) und ein vorwärts gerichtetes Rückstellsignal für den Integrator (17) abgibt, und damit diesen Integrator (17) immer dann auf einen vorbestimmten Minimalwert zurückstellt, wann immer das Ausgangssignal der ersten Steuerstufe (13) sich ändert.

4. Hörgerät nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die zweite Steuerstufe (16) zwischen ihrem Eingang und einem zweiten Eingang des Integrators (17) einen Null-Durchgangs-Detektor (23) enthält, der das Rückstellsignal für den Integrator (17) zum Rückstellen dieses Integrators auf einen vorbestimmten Minimalwert liefert, wann immer das Ausgangssignal der ersten Steuerstufe (13) sich ändert, d.h., wann immer der Eingangsschall des Hörgerätes den vorgegebenen Wert des Percentil-Generators überschreitet.

5. Hörgerät nach Anspruch 1, dadurch gekennzeichnet, daß die zweite Steuerstufe (16) außerdem eine Gleichrichterstufe (21) für die Gleichrichtung und Skalierung der vorbestimmten Steuerparameter der ersten Steuerstufe (13) und eine Übertragungs-Steuerschaltung (26) für die Ansteuerung des zweiten Integrators (17) aufweist, dessen Ausgang mittels einer Vergleichsstufe (24) mit dem Eingang der zweiten Steuerstufe (16) verbunden ist, wobei diese Vergleichsstufe (24) das Ausgangssignal des zweiten Integrators (17) mit einem vorgegebenen maximal zulässigen Wert (25) vergleicht, und damit die Durchschaltung des Ausgangssignals des Verstärkerblocks (22) nach dem zweiten Integrator (17) mittels einer Übertragungs-Steuerstufe (26) steuert.

6. Hörgerät nach Anspruch 1, gekennzeichnet durch eine der Steuerung eines dritten Integrators (20) dienende dritte Steuerstufe (19) und durch eine zwischen der zweiten Steuerstufe (16) und dem zweiten Integrator (17) eingeschaltete zweite Multiplizierstufe (18), wobei der Ausgang des dritten Integrators (20) sowohl mit der zweiten Multiplizierstufe (18) als auch mit einem Eingang der dritten Steuerstufe (19) für eine Gleichrichtung und Skalierung der Steuerparameter der ersten Steuerstufe (13) verbunden ist, und damit der Erzeugung eines positiven Steuersignals für den dritten Integrator (20) und eines für diesen bestimmten vorwärts gerichteten Rückstellsignals dient, wann immer sich das Vorzeichen des Ausgangssignals der ersten Steuerstufe (13) ändert.

7. Hörgerät nach Anspruch 1, dadurch gekennzeichnet, daß die Werte der vorbestimmten Parameter und/oder der vorgegebenen Skalierfaktoren der Steuerstufen (13, 16, 19) für die Steuerung der Integratoren (14, 17, 20) voreingestellt, programmiert oder programmgesteuert sein können.

8. Hörgerät nach Anspruch 1, dadurch gekennzeichnet, daß die Werte der Ausgangssignale der Steuerstufen (13, 16, 19) für positive oder negative Änderungen der Werte der Integratoren (14, 17, 20) gleich groß oder ungleich groß sein können.

9. Hörgerät nach Anspruch 1, dadurch gekennzeichnet, daß für die kontinuierliche Ermittlung einer vom Eingangssignal abgeleiteten Signalfolge für die mathematische Verarbeitung des Eingangssignals mittels vorgegebener oder vorgegebbarer Algorithmen oder Rechenregeln zwischen dem Eingang des Hörgerätes und dem Eingang des Percentil-Generators (6) eine Detektorstufe (11) eingeschaltet ist.

10. Hörgerät nach Anspruch 1, dadurch gekennzeichnet, daß für die kontinuierliche Ermittlung der Einhüllenden des Eingangssignals als Detektorstufe (11) zwischen dem Eingang des Hörgerätes und dem Eingang des Percentil-Generators eine Gleichrichterstufe angeordnet ist.

