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(54) **System for measuring heart rate and respiration rate of small animals**

Messsystem für Herz- und Atmungsrate kleiner Tiere

Système de mesure de la fréquence cardiaque et respiratoire de petits animaux

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(73) Proprietor: **Japan Science and Technology Agency**
Kawaguchi-shi,
Saitama 332-0012 (JP)

(72) Inventors:
- **SATO, Shinichi**
  Akita-shi, Akita 010-0834 (JP)
- **YAMADA, Katsuya**
  Akita-shi, Akita 010-1101 (JP)
- **INAGAKI, Nobuya**
  Akita-shi, Akita 010-0873 (JP)

(74) Representative: **Hoarton, Lloyd Douglas Charles**
Forrester & Boehmert
Pettenkoferstrasse 20-22
80336 Munich (DE)

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Description

Technical Field

[0001] The present invention relates to a device for maintaining body temperature having heart rate and respiratory rate detection function for small animals and to a heart rate and respiratory rate measurement system for small animals using the device.

Background Art

[0002] The inventors of the present invention have already proposed a heater device for keeping a mouse whose body temperature is decreased due to anesthesia in a normal physiological state in "body temperature keeping device for small animal", particularly for a mouse (Japanese Unexamined Patent Application Publication No. 2002-51662). The respiratory rate and heart rate of a small animal are not subject to measurement in this heater device.

[0003] However, monitoring the respiratory rate and heart rate of an anesthetized animal, in addition to maintaining the body temperature of the animal, in a physiological experiment is essential for determining the physiological state of the animal.

[0004] Although there are known technologies for measuring the body temperature or respiratory rate of human beings to keep them in a comfortable state on a carpet used by the human beings, it is necessary to devise measuring methods specific to small animals in order to measure the physiological state of the animals that are much smaller than human beings. Simple and reliable physiological and experimental devices for small animals have not yet been provided.

Disclosure of Invention

[0005] As described above, electrodes for electrocardiograms or respiratory monitoring devices suitable for very small animals, such as mice, have hardly been available. Although electrodes for electrocardiograms or the like handmade by researchers have been used in experiments in the present circumstances, they can cause an animal pain because they are not optimum. In addition, there are numerous cases in which it is quite difficult to mount the electrodes for the electrocardiogram or the like. Accordingly, it disadvantageously takes a long time to prepare for monitoring the respiratory rate and heart rate of a small animal.

[0006] US2002/0014951 discloses, in paragraph [0053], the use of a plurality of pressure sensors beneath the resting surface of a bed for humans.

[0007] WO01/95841 discloses a heating pad system including a heating pad that can be used for warming patients during various hospital procedures.

[0008] US 5 853 005 discloses a heart rate and respiratory rate measurement system for animals, comprising:

(a) a heater;

(b) a pressure sensor between insulation sheets;

(c) a spacer between the insulation sheets;

(d) a temperature sensor;

(e) a control device for maintaining the body temperature of the animals and for acquiring information from the pressure-sensitive sensor to determine respiratory rate and heart rate when the chest of the animal is placed on the pressure-sensitive sensor; and

(f) a monitoring device for monitoring the respiratory rate and heart rate of the animal.

[0009] In order to solve the problems described above, it is an object of the present invention to provide a device for maintaining body temperature haying heart rate and respiratory rate detection function for small animals and a heart rate and respiratory rate measurement system for small animals using the device, which are capable of being simply and easily set up without causing the small animal pain.

[0010] The present invention provides a heart rate and respiratory rate measurement system for a small animal as defined in the appended claims.

[0011] As described above, according to the present inventions, the sheet pressure-sensitive sensor is provided on an area on the surface of the heater. The area is covered with the chest of a small animal (the portion beneath the heart) when the small animal is placed on the heater for maintaining the body temperature thereof. It is possible to detect the oscillation (change in pressure) due to the respiration and heartbeats of the small animal that is in contact with the pressure-sensitive sensor to monitor the respiratory rate and the heart rate of the small animal.

[0012] In other words, the device for detecting the respiratory rate and heart rate is integrated on the surface of the heater for maintaining the body temperature, so that not only the body temperature of the small animal can be maintained but also the respiratory rate and heart rate of the small animal can be monitored.

Brief Description of the Drawings

[0013]

Fig. includes diagrams showing the structure of a device for maintaining body temperature having heart rate and respiratory rate detection function for small animals according to an embodiment of the present invention.

Fig. 2 illustrates a state in which a mouse is placed on the device for maintaining body temperature hav-

ing heart rate and respiratory rate detection function for small animals according to the embodiment of the present invention.

Fig. 3 is a block diagram of a heart rate and respiratory rate measurement system for small animals using the device for maintaining body temperature having heart rate and respiratory rate detection function for small animals, according to an embodiment of the present invention.

Fig. 4 shows an exemplary circuit for detecting a heartbeat signal used in the device for maintaining body temperature having heart rate and respiratory rate detection function for small animals according to an embodiment of the present invention.

Fig. 5 is a circuit diagram of a heartbeat-signal shaping circuit, which is a simple circuit example that specifically realizes a peak-hold circuit, used in the device for maintaining body temperature having heart rate and respiratory rate detection function for small animals according to an embodiment of the present invention.

Fig. 6 is a graph showing a heartbeat signal of a mouse output from a pressure-sensitive sensor in the device for maintaining body temperature having heart rate and respiratory rate detection function for small animals according to an embodiment of the present invention, when a low-performance high-pass filter is used.

Fig. 7 is a graph showing the heartbeat signal of the mouse output from the pressure-sensitive sensor in the device for maintaining body temperature having heart rate and respiratory rate detection function for small animals when a low-performance high-pass filter is used, in which the time base in Fig. 6 is expanded.

Fig. 8 is a graph showing an output from a low band-pass filter (respiration of a mouse) according to an embodiment of the present invention.

Fig. 9 is a graph (No. 1) showing an output from a high band-pass filter (heartbeats of a mouse) according to an embodiment of the present invention.

Fig. 10 a graph (No. 2) showing an output from the high band-pass filter (heartbeats of a mouse) according to the embodiment of the present invention.

Best Mode for Carrying Out the Invention

[0014] Embodiments of the present invention will be described in detail below.

[0015] Fig. 1 includes diagrams showing the structure of a device for maintaining body temperature having heart rate and respiratory rate detection function for small animals according to an embodiment of the present invention. Fig. 1(a) is an exploded perspective view of the device for maintaining body temperature having heart rate and respiratory rate detection function for small animals. Fig. 1(b) is a perspective view of the device for maintaining body temperature having heart rate and respiratory rate detection function for small animals. Fig. 2 illustrates a state in which a mouse is placed on the device for maintaining body temperature having heart rate and respiratory rate detection function for small animals. Fig. 3 is a block diagram of a heart rate and respiratory rate measurement system for small animals using the device for maintaining body temperature having heart rate and respiratory rate detection function for small animals.

[0016] Referring to Figs. 1(a) to 3, reference numeral 1 denotes a flat-plate heater, reference numeral 2 denotes a heater-current supplying line, reference numeral 3 denotes a thin insulation sheet, reference numeral 4 denotes a sheet pressure-sensitive sensor, reference numeral 5 denotes a signal line of the pressure-sensitive sensor 4, reference numeral 6 denotes a spacer, reference numeral 6A denotes a hole formed in the spacer 6, into which the pressure-sensitive sensor 4 fits, reference numeral 7 denotes a mouse, reference numeral 8 denotes a temperature sensor, reference numeral 9 denotes a signal line of the temperature sensor 8, reference numeral 10 denotes a control device, reference numeral 11 denotes an input interface, reference numeral 12 denotes a low band-pass filter (LBPF), reference numeral 13 denotes a high band-pass filter (HBPF), reference numeral 14 denotes a processor, reference numeral 15 denotes a storage unit (memory: storage medium) for storing programs, reference numerals 16 and 17 denote output interfaces, reference numeral 18 denotes a power supply, reference numeral 19 denotes an observation device, and reference numeral 20 denotes a heart rate and respiratory rate monitoring device for small animals.

