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(54) Title: DETERMINING CONTACT WITH A BODY

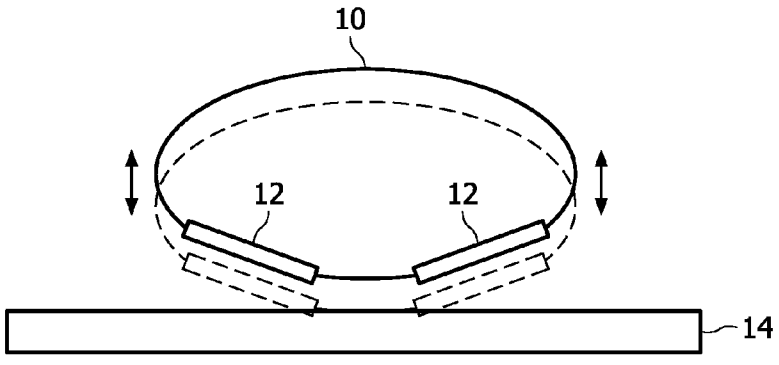


FIG. 1

(57) Abstract: A method and apparatus for determining a quality of physical contact of a sensor (12) with a body is presented. The method comprises the steps of : vibrating the sensor at a substantially constant frequency; analysing a signal detected by the sensor and which is influenced by the sensor vibration; determining the quality of physical contact based on the determined modulation of the signal.

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Determining contact with a body

FIELD OF THE INVENTION

This invention relates to determining physical contact with a body, and more particularly, to determining a quality of physical contact of a sensor with a body.

BACKGROUND AND PRIOR ART

Devices comprising one or more sensors for detecting physiological signals of a user are known. For example, a handheld vibrating massage device has been proposed which has one or more sensors to detect physiological signals of the user. Based on the detected physiological signals, the physiological state and/or the emotional state of the user may be determined and the vibration of the massage device may be controlled so as to better reflect the determined state of the user.

When using such vibrating (massage) devices as part of a system, it is important to know a quality (for example, the contact pressure or contact area) of the contact with the body since this may determine the sensation which the user feels.

Furthermore, for devices comprising one or more sensors to detect physiological signals of a user, it is important that a signal measured by the sensor(s) is accurate so as to enable correct determination of the actual state of the user. The quality of the contact of the sensor(s) with the body may directly affect the accuracy of sensed data from the sensor(s).

SUMMARY OF THE INVENTION

According to the invention, there is provided a method for determining a quality of physical contact of a sensor with a body, the method comprising the steps of: vibrating the sensor at a frequency of vibration; analysing a signal detected by the sensor and which is influenced by the sensor vibration; determining the quality of physical contact based on the analysed signal.

The signal detected by the sensor may be calibrated based on the determined quality of physical contact.

The method may further comprise using the vibration frequency of the sensor to calibrate the signal detected by the sensor. For example, the amplitude of the analysed signal may be used as an indication of the pressure of contact of the sensor with the body, or alternatively as a calibration tool to adjust absolute level of a signal from the sensor.

According to another aspect of the invention, there is provided a computer program comprising computer program code means adapted to perform all of the steps of the method, when said program is run on computer.

According to another aspect of the invention, there is provided said computer program embodied on a computer readable medium.

According to another aspect of the invention, there is provided an apparatus for determining a quality of physical contact of a sensor with a body, the apparatus comprising: vibration means adapted to cause the sensor to vibrate at a frequency of vibration; a processor unit adapted to analyse a signal detected by the sensor, the signal being influenced by the sensor vibration, and to determine the quality of physical contact based on the analysed signal.

According to yet another aspect of the invention, there is provided a device comprising: a sensor adapted to contact a body and to detect a physiological signal from the body; and apparatus for determining a quality of physical contact of the sensor with the body according to the invention. In a further embodiment of the device said device is a hand-held massage device.

The sensing function of the sensor may be based upon an electrical contact with the body, for example the skin of a user, and may preferably be a skin conductivity sensor.