11. Hörgerät gemäß Anspruch 1 mit mindestens zwei Kanälen, dadurch gekennzeichnet, daß in mindestens zwei parallelen Kanälen mindestens zwei Percentil-Generatoren parallel angeordnet sind, wobei die parallelen Kanäle im wesentlichen benachbarte aneinanderstoßende Frequenzbänder abdecken, wobei die Ausgänge der Integratoren dieser Percentil-Generatoren (6) der jeweiligen Kanäle mit Eingängen einer Kombinations- und Steuerlogik

verbunden sind, die ihrerseits mit dem Signalprozessor (5) des jeweiligen Kanals über mindestens eine Steuerleitung verbunden ist.

5 Revendications

1. Prothèse auditive comprenant au moins un microphone (1) pour la génération d'un signal d'entrée, au moins un canal de traitement des signaux (4) recevant et traitant au moins une fraction dudit signal d'entrée afin de produire au moins un signal de sortie, un amplificateur de sortie (9) pour l'amplification d'au moins un signal de sortie, et un transducteur de sortie (10) activé par le signal de sortie amplifié, au moins un canal avec un circuit de traitement des signaux (5) pour le traitement de la dite fraction du signal d'entrée en fonction du signal de sortie provenant d'un estimateur en centiles (6), ledit estimateur comprenant un étage comparateur (12) permettant de comparer ladite fraction du signal d'entrée par rapport à une valeur intégrée, un étage de contrôle (13) activé par un signal de sortie provenant dudit étage comparateur (12) transmettant un signal de contrôle à l'intégrateur représentant une valeur et un sens d'intégration en fonction de ladite comparaison, et un intégrateur (14) activé par ledit signal de contrôle, chargé de fournir ladite valeur intégrée à l'étage comparateur (12), et, en tant que signal de sortie transmis au dit circuit de traitement des signaux (5), caractérisée par un étage multiplicateur (15) interconnecté entre la sortie du premier étage de contrôle mentionné (13) et l'entrée dudit intégrateur (14) pour modifier ladite valeur du signal de contrôle transmise à l'intégrateur par le premier étage de contrôle (13), et par un deuxième étage de contrôle (16) activé par le signal de contrôle transmis à l'intégrateur par le premier étage de contrôle (13) pour contrôler un deuxième intégrateur (17) chargé de transmettre un signal de modification à l'étage multiplicateur (15).
2. Prothèse auditive selon la revendication 1, caractérisée en ce que la sortie du deuxième intégrateur (17) fournit un signal de valeur intégrée à une autre entrée du deuxième étage de contrôle (16).
3. Prothèse auditive selon la revendication 1, caractérisée en ce que le deuxième étage de contrôle (16) fournit une version rectifiée et pondérée des paramètres de contrôle prédéfinis du premier étage de contrôle (13), générant un signal de contrôle positif pour le deuxième intégrateur (17) et un signal de réinitialisation vers l'avant destiné au deuxième intégrateur (17) en vue d'établir une valeur minimale prédéfinie dudit intégrateur (17) lorsque le signal de sortie du premier étage de contrôle (13) change.
4. Prothèse auditive selon les revendications 1 et 2, caractérisée en ce que le deuxième étage de contrôle (16) contient un étage détecteur de passage par zéro (23) inséré entre l'entrée dudit étage de contrôle (16) et une deuxième entrée du deuxième intégrateur (17), destiné à fournir le signal de réinitialisation audit intégrateur (17) pour réinitialiser celui-ci à une valeur minimale prédéfinie lorsque la sortie du premier étage de contrôle (13) change, donc lorsque le son entrant de la prothèse auditive dépasse la valeur de l'estimateur en centiles.
5. Prothèse auditive selon la revendication 1, caractérisée en ce que le deuxième étage de contrôle (16) comprend, en plus, un étage rectificateur (21), un étage de gain (22) et un étage de contrôle de transmission (26) contrôlant le deuxième intégrateur (17), en vue de rectifier et de pondérer les paramètres de contrôle prédéfinis du premier étage de contrôle (13) pour contrôler le deuxième intégrateur (17), dont la sortie est connectée à l'entrée du deuxième étage de contrôle (16) par le biais d'un étage comparateur (24) visant à comparer ladite sortie avec une valeur maximale autorisée prédéfinie (25) pour contrôler le passage de la sortie de l'étage de gain (22) vers le deuxième intégrateur (17) au moyen de l'étage de contrôle de transmission (26).
6. Prothèse auditive selon la revendication 1, caractérisée par un troisième étage de contrôle (19) connecté au premier étage de contrôle (13) pour le contrôle d'un troisième intégrateur (20), et un deuxième multiplicateur (18) connecté entre le deuxième étage de contrôle (16) et le deuxième intégrateur (17), et également avec la sortie du troisième intégrateur (20), laquelle est également connectée avec le troisième étage de contrôle (19) pour la rectification et la pondération des paramètres prédéfinis du premier étage de contrôle (13), générant un signal de contrôle positif pour le troisième intégrateur (20) ainsi qu'un signal de réinitialisation vers l'avant destiné au dit intégrateur en vue d'établir une valeur minimale prédéfinie pour cet intégrateur (20) lorsque le signe du signal de sortie du premier étage de contrôle (13) change.
7. Prothèse auditive selon la revendication 1, caractérisée en ce que les valeurs des paramètres prédéfinis et/ou des facteurs de pondération prédéfinis des étages de contrôle (13, 16, 19) utilisés pour le contrôle des intégrateurs (14, 17, 20) peuvent être prédéterminées, programmées ou réglées par programme.