[0017] As shown in Fig. 1(a), the sheet pressure-sensitive sensor 4 (piezoelectric device or the like), which is sandwiched between the thin insulation sheets 3, 3 or the like, is disposed over the flat-plate heater 1 to which the heater-current supplying line 2 is connected.

[0018] The hole 6A into which the pressure-sensitive sensor 4 fits is formed in the spacer 6. The spacer 6 is a metallic plate in order to equalize the temperature distribution and to disperse the load of a small animal.

[0019] The signal line 5 of the pressure-sensitive sensor 4 and the signal line 9 of the temperature sensor 8 are connected to the control device 10. The heater-current supplying line 2 is connected to the power supply 18, which can be controlled by the control device 10.

[0020] Since the output from the pressure-sensitive sensor 4 is an electrical signal on which the respiratory rate and heart rate of a small animal (for example, the mouse 7 in Fig. 2) are superimposed, filtering the electrical signal through the low band-pass filter (LBPF) 12 produces a waveform corresponding to the respiration of the small animal and filtering the electrical signal through the high band-pass filter (HBPF) 13 produces a waveform corresponding to the heartbeat of the small animal. In other words, a process for separating, shaping and displaying the electrical signal, on which the respiratory rate and the heart rate output from the pressure-sensitive sensor 4 are superimposed, is performed. The

shaped signal is observed on the external observation device (for example, an oscilloscope) 19. Furthermore, the frequency of the signal is measured and the measured frequency is displayed on an LED screen to monitor the respiratory rate and the heart rate of the small animal with the monitoring device 20. The body temperature of the small animal, which is output from the temperature sensor 8, can be controlled by the control device 10. Detection means of heartbeat signals according to the present invention will now be described in detail.

[0021] Fig. 4 shows an exemplary circuit for detecting a heartbeat signal, used in the device for maintaining body temperature having heart rate and respiratory rate detection function for small animals, according to an embodiment of the present invention. Fig. 5 is a circuit diagram of a heartbeat-signal shaping circuit, which is a simple circuit example that specifically realizes a peak-hold circuit, used in the device for maintaining body temperature having heart rate and respiratory rate detection function for small animals.

[0022] Referring to Figs. 4 and 5, reference numeral 101 denotes a high band-pass filter circuit (HBPF) including an HPF (high-pass filter) 111, an amplifier 112, an integration circuit 113, and a differential amplifier 114. Reference numeral 115 denotes an output signal line of the differential amplifier 114.

[0023] Reference numeral 120 denotes a heartbeat-signal shaping circuit. Reference numeral 121 denotes a positive-signal peak-hold circuit including a diode (forward connection) 122, and a resistor 123 and a capacitor 124 connected in parallel between the output side of the diode 122 and the ground. Reference numeral 125 denotes a negative-signal peak-hold circuit including a diode 126 (backward connection), and a resistor 127 and a capacitor 128 connected in parallel between the output side of the diode 126 and the ground. Reference numeral 131 denotes a differential amplifier to which the output signal from the positive-signal peak-hold circuit 121 and the output signal from the negative-signal peak-hold circuit 125 are supplied, reference numeral 132 denotes a comparator connected to the differential amplifier 131, and reference numeral 133 denotes an output signal line of the comparator 132. A digitized heartbeat signal is output through the output signal line 133 of the comparator 132.

[0024] Fig. 6 is a graph showing a heartbeat signal of a mouse output from the device for maintaining body temperature having heart rate and respiratory rate detection function for small animals, according to an embodiment of the present invention. Fig. 7 is a graph showing the heartbeat signal of the mouse output from the device for maintaining body temperature having heart rate and respiratory rate detection function for small animals, in which the time base in Fig. 6 is expanded. Figs. 6 and 7 show the heartbeat signal of the mouse output when a low-performance high-pass filter is used. Signal components of noise and respiration are insufficiently separated in Figs. 6 and 7.

[0025] Fig. 8 is a graph showing an output from a low band-pass filter (respiration of a mouse) according to an embodiment of the present invention. A signal having a period of about 350 milliseconds representing a respiratory signal of a mouse is shown in Fig. 8. Signal components of heartbeats are completely separated.

[0026] Fig. 9 is a graph showing an output from a high band-pass filter (heartbeats of a mouse) according to an embodiment of the present invention. A high-amplitude signal having a period of about 100 milliseconds representing a heartbeat signal of a mouse is shown in Fig. 9. The heartbeat signal can be visually and clearly discriminated from small noise having a low amplitude around the base line. In addition, the heartbeat signal in Fig. 9 is clearly different from the heartbeat signal shown in Fig. 7. It has been confirmed based on the correspondence to an electrocardiogram (ECG) that the signal in Fig. 9 is a heartbeat signal. As described above, with the high band-pass filter circuit of the present invention shown in Fig. 4, the analog signal output of the heartbeats of a mouse, having a high SN ratio, can be obtained.

[0027] Fig. 10 is a graph showing an example in which two heartbeat pulses correspond to one heartbeat, among outputs from the high band-pass filter (heartbeats of a mouse) according to an embodiment of the present invention. Referring to Fig. 10, two pulses having high amplitudes are shown during a period of about 100 milliseconds. One or two high oscillations are detected per one heartbeat with a pressure-sensitive sensor depending on the physiological state or individual difference of a small animal. Each of the oscillations is converted into one or two heartbeat pulses. An example in which two heartbeat pulses correspond to one heartbeat is shown in Fig. 10.

[0028] Referring to Figs. 6 and 7, the horizontal axis represents time (ms) and the vertical axis represents voltage (mV). Referring to Figs. 8 to 10, the horizontal axis represents time (ms) and the vertical axis represents voltage (V).

[0029] As described above, according to the present invention, the process for separating, shaping and displaying the electrical signal, on which the respiratory rate and the heart rate are superimposed, is performed by filtering the outputs from the pressure-sensitive sensor 4 through the low band-pass filter (LBPF) 12 and the high band-pass filter (HBPF) 13. However, since a waveform having a low SN ratio, as shown in Figs. 6 and 7, is produced when a low-performance high-pass filter is used in the shaping of the heartbeat signals, a high-performance high band-pass filter must be used. A high band-pass filter that can be manufactured at a lower cost and that has a proprietary circuit configuration, such as the high band-pass filter circuit (HBPF) 101 shown in Fig. 4, is used in the present invention, so that an analog output waveform of the heartbeat signal having a high SN ratio, as shown in Fig. 8, can be obtained. The integration circuit 113 may be a simple series circuit including a resistor and a capacitor. The shaped signal is monitored by the

external observation device 19, such as an oscilloscope. In addition, only the components highly oscillating in the positive and negative directions can be extracted within a limited time period of around several milliseconds of a heartbeat signal by using the circuit in which the positive-signal peak-hold circuit 121 and the negative-signal peak-hold circuit 125, which have a holding time of around several milliseconds, are connected to the two outputs of the differential amplifier 131 in the heartbeat-signal shaping circuit 120 within the processor 14. The addition of this circuit allows the heartbeat signal to be easily detected even when the noise level is high. The positive-signal peak-hold circuit 121 and the negative-signal peak-hold circuit 125 may be replaced with simple circuits, as shown in Fig. 5, in which the capacitors 124 and 128 are connected in parallel to the resistors 123 and 127, respectively, in the rectification circuit having the diodes 122 and 126 connected in series to the resistors. Among the output heartbeat pulses digitized in these circuits, pulses caused by noise are eliminated by a microprocessor in the processor 14, and it is determined whether a pattern is such that one pulse corresponds to one heartbeat, as shown in Fig. 9, or a pattern is such that two pulses correspond to one heartbeat, as shown in Fig. 10. The calculated result is displayed on an LED screen to monitor the respiratory rate and the heart rate of a small animal with the monitoring device 20.

