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(54) **INPUT DEVICE**

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(73) Proprietor: **Nokia Technologies Oy**
02610 Espoo (FI)

(72) Inventors:
- **RADIVOJEVIC, Zoran**
  Cambridge CB1 3RR (GB)
- **SAUNAMÄKI, Jarkko Tapio**
  FI-01200 Vantaa (FI)
- **RYHÄNEN, Teuvo Tapani**
  FI-00200 Helsinki (FI)
- **LACOUR, Stephanie P.**
  Willingham CB24 5LH (GB)

(74) Representative: **Sayer, Robert David**
Venner Shipley LLP
200 Aldersgate
London EC1A 4HD (GB)

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Description

[0001] The invention relates to an input device for a user interface. In particular, the invention relates to an input device arranged to monitor movement of a user by mapping and recording deformations of their skin.

[0002] Conventional user interfaces often include a set of electromechanical switches located on the electronic device to be controlled, such as the text keyboard on a laptop computer, a numerical keypad on a mobile telephone and so on. However, this approach may require a considerable number of dedicated switches in order to provide sufficiently flexible user interaction. Portable devices, such as handheld gaming devices, laptop computers, near-eye portable displays (NED), mobile telephones, personal multimedia players, personal digital assistants and so on, are subject to size limitations and/or the need to maximise the size of other user interface components, such as display screens. The need to provide dedicated switches may conflict with the miniaturisation of such devices. For instance, in the case of near-eye displays, there are limitations on the type of user interaction solutions that can be provided because of space constraints and the fragility of the overall system, which may be disturbed when touched by the user.

[0003] One alternative approach is the provision of a separate input device, such a mouse or remote control. Recently, there has been a great deal of interest in the provision of separate input devices that can be worn by a user and controlled by movement or gestures. For instance, some prior art input devices have taken the form of gloves equipped with a variety of discrete sensors for monitoring the position, posture and/or motion of the user's hands. In particular, a number of devices have been provided with strain gauges for monitoring flexure of a user's finger joints. The use of such input devices can permit a more natural and intuitive interaction between the user and the device. Such considerations may be particularly important in gaming, virtual reality or wearable electronics applications.

[0004] US2002/075232 discloses a data glove comprising electrodes separated by a separation distance to form an electrical path from one electrode to the other by a separation distance to form an electrical path. US7084884 discloses a method of controlling the display of an image by sensing manipulation of a user object. US2004/174337 discloses a force-feedback apparatus and an image correcting method. US6701296 discloses strain-sensing goniometers.

[0005] The invention is set out in the appended set of claims.

[0006] Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, of which:

Figure 1a depicts an input device according to a first embodiment of the invention when in a first position, when controlling an external device;

Figure 1b depicts the input device of Figure 1a in a second position;

Figure 2 is a plan view of the network of sensors in the input device of Figure 1a;

Figure 3 is a perspective view of a network of sensors and a readout architecture of the input device of Figure 1a;

Figure 4 is a cross-sectional view of part of the input device of Figure 1a;

Figure 5 is a block diagram of the input device of Figure 1a;

Figures 6, 7 and 8 are cross-sectional views of input devices according to second, third and fourth embodiments of the invention;

Figure 9 depicts the use of the input device of Figure 1 with another input device according to a fifth embodiment of the invention to control a computer;

Figure 10 depicts an input device comprising an integrated device, according to a sixth embodiment of the invention;

Figure 11a depicts an input device according to a seventh embodiment of the invention, arranged to control a near-eye display apparatus, when in a first position;

Figure 11b depicts an image displayed by the near-eye display apparatus of Figure 11a when the input device is in the first position;

Figure 12a depicts the input device of Figure 11a, when in a second position;

Figure 12b depicts an image displayed by the near-eye display apparatus of Figure 11a when the input device is in the second position;

Figure 13a depicts the input device of Figure 11a, when in a third position;

Figure 13b depicts an image displayed by the near-eye display apparatus of Figure 11a when the input device is in the third position;

Figure 14a depicts the input device of Figure 11a, when in a fourth position;

Figure 14b depicts an image displayed by the near-eye display apparatus of Figure 11a when the input device is in the fourth position;

Figure 15a depicts the input device of Figure 11a, when in a fifth position;

Figure 15b depicts an image displayed by the near-eye display apparatus of Figure 11a when the input device is in the fifth position; and

Figure 16 depicts the input device of Figure 11a when used in a robotic application.

[0007] Figures 1a and 1b depict an input device 1 according to a first embodiment of the invention for controlling an external device 2. In this particular example, the external device 2 is a personal digital assistant or tablet PC type device.