8. Prothèse auditive selon la revendication 1, caractérisée en ce que les valeurs des signaux de sortie des étages de contrôle (13, 16, 19) peuvent (ou non) être égales pour les modifications positives ou négatives à effectuer sur les intégrateurs (14, 17, 20).

9. Prothèse auditive selon la revendication 1, caractérisée en ce que, pour les besoins de la détermination continue d'une séquence du signal d'entrée, un étage de détection (11) est connecté entre l'entrée de la prothèse auditive et l'entrée de l'estimateur en centiles (6) à des fins de traitement mathématique du signal d'entrée par le biais d'algorithmes prédéfinis ou prédéfinissables, ou de règles de calcul.

10. Prothèse auditive selon la revendication 1, caractérisée en ce que, pour les besoins de la détermination continue de l'enveloppe du signal d'entrée, un rectificateur servant d'étage de détection (11) est connecté entre l'entrée de la prothèse auditive et l'entrée de l'estimateur en centiles (6).

11. Prothèse auditive selon la revendication 1 avec au moins deux canaux, caractérisée en ce qu'au moins deux estimateurs en centiles (6) sont montés en parallèle dans au moins deux canaux parallèles couvrant essentiellement des bandes de fréquence adjacentes et où les sorties des intégrateurs de ces estimateurs (6) pour les canaux respectifs sont connectées aux entrées d'une logique combinatoire et de contrôle, ladite logique étant connectée à son tour au processeur de signaux (5) du canal respectif via au moins une ligne de contrôle.