[0030] As described above, according to the present invention, placing a small animal on the device for maintaining body temperature having heart rate and respiratory rate detection function for small animals allows not only the body temperature of the small animal to be maintained but also the respiratory rate and the heart rate to be monitored without being affected by noise or a change in pattern of the heartbeat signal of the small animal. This device for maintaining body temperature is a breakthrough device that has been required for eliminating the need for mounting and wiring of electrodes for an electrocardiogram and for saving time and effort for adjusting the device. The same is true for the respiratory rate measurement system for small animals, and the experimental space can be reduced because an external device is not necessary. In other words, the introduction of the device according to the present invention advantageously and largely reduces the time and effort required for preparation for an experiment and assures a sufficient experimental space. Furthermore, there is no need for additionally buying an expensive respiration monitor or electrocardiograph, thus achieving a great economical effect.

[0031] As a high-level application of the device for maintaining body temperature having heart rate and respiratory rate detection function for small animals, provision of an output interface that is used for observing the strength or pattern of the heartbeats and the lung activity of a small animal permits analysis of information indicating the physiological state of the heart, which was not capable of being measured with known methods using electrocardiogram or blood pressure, or permits analysis of the activity of the heart or lung. Hence, the present invention can attain a new development in medical research fields.

Industrial Applicability

[0032] With the device for maintaining body temperature having heart rate and respiratory rate detection function for small animals and the heart rate and respiratory rate measurement system for small animals using the device according to the present invention, only placing a small animal on the device for maintaining body temperature having heart rate and respiratory rate detection function for small animals allows not only the body temperature of the small animal to be maintained but also the respiratory rate and the heart rate of the small animal to be monitored. Hence, the device for maintaining body temperature having heart rate and respiratory rate detection function for small animals and the heart rate and respiratory rate measurement system for small animals using the device are preferable as experimental apparatuses for noninvasively and simply measuring physiologically-required basic data of a small animal without fail.

Claims

1. A heart rate and respiratory rate measurement system for a small animal comprising:

   (a) a flat-plate heater (1);
   (b) a pressure-sensitive sensor (4) sandwiched between thin insulation sheets (3) and provided on the flat-plate heater (1);
   (c) a spacer (6) sandwiched between the thin insulation sheets (3) wherein the spacer (6) is a metallic plate having a hole (6A) in which the pressure-sensitive sensor (4) is fitted;
   (d) a temperature sensor (8) provided on the spacer (6);
   (e) a control device (10) for maintaining the body temperature of the small animal and for acquiring information from the pressure-sensitive sensor (4) to determine respiratory rate and heart rate when the chest of the small animal is placed on the pressure-sensitive sensor (4); and
   (f) a monitoring device (20) for monitoring the respiratory rate and heart rate of the small animal.

2. The heart rate and respiratory rate measurement system for a small animal according to Claim 1, **characterized by** further comprising a low band-pass filter (12) for processing the information acquired from the pressure-sensitive sensor (4) to measure the respiratory rate of the small animal and a high band-pass filter (13) for processing the information acquired from the pressure-sensitive sensor (4) to

measure the heart rate of the small animal.

3. The heart rate and respiratory rate measurement system for a small animal according to Claim 2, **characterized by** further comprising a terminal which outputs analog signal waveforms of the heartbeats and respiration from the filters (12, 13), and **characterized by** converting the output from the terminal into a digital signal to measure the heart rate and the respiratory rate.

4. The heart rate and respiratory rate measurement system for a small animal according to Claim 2, **characterized by** further comprising a terminal which outputs analog signal waveforms of the heartbeats and respiration from the filters (12, 13), and an observation device for observing the heartbeats and the respiration based on the output from the terminal.

5. The heart rate and respiratory rate measurement system for a small animal according to Claim 3, **characterized by** further comprising a microprocessor (14) including a storage medium (15) that stores a program for eliminating pulses caused by noise among the digital signal and for determining whether the digital signal contains a pattern wherein one pulse corresponds to one heartbeat or a pattern wherein two pulses correspond to one heartbeat.

6. The heart rate and respiratory rate measurement system for a small animal according to Claim 3, **characterized by** further comprising a high band-pass filter circuit (101) comprising:

   a high-pass filter (111) for receiving the output from the pressure-sensitive sensor (4) to produce a filtered output;
   an amplifier (112) for amplifying the filtered output to produce an amplified signal;
   an integration circuit (113) that receives the amplified signal; and
   a first differential amplifier (114) that receives the amplified signal from the amplifier (112) and the output from the integration circuit (113) to provide an analogue waveform corresponding to the heartbeat of the small animal.

7. The heart rate and respiratory rate measurement system for a small animal according to Claim 6, **characterized by** further comprising a circuit (120) for generating the digital signal for measuring the heart rate, comprising a positive-signal peak-hold circuit (121) and a negative-signal peak-hold circuit (125), which have a holding time of around several milliseconds, connected between the output terminal of the high band-pass filter circuit (101) and the two input terminals of a second differential amplifier (131).

8. The heart rate and respiratory rate measurement system for a small animal according to Claim 7, **characterized in that** each of the peak-hold circuits (121, 125) includes a capacitor (124, 128) connected in parallel to a resistor (123, 127) in a rectification circuit having a diode (122, 126) connected in series to the resistor (123, 127).

Patentansprüche

1. System zur Messung der Herzfrequenz und der Atemfrequenz für ein Kleintier, wobei das System Folgendes umfasst:

   (a) ein Flachplatten-Heizelement (1);
   (b) einen druckempfindlichen Sensor (4), der zwischen dünnen Isolierplatten (3) eingeschoben und auf dem Flachplatten-Heizelement (1) vorgesehen ist;
   (c) eine Abstandsplatte (6), die zwischen den dünnen Isolierplatten (3) eingeschoben ist, wobei es sich bei der Abstandsplatte (6) um eine Metallplatte mit einer Öffnung (6A) handelt, in die der druckempfindliche Sensor (4) eingepasst ist;
   (d) einen Temperatursensor (8), der auf der Abstandsplatte (6) vorgesehen ist;
   (e) eine Steuervorrichtung (10) zum Aufrechterhalten der Körpertemperatur des Kleintiers und zum Erfassen von Informationen von dem druckempfindlichen Sensor (4), um die Atemfrequenz und die Herzfrequenz zu bestimmen, wenn die Brust des Kleintiers auf dem druckempfindlichen Sensor (4) platziert wird; und
   (f) eine Überwachungsvorrichtung (20) zum Überwachen der Atemfrequenz und der Herzfrequenz des Kleintiers.

2. System zur Messung der Herzfrequenz und der Atemfrequenz für ein Kleintier nach Anspruch 1, **dadurch gekennzeichnet, dass** es weiterhin einen Tief-Bandpassfilter (12) zum Verarbeiten der von dem druckempfindlichen Sensor (4) erfassten Informationen, um die Atemfrequenz des Kleintiers zu messen, und einen Hoch-Bandpassfilter (13) zum Verarbeiten der von dem druckempfindlichen Sensor (4) erfassten Informationen, um die Herzfreguenz des Kleintiers zu messen, umfasst.

3. System zur Messung der Herzfrequenz und der Atemfrequenz für ein Kleintier nach Anspruch 1, **dadurch gekennzeichnet, dass** es weiterhin ein Endgerät umfasst, das analoge Signalwellenformen der Herzschläge und der Atmung von den Filtern (12, 13) ausgibt, und **dadurch gekennzeichnet, dass** es die Ausgabe von dem Endgerät in ein digitales Signal unwandelt, um die Herzfrequenz und die

Atemfrequenz zu messen.

4. System zur Messung der Herzfrequenz und der Atemfrequenz für ein Kleintier nach Anspruch 2, **dadurch gekennzeichnet, dass** es weiterhin ein Endgerät, das analoge Signalwellenformen der Herzschläge und der Atmung von den Filtern (12, 13) ausgibt, und eine Beobachtungsvorrichtung zum Beobachten der Herzschläge und der Atmung auf Basis der Ausgabe von dem Endgerät umfasst.