[0008] The input device 1 comprises a sleeve 3, configured to fit over a joint 4 in a user's index finger 5.

[0009] The sleeve 3 is arranged to conform to the user's skin and to undergo resilient deformation according to stretching and relaxation of the user's skin. In this particular example, the sleeve 3 is formed of a soft, conformable material, such as natural rubber, silicone, another elastomer or elastomer-like material that encapsulates the electrical components of the input device 1. In some embodiments of the invention, the sleeve 3 may be formed of a sensing composite rubber or elastomer doped with electrically conducting particles, piezoelectric particles or similar particles.

[0010] Figure 1a depicts the input device 1 when the finger 5 is in a first, unbent, position. An output signal corresponding to the position of the finger is transmitted from the input device 1 to the external device 2 via a wireless communication link 6.

[0011] Examples of suitable wireless communication links include Bluetooth(RTM) connections, Wibree links and so on.

[0012] Figure 1b depicts the input device 1 of Figure 1a when the user's finger 5 is in a second, bent, position and the transmission of a corresponding output signal from the input device 1 to the external device 2 via the wireless communication link 6. As shown in Figures 2, 3 and 4, the input device 1 comprises a plurality of elastic conductors 7a-7c extending along a first direction and a second plurality of elastic conductors 8a-8c extending along a second direction. The conductors 7a-7c, 8a-8c are formed on or embedded in the sleeve 3, and connect a plurality of sensors, or detection modules, 9a-9i to provide a readout architecture for the network of detection modules.

[0013] In this particular embodiment, the conductors 7a-7c, 8a-8c extend along straight lines to connect the sensing and processing elements of the input device 1. However, in other embodiments of the invention, the conductors 7a-7c, 8a-8c may take other forms. For instance, the conductors 7a-7c, 8a-8c may be curved, in a spiral form or similar manner to a spring for example, or have a zig-zag form to accommodate the placement of the sensing and processing elements and in accordance with the desired sensitivity of the overall system. The conductors 7a-7c, 8a-8c may be thin metallic films, that is, films having a sub-micrometre thickness, of gold, silver or copper. Such films may, if required, include micro-cracks in order to increase their elasticity. Alternatively, the conductors 7a-7c, 8a-8c may be formed of a conductive composite elastic layer in which conductive particles are embedded in an elastic polymeric matrix. The embedded particles may be micro-sized metallic particles , nano-sized carbon fullerenes ("bucky balls"), carbon nano-fibres, or microscopic metallic fibres or metal covered fibre networks. Such elastic composites or thin films on elastomers may be elongated, reversibly, by up to 50% in two dimensions simultaneously, while remaining electrically conductive. Such a level of reversible stretchability permits sensing of deformation of the user's skin.

[0014] In this particular example, the input device 1 comprises nine detection modules 9a-9i in the form of a 3 x 3 array. However, in other embodiments of the invention, more or fewer detection modules 9a-9i may be provided and arranged in other manners. The conductors 7a-7c, 8a-8c are connected to a controller 10 and are used for addressing and reading out from the individual detection modules 9a-9i using switches 11a-11f.

[0015] Each detection module 9a-9i comprises a sensing element 12a-12i of a sensing material in which an electrical property, such as charge generation, resistance or capacitance, changes in response to in-plane and out-of-plane deformations, that is, when stretched and/or flexed. Depending on the type of sensing element 12a-12i employed, the detection modules 9a-9i may detect flexure and/or two-dimensional stretching, or a combination of the two, for example, through the monitoring of one or more of localised charges, that is, voltages, generated by the sensing elements 12a-12i in response to stretching and/or flexure, resistance changes, where the sensing elements 12a-12i are formed of flexure sensitive piezoelectric, and, where the sensing elements 12a-12i are configured to change their capacitance in response to stretching and/or flexure, localised capacitance changes of the sensing elements 12a-12i. These sensing techniques may be used and, if required, combined, in order to monitor complex skin deformations in three dimensions and, if required, to provide high resolution mapping thereof.

[0016] Suitable materials for forming the sensing elements 12a-12i include thin metal electrodes, or a piezoelectric ceramic material such as lead-zirconate-titanate (PZT), polyvinylidene fluoride (PVDF), elastomers and/or elastomeric composites having appropriate sensing properties and suitable nano-structured inorganic materials, such highly aligned zinc oxide (ZnO) nanomaterials. The detection modules 9a-9i, conductors 7a-7c, 8a-8c and, optionally, the controller 10, are covered by the elastic encapsulation material 13 forming the sleeve 3.