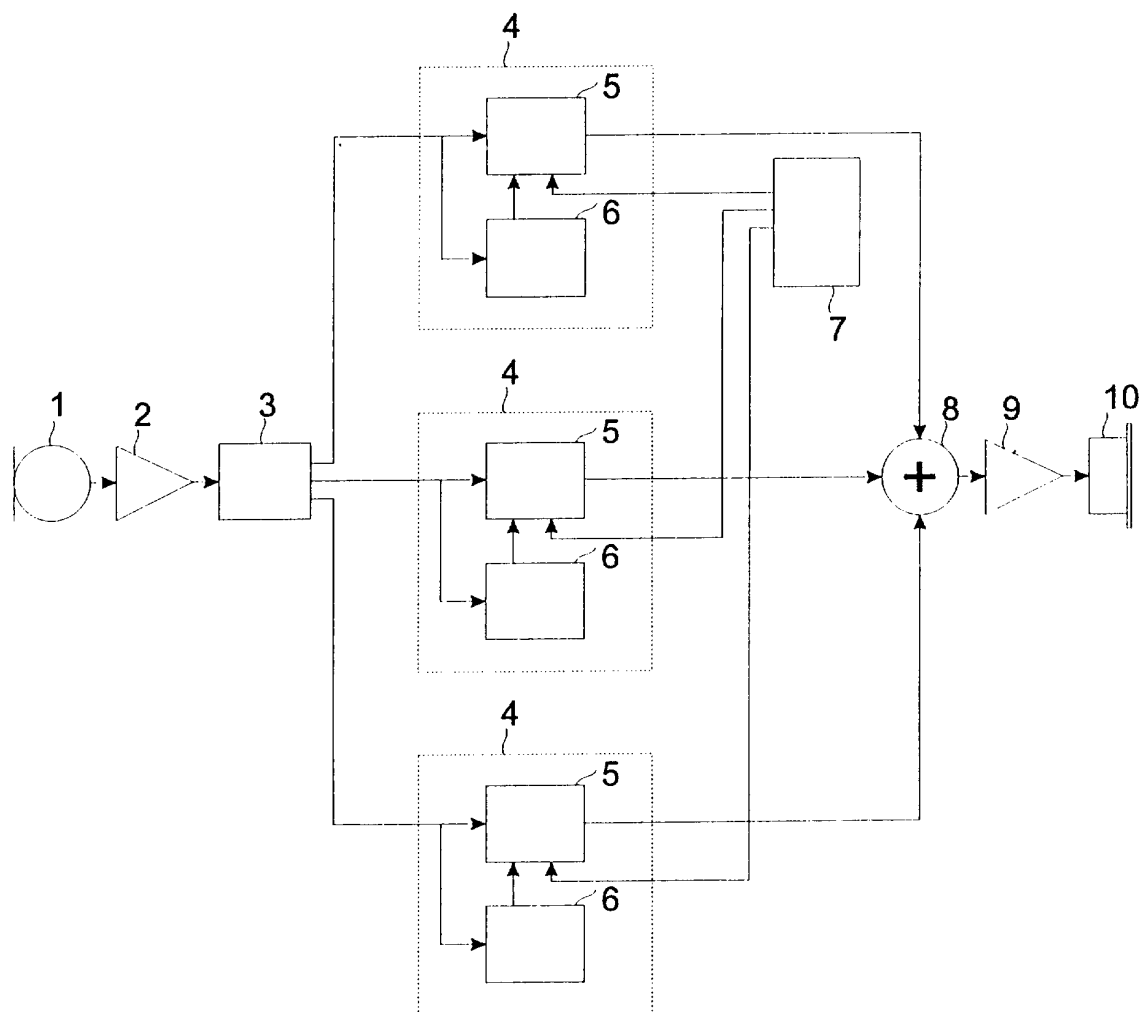


Fig. 1