5. System zur Messung der Herzfrequenz und der Atemfrequenz für ein Kleintier nach Anspruch 3, **dadurch gekennzeichnet, dass** es weiterhin einen Mikroprozessor (14) umfasst, der ein Speichermedium (15) beinhaltet, das ein Programm speichert, um Impulse, die von Rauschen verursacht werden, aus dem digitalen Signal zu eliminieren und zu bestimmen, ob das digitale Signal ein Muster, in dem ein Impuls einem Herzschlag entspricht, oder ein Muster, in dem zwei Impulse einem Herzschlag entsprechen, enthält.

6. System zur Messung der Herzfrequenz und der Atemfrequenz für ein Kleintier nach Anspruch 3, **dadurch gekennzeichnet, dass** es weiterhin eine Hoch-Bandpassfilter-Schaltung (101) umfasst, die Folgendes umfasst:

einen Hochpassfilter (111) zum Empfangen der Ausgabe von dem druckempfindlichen Sensor (4), um eine gefilterte Ausgabe zu produzieren;
einen Verstärker (112) zum Verstärken der gefilterten Ausgabe, um ein verstärktes Signal zu produzieren;
eine Integrationsschaltung (113), die das verstärkte Signal empfängt; und
einen ersten Differentialverstärker (114), der das verstärkte Signal von dem Verstärker (112) und die Ausgabe von der Integrationsschaltung (113) empfängt, um eine analoge Wellenform zu liefern, die dem Herzschlag des Kleintiers entspricht.

7. System zur Messung der Herzfrequenz und der Atemfrequenz für ein Kleintier nach Anspruch 6, **dadurch gekennzeichnet, dass** es weitherhin Schaltung (120) zum Erzeugen des digitalen Signals zum Messen der Herzfrequenz umfasst, die eine Positivsignal-Peak-Holding-Schaltung (121) und eine Negativsignal-Peak-Holding-Schaltung (125) umfasst, die eine Haltezeit von ungefähr mehreren Millisekunden aufweisen, und die zwischen dem Ausgabeendgerät der hoch-Bandpassfilter-Differentialverstärkers (131) angeschlossen ist.

8. System zur Messung der Herzfrequenz und der Atemfrequenz für ein Kleintier nach Anspruch 7, **dadurch gekennzeichnet, dass** jede der Peak-Holding-Schaltungen (121, 125) einen Kondensator (124, 128), der mit einem Widerstand (123, 127) parallel geschaltet ist, in einer Gleichrichtungsschaltung mit einer Diode (122, 126), die mit dem Widerstand (123, 127) in Reihe geschaltet ist, beinhaltet.

Revendications

1. Un système de mesure du rythme cardiaque et respiratoire pour un petit animal, comprenant :

(a) un panneau plat chauffant (1) ;
(b) un capteur sensible à la pression (4) pris en sandwich entre de minces feuilles isolantes (3) et placé sur le panneau plat chauffant (1) ;
(c) un espaceur (6) pris en sandwich entre les minces feuilles isolantes(3) dans lequel l'espaceur (6) est une plaque métallique pourvue d'un trou (6A) dans lequel le capteur sensible à la pression (4) est fixé ;
(d) un capteur de température (8) placé sur l'espaceur (6);
(e) un appareil de contrôle (10) pour maintenir la température corporelle du petit animal et pour l'acquisition de l'information à partir du capteur sensible à la pression (4) pour déterminer le rythme cardiaque et respiratoire lorsque la poitrine du petit animal est placée au contact du capteur sensible à la pression (4) ; et
(f) un appareil de monitoring (20) pour contrôler monitoring le rythme cardiaque et respiratoire d'un petit animal.

2. Le système de mesure du rythme cardiaque et respiratoire chez un petit animal conforme à la Revendication 1, **caractérisé par le fait qu'**il comprend en plus un filtre passe-bas (12) pour le traitement de l'information acquise à partir du capteur sensible à la pression (4) pour mesurer le rythme respiratoire du petit animal et un filtre passe-haut (13) pour le traitement de l'information acquise à partir du capteur sensible à la pression (4) pour mesurer le rythme cardiaque du petit animal.

3. Le système de mesure du rythme cardiaque et respiratoire chez un petit animal conforme à la Revendication 2, **caractérisé par le fait qu'**il comprend en plus un terminal qui produit des ondes analogiques des battements cardiaques et de la respiration à partir des filtres (12, 13), et **caractérisé par le fait qu'**il convertit la sortie du terminal en signal numérique pour mesurer les rythmes cardiaque et respiratoire.

4. Le système de mesure du rythme cardiaque et respiratoire chez un petit animal conforme à la Reven-

dication 2, **caractérisé par le fait qu'**il comprend en plus un terminal qui produit des ondes analogiques des battements cardiaques et de la respiration à partir des filtres (12, 13), et un appareil d'observation pour l'observation des battements cardiaques et de la respiration basée sur la sortie du terminal.

5. Le système de mesure du rythme cardiaque et respiratoire chez un petit animal conforme à la Revendication 3, **caractérisé par le fait qu'**il comprend en plus un microprocesseur (14) incluant un composant de stockage (15) qui stocke un programme d'élimination des impulsions causées par le bruit autour du signal numérique et permettant de déterminer si le signal numérique contient un motif dans lequel une impulsion correspond à un battement ou un motif dans lequel deux impulsions correspondent à un battement.

6. Le système de mesure du rythme cardiaque et respiratoire chez un petit animal conforme à la Revendication 3, **caractérisé par le fait qu'**il comprend en plus un circuit filtre passe-haut (101) comprenant :

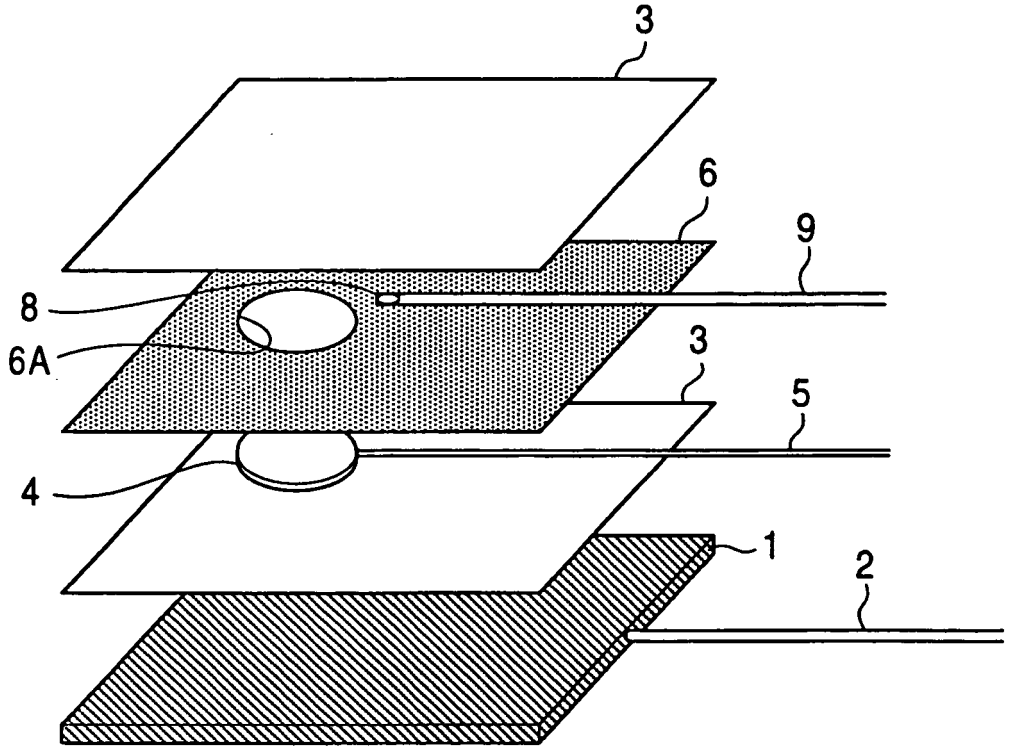
un filtre passe-haut (111) pour la réception du débit du capteur sensible à la pression (4) et la production d'un débit filtré ;
un amplificateur (112) pour l'amplification du débit filtré et la production d'un signal amplifié ;
un circuit intégré (113) qui reçoit le signal amplifié ; et
un premier amplificateur différentiel (114) qui reçoit le signal amplifié par l'amplificateur (112) et le débit du circuit intégré (113) pour former une onde analogique correspondant aux battements cardiaques du petit animal.