BRIEF DESCRIPTION OF THE DRAWINGS

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

Fig. 1 illustrates a vibrating device according to an embodiment of the invention;

Fig. 2 is a graph showing detected conductivity against time obtained for the embodiment of Fig. 1;

Fig. 3 shows a modification of the embodiment of Fig. 1;

Fig. 4 is a graph showing detected conductivity against time obtained for the embodiment of Fig. 3;

Fig. 5 shows another modification of the embodiment of Fig. 1;

Fig. 6 is a graph showing detected conductivity against time obtained for the embodiment of Fig. 5;

Fig. 7 shows yet another modification of the embodiment of Fig. 1;

Fig. 8 is a graph showing detected conductivity against time obtained for the embodiment of Fig. 7; and

Fig. 9 is a schematic diagram of a device according to another embodiment of the invention.

The dimensions of the diagrams are not to scale and like reference numerals refer to like elements throughout.

DETAILED DESCRIPTION

The present invention provides a method and apparatus for determining a quality of physical contact of a sensor with a body, thereby enabling determination of a level of reliability of signals provided by the sensor for example. The determined quality of physical contact of the sensor with a body may also be used to calibrate the sensor, so as to take account for a factor such as contact pressure which may alter data readings obtained by the sensor.

Referring first to Fig. 1, a vibrating device according to an embodiment is illustrated. The vibrating device 10 comprises first and second sensor electrodes 12 adapted to detect an electrical contact with a body 14 (for example, the skin of a user). More specifically, the sensor electrodes 12 are Galvanic Skin Resistance (GSR) sensors adapted to detect the electrical conductivity of the skin 14 of a person.

The device is positioned next to the skin 14 of a user with the sensor electrodes 12 oriented so that they face towards the skin 14. The device 10 is then vibrated at a substantially fixed frequency so that is oscillated between a first and second position. So as to avoid confusion with mains frequency, for example 50Hz, the frequency of oscillation is greater than 50Hz, preferably greater than 150Hz, and even more preferably not equal to an integer multiple of 50Hz.

In Fig. 1, the first position is illustrated using solid lines. When in the first position, the device 10 is spaced apart from the skin 14 so that the sensor electrodes 12 do not contact the skin 14. Conversely, the second position of the device 10 is illustrated using dashed lines. When in the second position, the device 10 touches the skin 14 so that the sensor electrodes 12 are in contact with the skin 14.

When the device 10 is not in contact with the skin 14 (i.e. when the device is in the first position illustrated in Fig. 1), the detected electrical conductivity between the sensor electrodes 12 is zero. When the device lightly touches the skin (i.e. when the device is in the second position illustrated by the dashed lines in Fig.1), the sensor electrodes 12 detect a non-zero value of electrical conductivity. Thus, the vibration of the device 10 results in regular periods where the sensor electrodes contact the body, separated by periods when they do not touch the body and zero conductivity is detected. Thus, when the detected conductivity (G) is plotted against time for such a situation, a graph resembling that shown in Fig. 2 is obtained, wherein the detected conductivity periodically increases above zero.

Referring now to Fig. 2, if the vibrating device 10 is pressed against the skin 14 so that sensor electrodes maintain contact with the skin 14 for longer periods of time during the oscillation of the device 12 between first and second positions, the vibration of the device 10 results in shorter (but still regular) periods where the sensor electrodes 12 are not in contact with the skin 14. When the detected conductivity (G) is plotted against time for the arrangement of Fig. 3, a graph resembling that shown in Fig. 4 is obtained, wherein the detected conductivity periodically increases above zero with a greater duty cycle than that of Fig. 2.

Pressing the device now further against the skin 14, the arrangement of Fig. 5 is obtained wherein the sensor electrodes 12 remain in contact with the skin 14 whilst the device 10 vibrates. It is observed that a plot of detected conductivity (G) against time, resembling that shown in Fig. 6, exhibits a periodic variation. Specifically, the detected conductivity increases as the vibration causes the electrodes to move towards the second position (in other words, when the contact pressure is increased), whereas the detected conductivity decreases when the vibration causes the electrodes 12 to move towards the first position (when the contact pressure is decreased).

As the pressure by which the device is pressed against the skin is further increased, the electrodes 12 of the device continue to be in better contact with the skin 14 of the body. Vibration of the device then results in progressively smaller periodic variations of the detected conductivity as the contact pressure increases. For example, referring to the Figs. 7 and 8, as the vibrating device 10 is pressed more firmly against the skin 14 of the body, the peak-to-peak amplitude of the periodic variations in the measured conductivity decreases. Thus, the measured conductivity tends towards a value that would otherwise be measured by a non-vibrating device.