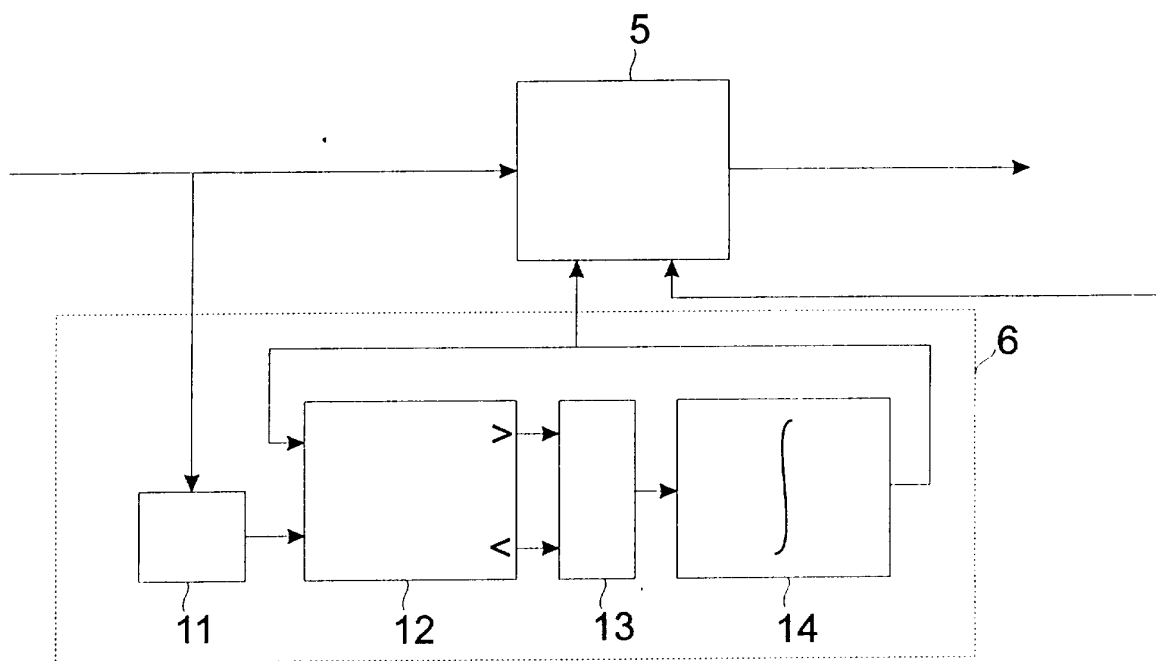


Fig. 2

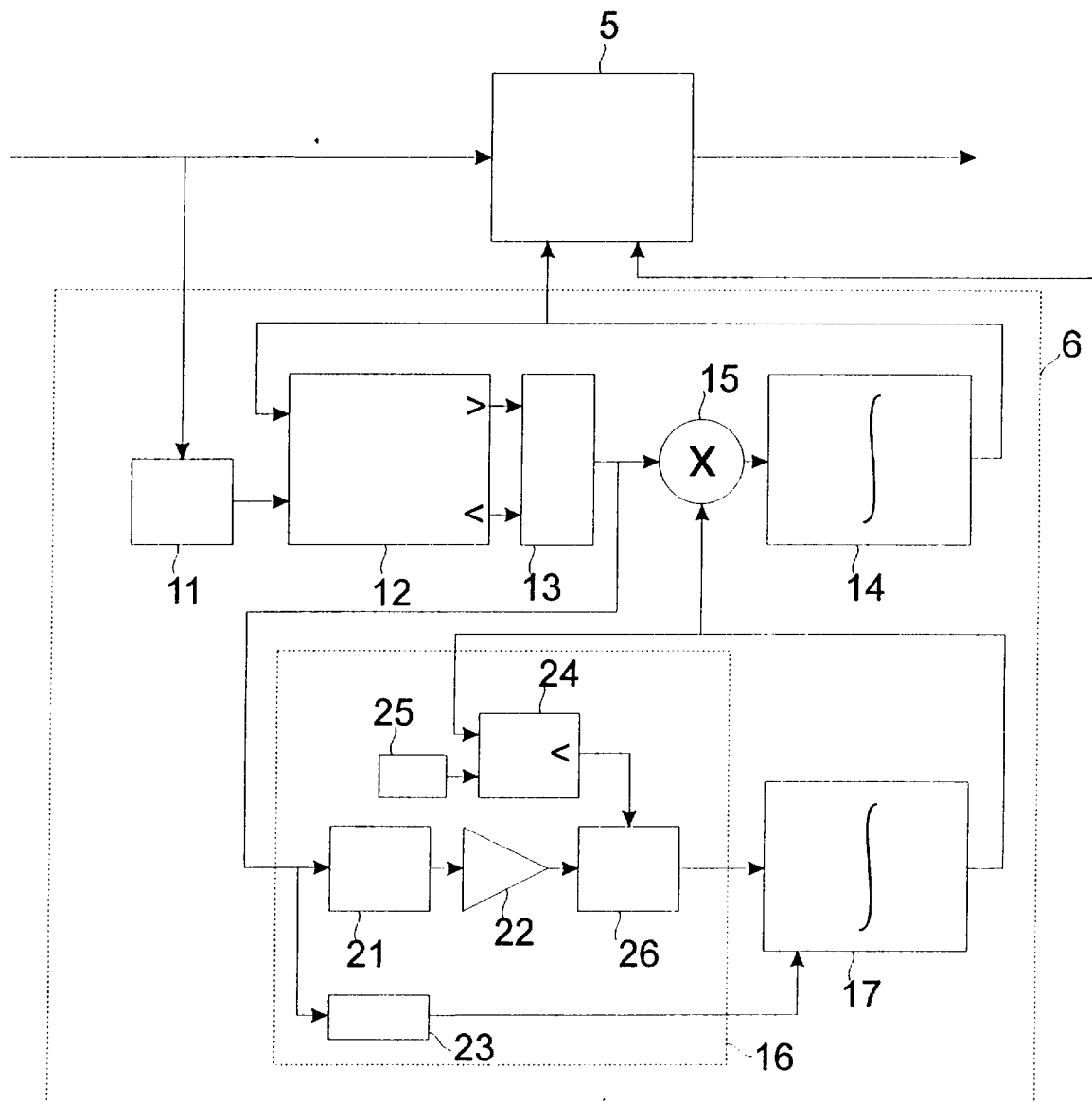