7. Le système de mesure du rythme cardiaque et respiratoire chez un petit animal conforme à la Revendication 6, **caractérisé par le fait qu'**il comprend en plus un circuit (120) pour générer le signal numérique permettant la mesure du rythme cardiaque, comprenant un circuit maintenant la valeur crête du signal positif (121) et un circuit maintenant la valeur crête du signal négatif (125), qui ont un temps de maintient de plusieurs millisecondes, monté entre le terminal de sortie du circuit filtre passe-haut (101) et les deux terminaux d'entrée d'un second amplificateur différentiel (131).

8. Le système de mesure du rythme cardiaque et respiratoire chez un petit animal conforme à la Revendication 7, **caractérisé par** la fait que chacun des circuits maintenant la valeur crête (121, 125) inclut un condensateur (124, 128) monté en parallèle avec une résistance (123, 127) dans un circuit rectificateur avec une diode (122, 126) montée en série avec une résistance (123, 127).

FIG. 1

(a)



(b)

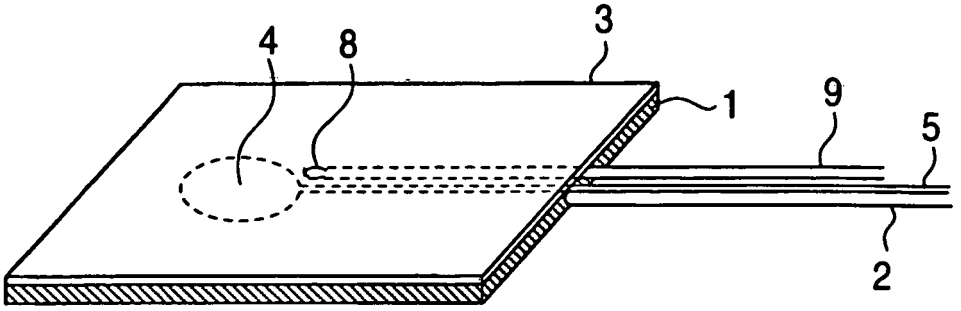


FIG. 2

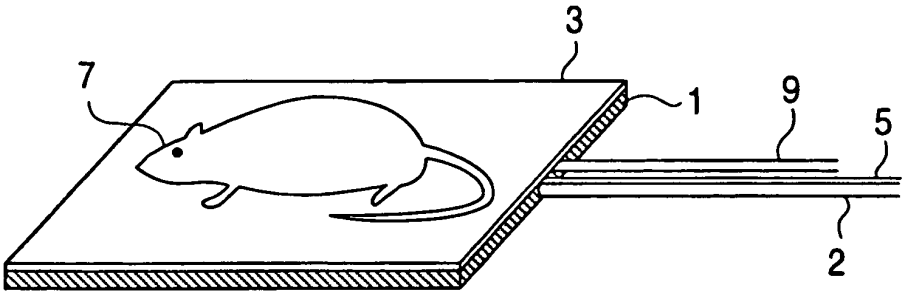

3
7
1
9
5
2

FIG. 3

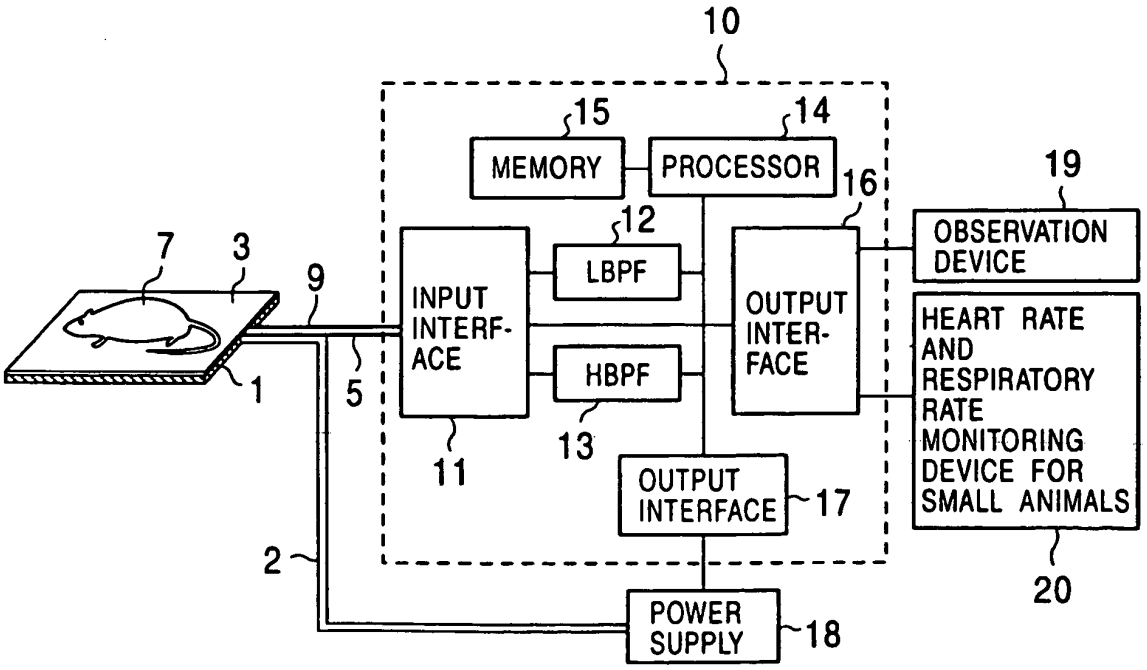

10
15
14
MEMORY
PROCESSOR
16
19
12
7
3
9
INPUT INTERF-ACE
LBPF
OUTPUT INTER-FACE
OBSERVATION DEVICE
HEART RATE AND RESPIRATORY RATE MONITORING DEVICE FOR SMALL ANIMALS
HBPF
1
5
11
13
OUTPUT INTERFACE
17
2
20
POWER SUPPLY
18

FIG. 4

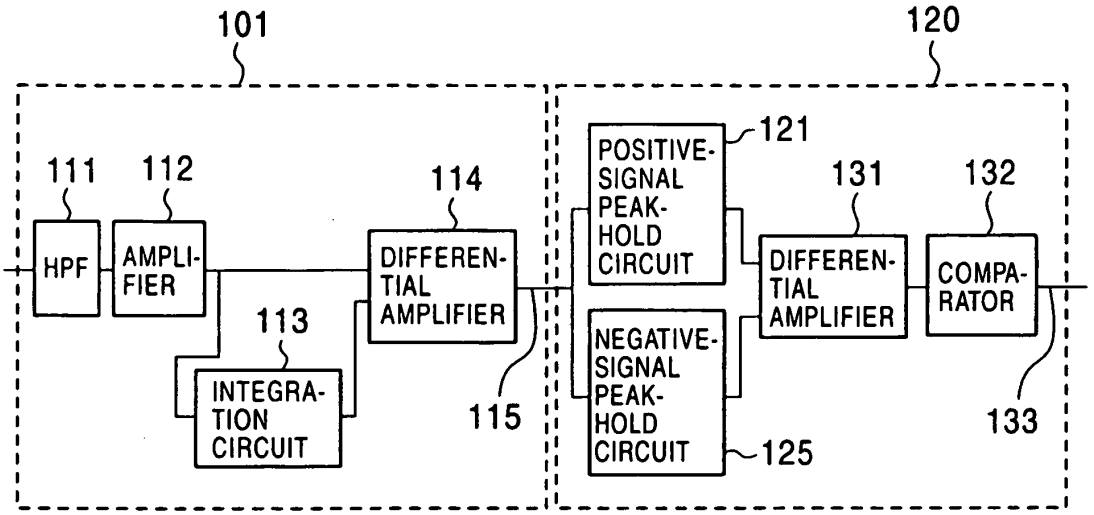

101
120
111
112
114
HPF
AMPLI-FIER
DIFFEREN-TIAL AMPLIFIER
113
INTEGRA-TION CIRCUIT
115
POSITIVE-SIGNAL PEAK-HOLD CIRCUIT
121
131
132
DIFFEREN-TIAL AMPLIFIER
COMPA-RATOR
NEGATIVE-SIGNAL PEAK-HOLD CIRCUIT
125
133