From the above description in relation to Figs. 1 to 8, it will be seen that the signal from the sensor electrodes 12 in the vibrating device 10 is modulated by the vibration of the device 10. More specifically, the modulation signal intensity varies strongly with the characteristics of the contact of the sensor 12 with the body 14.

If the signal from the sensor electrodes 12 exhibits a strong modulation with the frequency of vibration of the device 10, this is indicative of the contact between the sensor electrodes 12 and the skin 14 of the body being poor. Such an indication may be used to determine that the vibrating device 10 is lightly touching the skin 14. Further, the strongly modulated signal from the sensor electrodes 12 may also be used to determine that readings from the sensor electrodes 12, used to determine the physiological state of a user for example, are not accurate since only a poor contact between the electrodes 12 and the skin 14 has been made.

Conversely, if the signal from the sensor electrodes 12 exhibits a weak modulation, this is indicative of the contact between the sensor electrodes 12 and the skin 14 of the body being good. Such an indication may be used to determine that the vibrating device is firmly pressed against the skin 14 of the body. Further, the weakly modulated signal from the sensor electrodes 12 may also be used to determine that readings from the sensor electrodes 12 are more reliable or accurate since only a good contact is present between the electrodes 12 and the skin 14. Whilst only two simple electrodes are depicted in Figs. 1 to 8, the electrodes may be configured in complicated shapes or patterns, such as interdigitated comb electrodes, or there may be a plurality of electrodes or electrode pairs distributed around the device.

Referring now to Fig. 9, an alternative embodiment comprises using the (known) vibration frequency of a device to calibrate the signals obtained by a sensor of the device.

A vibrating massage device 20 comprises a motor 22, a processor 24, memory means 25 and a GSR sensor 26.

The motor 22 comprise an off-set pivot for vibrating the device 20 when the motor is operated. The motor 22 is operated and controlled by the processor 24, which is also adapted to receive detected signals from the GSR sensor 26 and to access data stored on the memory means 25. The processor 24 comprises a calibration unit 24a adapted to calibrate signals from the GSR sensor 26 based on a determined quality of physical contact.

When the device is operated, the processor 24 is adapted to process the signals received from the GSR sensor 26 so as to determine a quality of physical contact of the GSR

sensor 26 with a body 28 and to calibrate the signals obtained by the GSR sensor 26 so as to account for the pressure by which the device is pressed against the body 28.

As was noted with reference to Figs. 1 to 8, the form of the signal obtained by the sensor 26 when the device is vibrating, and in particular the amplitude of the modulation of the obtained signal, can be used to determine if the sensor 26 is in contact with the body 28 and at what pressure the sensor is being pressed against the body 28. For example, it may be determined that the pressure lies within one of a plurality of pressure ranges, such as "just in contact, light touch, medium touch, high pressure contact".

Based on the determined pressure, the signals from the sensor 26 can be calibrated. For example, data regarding calibration offsets and/or constants are stored in the memory means 25 in the form of a look-up table. The processor 24 uses a determined quality (for example, pressure) of the physical contact made between the sensor 26 and the body 28 in conjunction with calibration data stored in the memory means 25 for the determined quality so as to calibrate signals from the sensor 26.

The processor 24 is also adapted to determine the reliability of the signals from the sensor 26. When the processor 24 determines that the amplitude of the signal modulation is below a predetermined in value (for example, a percentage of the absolute signal, say <5%), the processor determines that the recorded value is reliable. Preferably, the highest recorded value (i.e. the peak value) is used for the signal, since it can be assumed that the physical contact between sensor 26 and body 28 is most robust at this point.

A calibration process can be undertaken by comparing the obtained signal value when the device is vibrating with the GSR signal recorded when the device is not vibrating and in best possible contact with the body (i.e. where increasing the contact pressure no longer increases the GSR signal). From this comparison, correction factors can be determined to predict the actual GSR signal from the recorded trace. The calibration data is preferably stored in the memory means 25 accessible by the processor 24.

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be capable of designing many alternative embodiments without departing from the scope of the invention as defined by the appended claims.

For example, although embodiments have been described with reference to GSR sensor, the invention is also applicable to other physiological measurements using contact with a body. Measurements of heart rate, muscle tension measurement, etc. could be employed.