[0017] In embodiments where encapsulation material 13 forming the sleeve 3 is a doped composite rubber or elastomer, some or all of the sensing elements 12a-12i may be portions of the sleeve 3, rather than separate elements.

[0018] As the finger 5 of the user is flexed around the joint 4, the sensing elements 12a-12i of the detection modules 9a-9i undergo corresponding complex deformation which can be monitored and mapped. In this particular example, the controller 10 is arranged to monitor charges generated by the sensing elements 12a-12i. The controller 10 obtains a reading of the required localised voltage, through the conductors 7a-7c, 8a-8c, at a certain sampling frequency. The conductors 7a-7c, 8a-8c are used to address and obtain a reading from individual ones of the detection modules 9a-9i. For instance, the controller 10 can obtain a reading of the charge generated by sensing element 12a by measuring the voltage between conductors 7a and 8a, by operating switches 11a to 11f accordingly, while the charge generated by sensing element 12b can be determined by measuring the voltage between conductors 7a and 8b, and so on.

[0019] The sampling frequency is chosen in accordance with a required mapping and monitoring precision. Depending on the particular application of the input device 1, the sampling rate may be a relatively low frequency, such as 25 Hz, or a relatively high frequency, such as 5 kHz.

[0020] The observed localised variables, in this case, the generated charges detected by the controller 10, can be used to determine a data matrix M_{ij} which reflects the complex deformation applied to the overall device 1 and the network of the sensing elements 12a-12i therein. Successive readings can provide a series of matrices $M_{ij}(t)$, through which the localised deformations can be used to reconstruct features of the motion or gesture of the finger 5.

[0021] In addition, the input device 1 can be controlled by the user pressing a specified portion of the sleeve 2. For instance, if the user presses onto one side of the sleeve 2 using a finger of another hand, this would cause a distinctive pattern of stretching and compression in the surrounding sensing elements 12a-12i.

[0022] As shown in Figure 5, the input device 1 also comprises a signal processor 14 for generating an output signal according to the readings obtained from the sensing elements 12a-12i.

[0023] In this particular example, a microprocessor 15 is configured to act as the controller 10 and the signal processor 14. The microprocessor 15 may also be arranged to perform functions associated with establishment of the wireless communications link 6.

[0024] The input device 1 also comprises a transceiver 16 and antenna 17 for transmitting and receiving signals via the wireless communications link 6.

[0025] In some embodiments of the invention, the input device 1 may be arranged to provide active feedback to a user by applying pressure or vibrations to the user's skin. In such a case, the controller 10 may generate a control signal or, where provided, the antenna 17 and transceiver 16 may be arranged to receive a control signal from the external device 2. The controller 10 may then cause the exertion of pressure or, where pressure is applied repeatedly, vibrations in accordance with the control signal. Such active feedback may be applied in response to an alert generated by the controller 10 or by the external device 2 or simply to provide an acknowledgement of a command input through the input device 1.

[0026] In embodiments where the sensing elements 12a-12i comprise materials such as PZT or PVDF, the sensing elements 12a-12i can be used to provide active feedback. In other words, the sensing elements 12a-12i may be arranged to operate in two modes. In a first mode, a sensing element 12a acts as a sensor detecting flexural deformations, when exposed to mechanical deformation. Meanwhile, in a second mode, the sensing element 12a functions as an actuator for generating mechanical vibrations, in accordance with a signal supplied from the controller 10 via the conductors 7a-7c, 8a-8c.

[0027] The input device 1 may be arranged to transmit the output signals from the detection modules 9a-9i to the external device 2. In such a case, the external device 2 would be arranged to execute software to generate a command signal based on the received output signals and/or reconstruct the motion of the user. Alternatively, the microprocessor 15 may be arranged to process the output signals before their transmission, to reduce the amount of data transmitted between the input device 1 and external device 2. In either case, the software executed in the microprocessor 15 or external device 2 may be configured to generate a signal that depends, in whole or in part, on the degree of deformation of the skin, the type of deformation, the speed at which the deformation has taken place and/or a reconstruction of the movement of user. The speed at which the deformation has taken place and/or the movement reconstruction can be determined according to time derivatives of the detected deformations, obtained from the comparison of successive readings from the individual detection modules 9a-9i. The use of successive readings may improve the reliability and stability with which the output signal of the input device 1 corresponds to the user's movements.

[0028] The software of the external device 2 may be configured to allow a user to assign commands to various gestures and/or motions of the input device 1, in order to customise the use of the input device 1 according to their own preferences.

[0029] In this particular example, the input device is powered by a battery 18 that can be recharged using charging circuitry 19.