FIG. 5

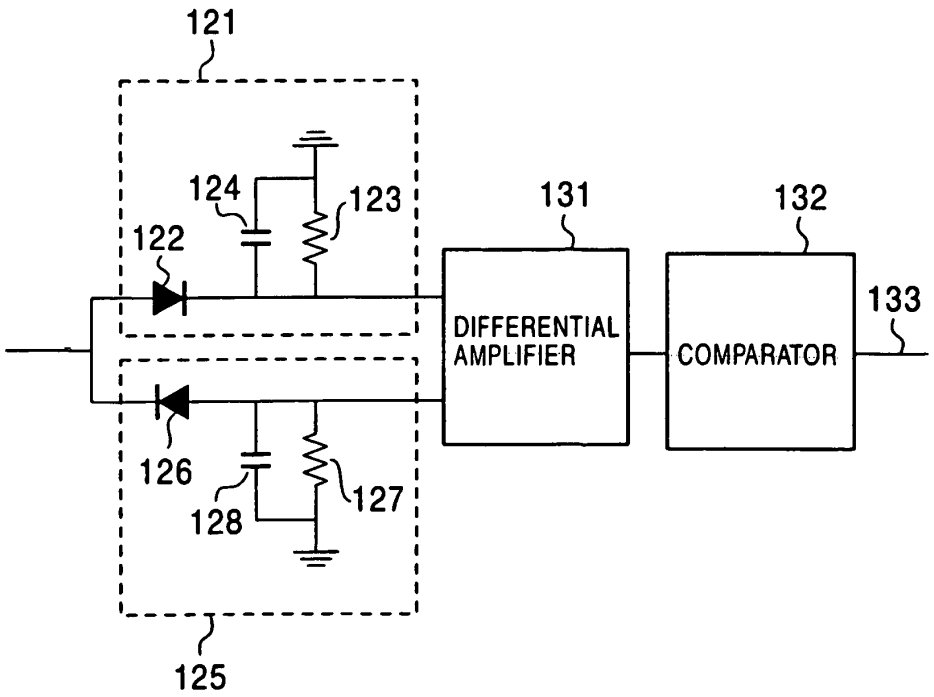

121
124
123
122
131
132
DIFFERENTIAL AMPLIFIER
COMPARATOR
133
126
128
127
125

FIG. 6

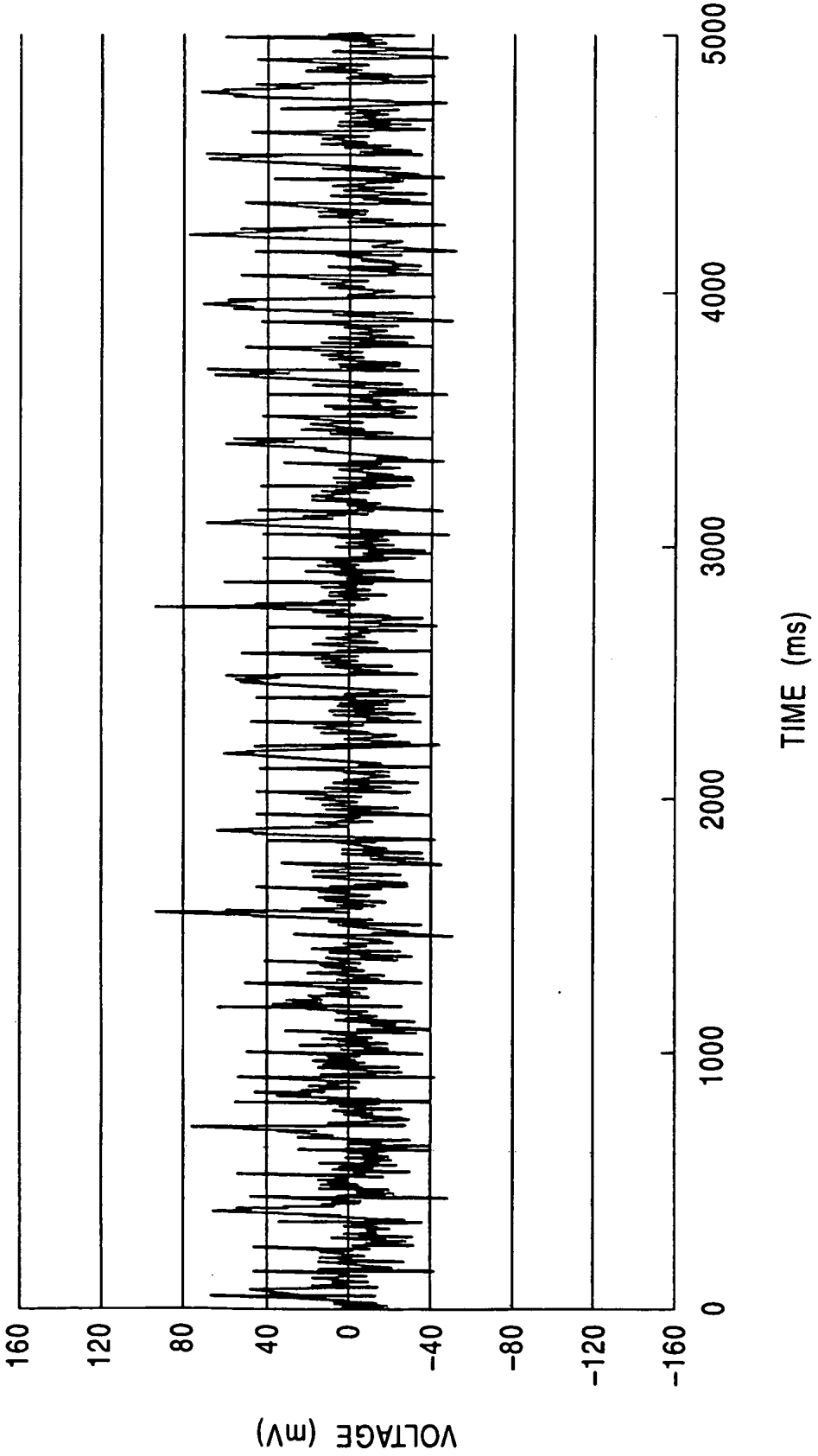

160
120
80
40
0
-40
-80
-120
-160
VOLTAGE (mV)
0
1000
2000
3000
4000
5000
TIME (ms)