Also, embodiments may determine the quality of physical contact based on the duty cycle of the signal. The duty cycle may be defined by the amount of time the signal exceeds a threshold level in a single cycle if the signal, divided by the time taken for a single cycle of the signal. In other words, the duty cycle can be expressed as a percentage of time by which the signal exceeds a threshold level in a single cycle of a signal undergoing substantially periodic oscillations. The threshold level may be chosen so as to be indicative of a no-contact situation between the sensor and the body, for example a zero level of conductivity in Figs. 2 and 4.

Whilst the invention has been described in terms of a vibrating device and a vibrating massage device, the invention is equally applicable to alternative embodiments which comprise imparting a vibration to a body contact sensor (like one used on exercise equipment, training bikes, wearable sensors on patches etc.) so as to determine a quality of physical contact between the sensor and a body, and to calibrate readings from such a sensor.

CLAIMS:

1. A method for determining a quality of physical contact of a sensor (26) with a body (28), the method comprising the steps of:

- vibrating the sensor at a frequency of vibration;
- analysing a signal detected by the sensor and which is influenced by the sensor vibration;
- determining the quality of physical contact based on the analysed signal.

2. A method according to claim 1, further comprising the step of calibrating the signal detected by the sensor based on the determined quality of physical contact.

3. A method according to claim 1 or 2, wherein the step of determining the quality of physical contact is based on the peak-to-peak amplitude of the signal.

4. A method according to claim 3, wherein the step of determining the quality of physical contact comprises the steps of:

- determining the quality of physical contact is high, if the peak-to-peak amplitude of the signal is lower than a predetermined value; and
- determining the quality of physical contact is low, if the peak-to-peak amplitude of the signal is greater than a predetermined value.

5. A method according to claim 1 or 2 wherein the step of determining the quality of physical contact is based on the duty cycle of the signal whereby the signal passes a threshold level.

6. A method according to claim 5, wherein the threshold level is representative of a situation in which there is no physical contact of the sensor (26) with the body (28).

7. Apparatus for determining a quality of physical contact of a sensor (26) with a body (28), the apparatus comprising:

- vibration means (22) adapted to cause the sensor to vibrate at a frequency of vibration;
- a processor unit (24) adapted to analyse a signal detected by the sensor, the signal being influenced by the senor vibration, and to determine the quality of physical contact based on the analysed signal.

8. Apparatus according to claim 7 further comprising a sensor calibration unit (24a) adapted to calibrate the signal detected by the sensor based on the determined quality of physical contact.

9. Apparatus according to claim 7 or 8, wherein the processor unit (24) is adapted to determine the quality of physical contact based on the peak-to-peak amplitude of the signal.

10. Apparatus according to claim 9, wherein the processor unit (24) is further adapted to determine that the quality of physical contact is high, if the peak-to-peak amplitude of the signal is lower than a predetermined value, and to determine that the quality of physical contact is low, if the peak-to-peak amplitude of the signal is greater than a predetermined value.

11. Apparatus according to claim 7 or 8, wherein the processor unit (24) is adapted to determine the quality of physical contact based on the duty cycle of the signal whereby the signal passes a threshold level.

12. Apparatus according to claim 11, wherein the threshold level is representative of a situation in which there is no physical contact of the sensor (26) with the body (28).

13. A device (20) comprising:
- a sensor (26) adapted to contact a body (28) and to detect a physiological signal from the body; and
- apparatus for determining a quality of physical contact of the sensor with the body according to any of claims 7 to 12.

14. A device according to claim 13, wherein the sensor (26) is a galvanic skin resistance sensor.

15. A computer program comprising computer program code means adapted to perform all of the steps of any of claims 1 to 6, when said program is run on computer.