[0030] The density of detection modules 9a-9i may depend on the precision required by the application of the input device 1. The mesh-type arrangement of Figures 2, 3 and 4 is particularly advantageous in arrangements requiring a high precision, and, therefore, a high density of detection modules. However, other types of arrangement can be used in place of the mesh.

[0031] Cross-sections of alternative sensing arrangements are shown in Figures 6, 7 and 8.

[0032] In a second embodiment of the invention, an input device corresponding to the block diagram of Figure 5 may be provided with an alternative arrangement of detection modules. As shown in Figure 6, the input device comprises detection modules in the form of sensing elements 20, provided on a substrate 21. One such sensing element 20 is depicted in Figure 6. The sensing elements 20 are directly deposited or mounted on the substrate 21, in which elastic conductors 22a, 22b are embedded. The conductors 22a, 22b are connected to the sensing element 20 on opposite sides of one of its surfaces.

[0033] As in the previous embodiment, the sensing elements 20 are configured respond to stretching and/or flexing by generating a charge or changing an electric property, such as resistance or capacitance. Elastic conductors 22a, 22b, are connected from opposite edges on the same side of the sensing element 20. The electronic components of the input device are covered in an encapsulation material 13 to form a sleeve.

[0034] Suitable materials for forming the sensing elements 20, conductors 22a, 22b and encapsulation material 13 are discussed above, in relation to the sensing elements 12a-12i, conductors 7a-7c, 8a-8c and encapsulation material 13 of the input device 1 of the first embodiment. As before, the sensing elements 20 may be portions of the encapsulation material 13 that forms the sleeve. The substrate 21 may be formed of an elastic material such as an elastomer, silicone, acrylic or polyurethane.

[0035] Figure 7 depicts part of an input device according to a third embodiment of the invention, which differs from the input device of Figure 6 by way of the integration of the sensing elements 20. In the input device of Figure 7, the sensing elements 20 are embedded in the substrate 21, so that the elastic conductors 22a, 22b overlie the sensing elements 20a, 20b.

[0036] Figure 8 depicts an input device according to a fourth embodiment of the invention, which comprises yet another alternative sensor arrangement. The input device of the fourth embodiment otherwise corresponds to the block diagram of Figure 5.

[0037] In the input device of Figure 8, sensing elements 23 are provided in the form of multiple segments of a layer of sensing material. However, in yet another embodiment of the invention, a sensing element may be provided that extends across the sleeve in a continuous layer.

[0038] Elastic conductors 24a-24d are arranged on either side of the sensing elements 23. The sensing elements 23 and conductors 24a-24d are covered in encapsulation material 13. Suitable materials for the sensing elements 23, conductors 24a-24d and encapsulation material 13 were described above, in relation to the sensing elements 12a-12i, conductors 7a-7c, 8a-8c and encapsulation material 13 of the input device 1 of the first embodiment.

[0039] The arrangement of Figure 8 permits stretching and flexing to be monitored by combining readings based on different pairs of conductors 24a-24d. For instance, pairs of the conductors 24a-24c and/or 24b-24d can be used to measure in-plane stretching. Meanwhile, crossed pairs of conductors, such as pairs 24a & 24d and/or 24b & 24c can be used to measure out-of-plane deformation, that is, flexure. The readings may be obtained using a similar readout architecture to that shown in Figure 3, with appropriate provision for taking multiple measurements based on the different conductor pairs.

[0040] In each of the embodiments shown in Figures 2 to 4, 6, 7 and 8, the conductors 22a, 22b are configured so that changes in their resistances when stretched are limited, minimal or even negligible. This ensures stable operation of the input device 1. Moreover, the sensing elements 20, 23 are not screened when the overall device is stretched and/or flexed.

[0041] Although the first to fourth embodiments have been described in relation to an input device that monitors the deformation of skin around the joint 4 of an index finger 5, other embodiments may be devised in which the input device is configured to placed around another joint instead of, or in addition to, the joint 4 of an index finger 5. Such joints include other joints of the index finger, the joints of other fingers, wrists, knees, toes and elbows.

[0042] If required, a system may be configured so that an external device 2 receives signals from more than one input device and combines the received signals, using software, to generate a command or control signal accordingly. For example, Figure 9 shows an arrangement in which the input device of Figure 1 is used in combination with a input device 25 to control a laptop computer 26. The input device 25 of Figure 9 is similar to the input device 1 of Figure 1a and may be configured with any of the sensor arrangements of the first to fourth embodiments or a suitable alternative sensor arrangement. However, the sleeve 28 has dimensions permitting it to fit around a user's wrist. In addition, in this particular example, the input device 25 is equipped with a larger number of detection modules 30 than the input device of Figure 1a.