Fig. 3

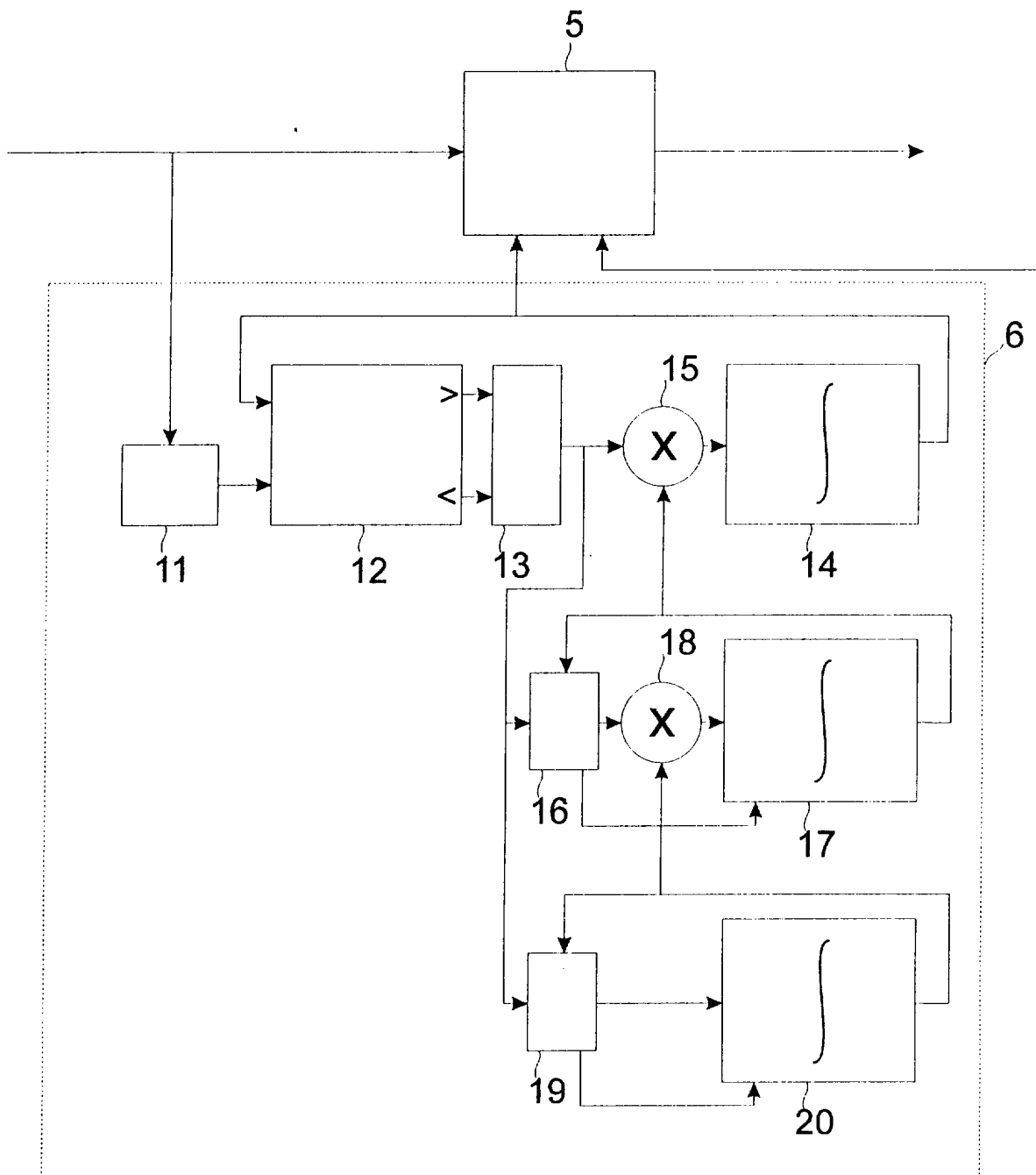