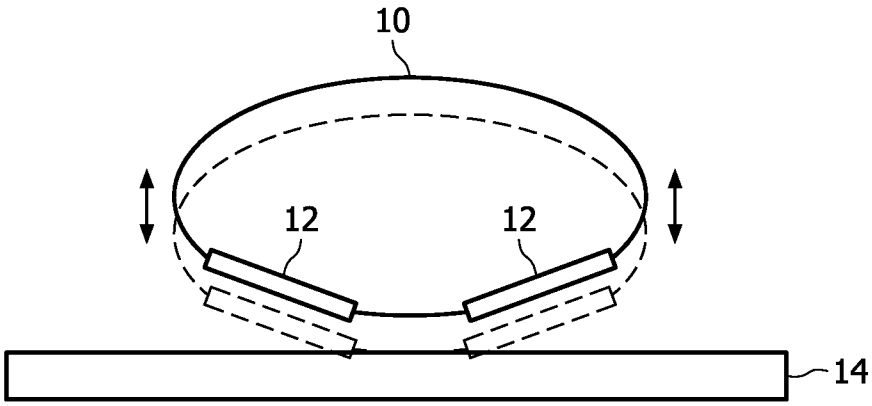


FIG. 1

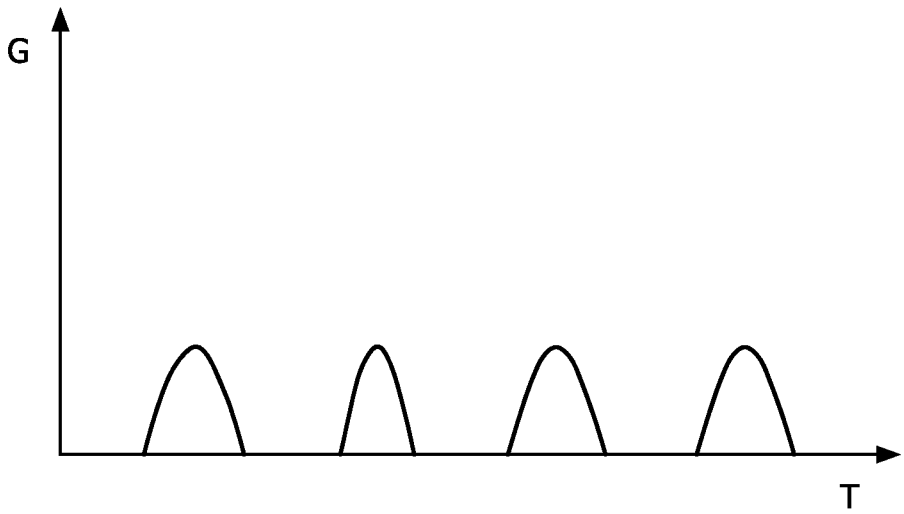


FIG. 2

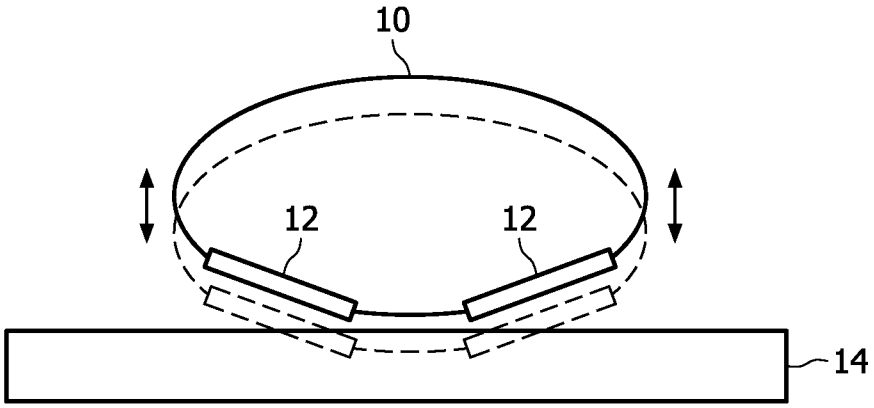


FIG. 3

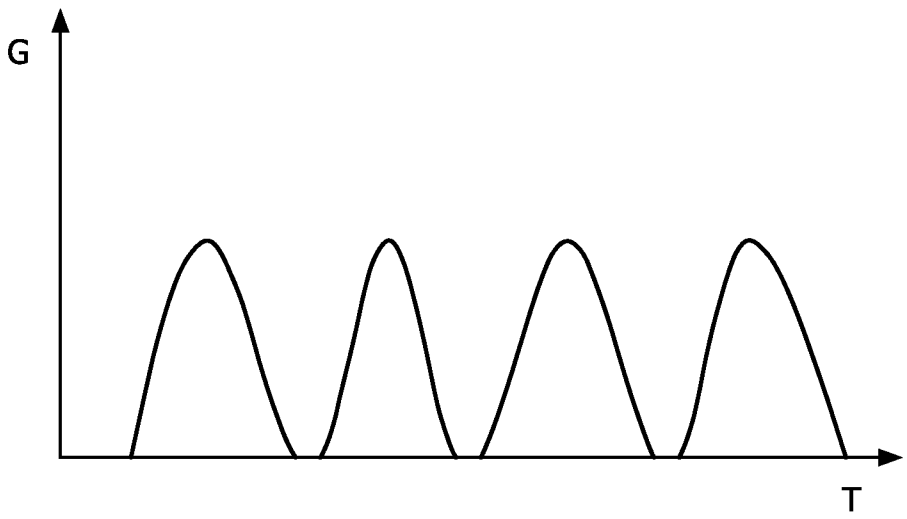


FIG. 4

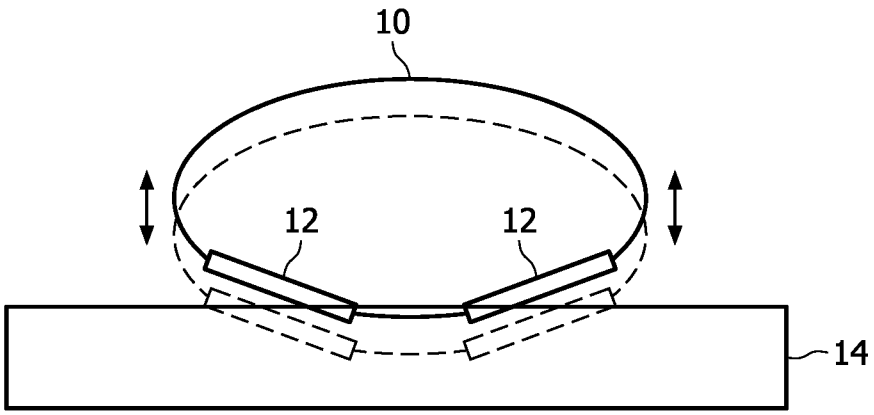


FIG. 5

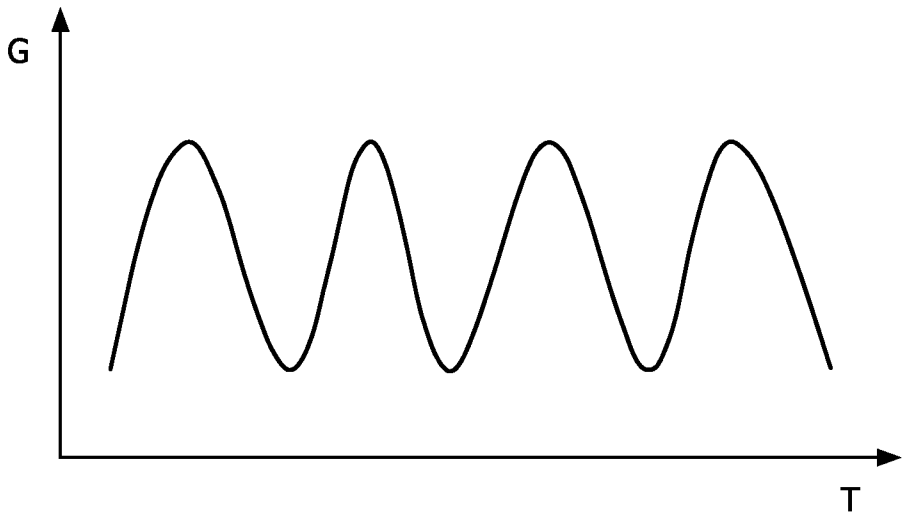