FIG. 7

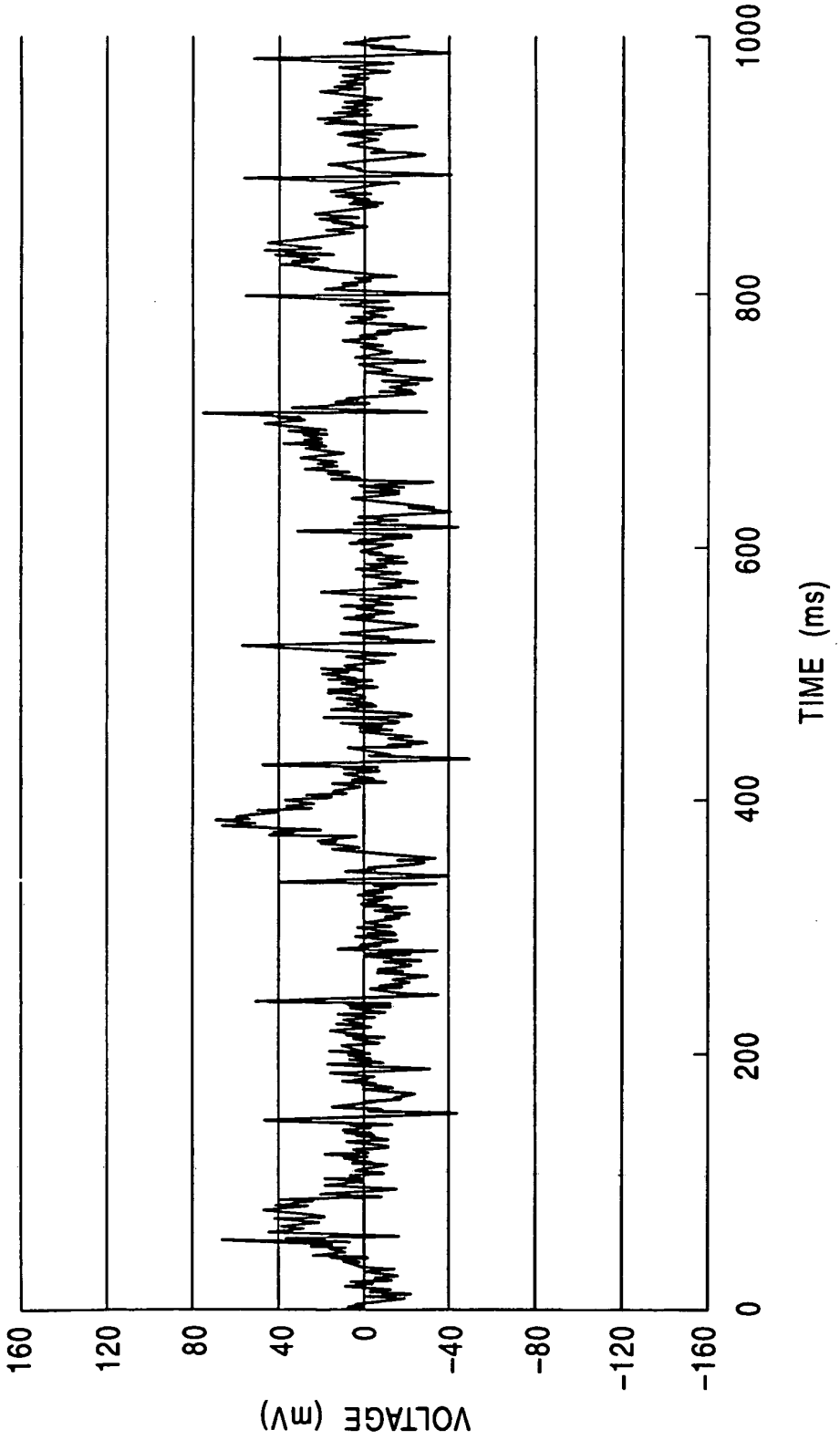

160
120
80
40
0
-40
-80
-120
-160
VOLTAGE (mV)
0
200
400
600
800
1000
TIME (ms)

FIG. 8

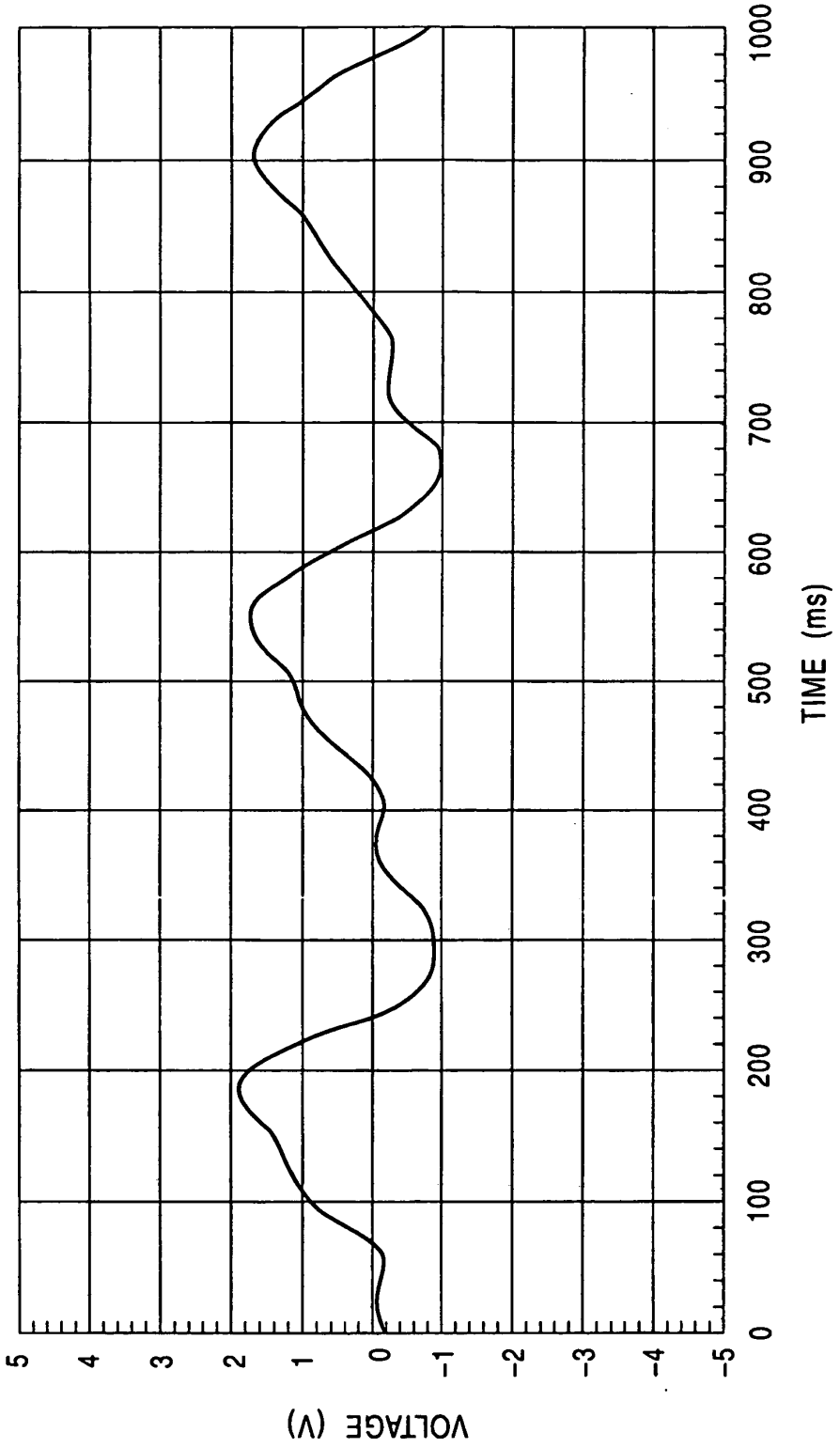

VOLTAGE (V)
5
4
3
2
1
0
-1
-2
-3
-4
-5
0
100
200
300
400
500
600
700
800
900
1000
TIME (ms)