Fig. 4

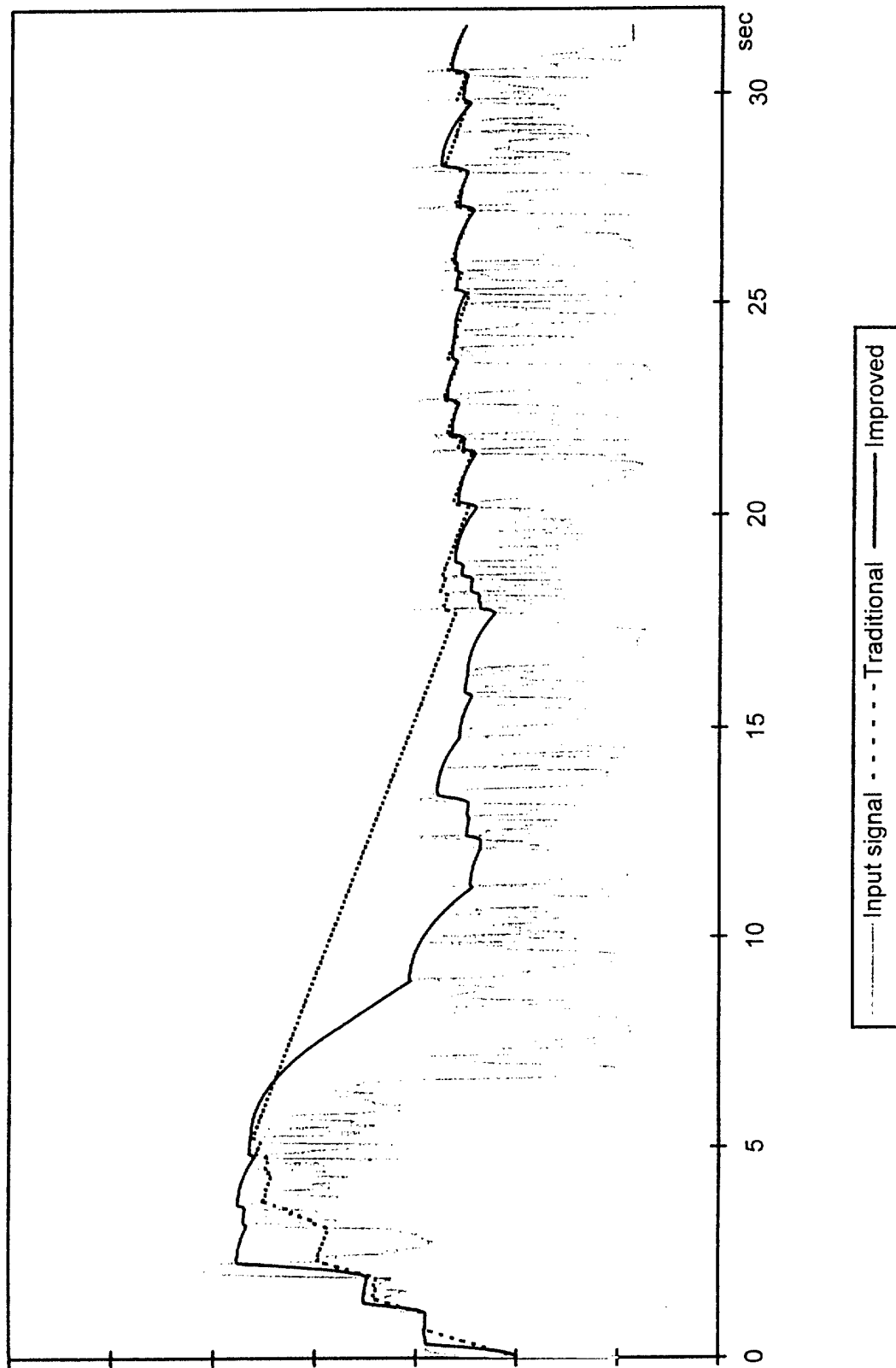


Fig. 5