FIG. 6

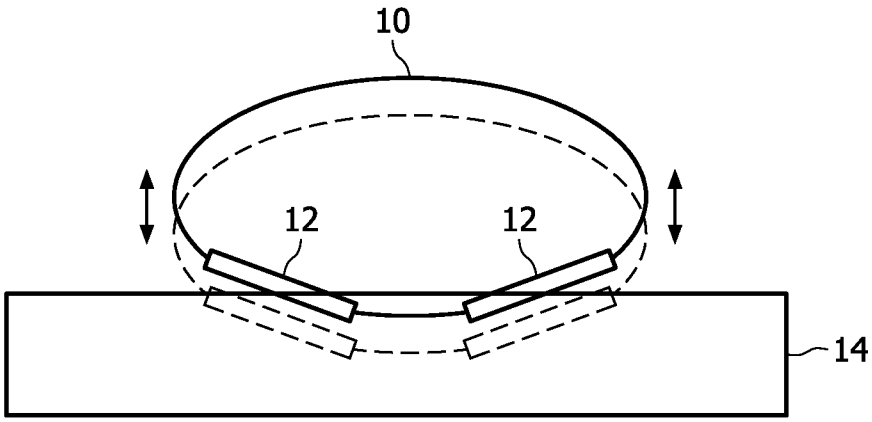


FIG. 7

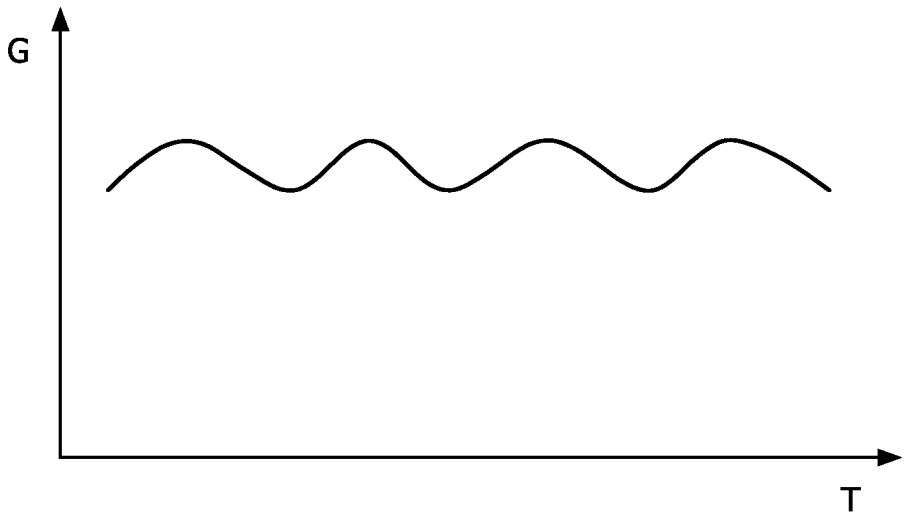


FIG. 8

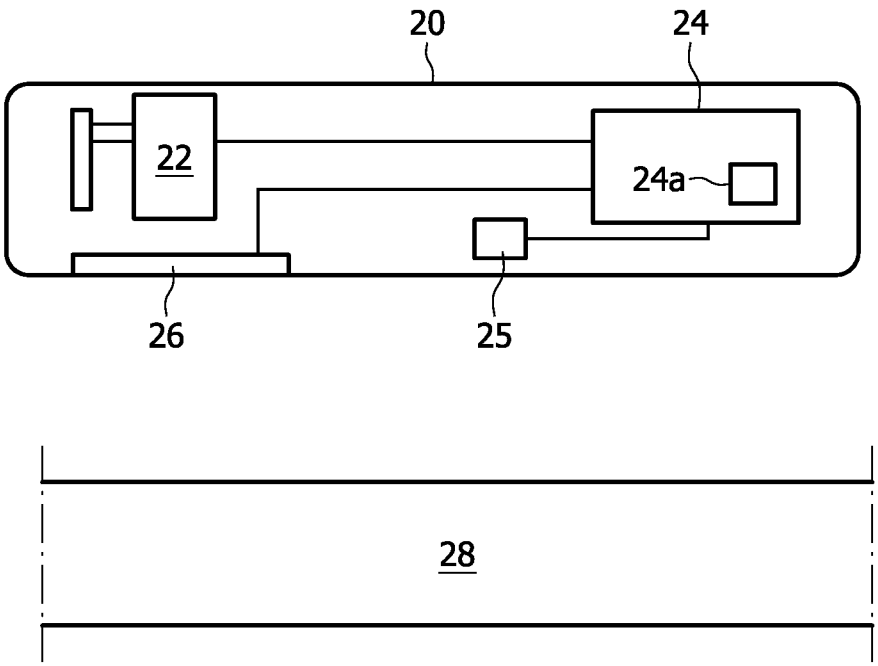


FIG. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2009/052306

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/053

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 September 2009	28/09/2009

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Trachterna, Morten

INTERNATIONAL SEARCH REPORT

International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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