FIG. 9

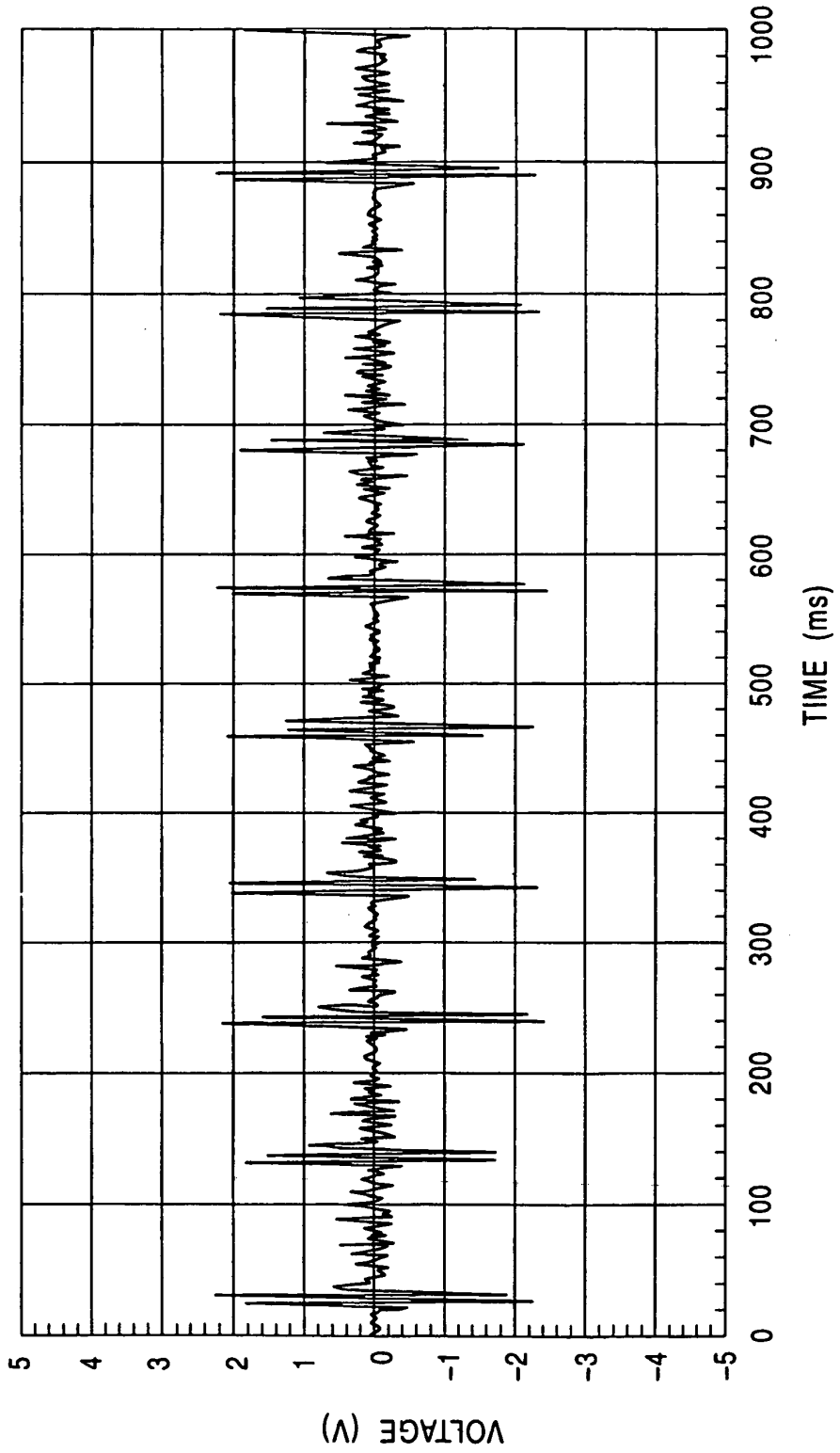
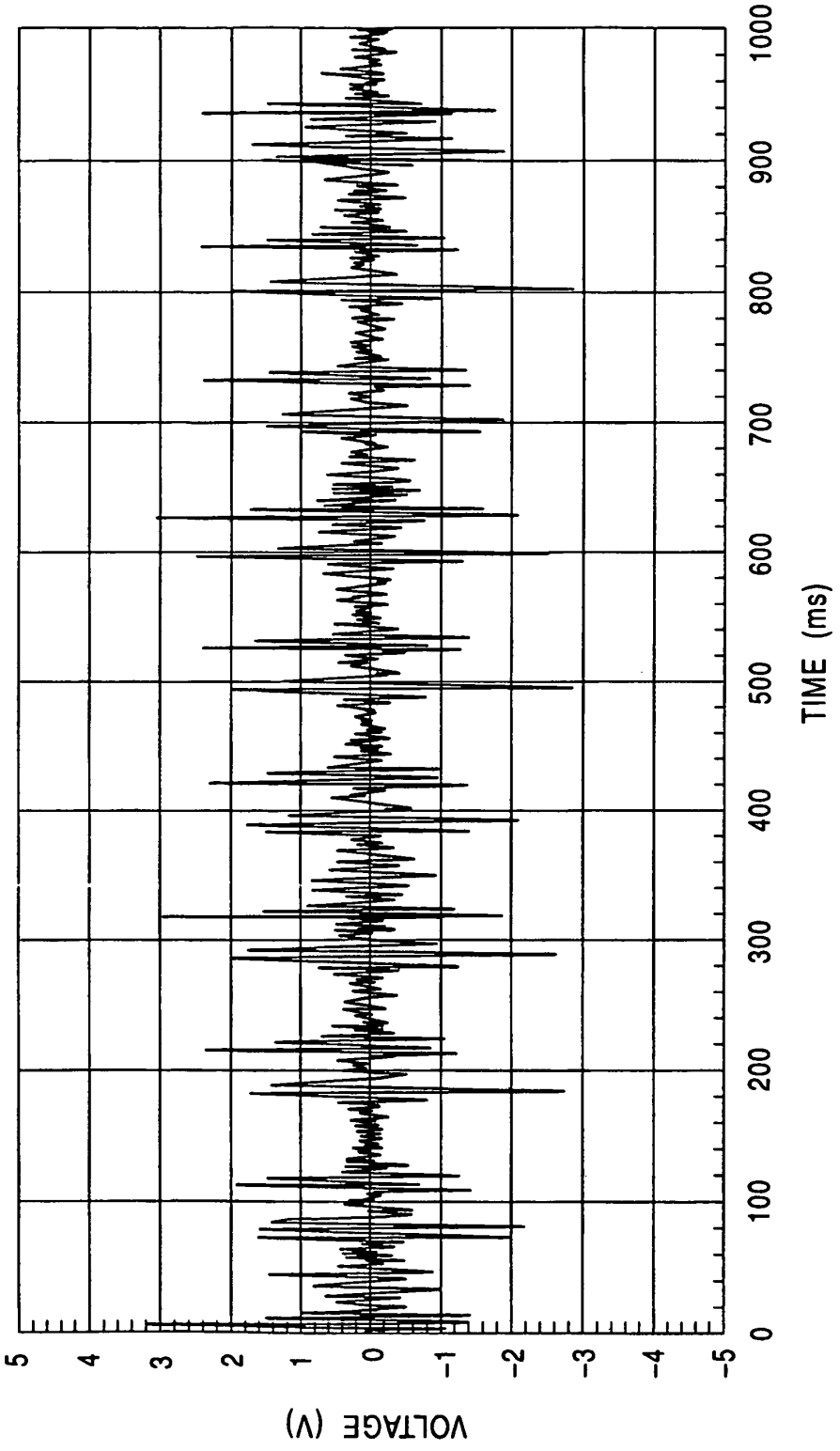

VOLTAGE (V)
5
4
3
2
1
0
-1
-2
-3
-4
-5
0
100
200
300
400
500
600
700
800
900
1000
TIME (ms)

FIG. 10


VOLTAGE (V)
5
4
3
2
1
0
-1
-2
-3
-4
-5
0
100
200
300
400
500
600
700
800
900
1000
TIME (ms)

REFERENCES CITED IN THE DESCRIPTION

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- US 20020014951 A **[0006]**
- WO 0195841 A **[0007]**
- US 5853005 A **[0008]**