[0043] The combination of the input device 1 with the wrist mounted input device 25 permits tracking of the motions that would normally be used to operate a mouse. A user can then move their wrist to cause a cursor 29 to move around the screen 30 of the laptop computer 26, for example, for browsing displayed content 31, and move their finger 4 to select or execute an item displayed on the computer screen 30, without requiring the provision of a mouse or touch keypad on the laptop 26.

[0044] In this manner, input devices 1, 25 according to embodiments of the invention may improve the portability of equipment such as laptop computers, PDAs and so on. Such input devices may also improve the usability of near-eye displays (NEDs), by providing a user interface that is comfortable and intuitive to use, which can allow the browsing of information without detriment to the user's privacy.

[0045] Additionally, one or both of the input devices 1, 25 may be arranged to serve as active alerting device in connection with the laptop computer 26 and digital content services therein. For instance, an alert signal might be wirelessly received by one or both input devices 1, 25 from the laptop computer 26 and initiate squeezing of the device 32 around the wrist of the user, or the application of pressure or vibrations to the skin, in the manner described hereinabove. Such an alert could be used to inform a user to the status of a process, such the arrival of a new message via SMS or e-mail arrival. The squeezing of the input device 1, 25 or the application of pressure/vibrations may be performed with different frequencies and with predefined pulsed structures associated to particular digital service. Frequency and intensity of squeezing, pressure or vibration may be correlated to importance of the new arrived message.

[0046] Examples of other embodiments to be placed around a user's wrist are shown in Figures 10 and 11a. Each of the input devices 32, 33 of Figures 10 and 11a may be configured with sensor arrangements according to any one of Figures 2 to 4, 6, 7 or 8 or a suitable alternative sensor arrangement.

[0047] The positioning of an input device 25, 32, 33 on a user's wrist permits the user to exert control over another device without necessarily limiting movement of their hands or fingers. In addition, such a position may be less uncomfortable for a user, as they may be accustomed to wearing a wristwatch around their wrist.

[0048] Unlike the previously described embodiments, the input device 32 of Figure 10 is arranged to control a second device 33 that is built into the same sleeve 34. The second device 33 may be integrated with the electronic components of the input device 32. In this example, communication between the input device 32 and second device 33 is performed via a wired connection, however communication between the second device 33 and another device 35 can be conducted over a wireless communications link 36. In such a case, the device 33 may be equipped with a transmitter and/or receiver, or with a transceiver. The other device 35 may be a device such as a mobile telephone, a telephone headset and so on. The second device 33 may comprise a personal audio player, FM radio receiver, GPS receiver or digital watch built into the sleeve 34, with components for communicating with another device 35 being provided where appropriate. By performing predetermined movements, the user can control the device 33 to perform functions such as accepting/rejecting an incoming phone call, browsing through received messages, switching the second device 33 on or off, adjusting volume, changing a song, tuning to a radio station, and so on, depending on the functionality of the second device 33.

[0049] As discussed above in relation to Figure 9, the input device 32 may be arranged to serve as active alerting device in response to alert signals received from an external device 35. Where the second device 33 comprises a GPS receiver and the external device 35 processes and/or determines location information relating to the user obtained from the second device 33, such an alert mechanism may be used to inform the user of their proximity to a predefined location, such as a shop or landmark.

[0050] The input device 37 of Figure 11a is similar to that of Figure 9. However, in this particular embodiment, the sleeve 38 is configured to extend over part of the user's hand 39. In this example, an aperture 40 is provided for a thumb 41 of the user to pass through, to assist in maintaining the position of the input device 37 on the user's wrist.

[0051] In Figure 11a, the input device 37 shown controlling the display of an image on a NED 43. The NED 43 is equipped with a receiver 44 for receiving TV signals or other audio visual data signals, for instance, from a computer 45. Alternatively, or additionally, the NED 43 may include a processor 46 for generating images according to received data signals. For instance, the NED 43 arranged to display images based on web page data received from the computer 45, directly or via the Internet 47, to provide a web-browser application, access to e-mails and/or access to remote data storage. The input device 37 may be arranged to communicate directly with a processor 46 within the NED 43, via a wired or wireless connection 48.

[0052] Figure 11a depicts the input device 37 when the hand 39 of the user is in a rest position, while Figure 11b depicts an example of an image 49 displayed by the NED 43 when it is determined that the user's hand 39 is in that position. An indicator 50, corresponding to the motion, position or gesture of the user's hand 39, is superimposed over the image 49. The indicator 50 may taken the form of a virtual projection of the user's hand 39, an icon, a pointer, and so on.. In this particular example, the indicator 50 is a semi-transparent icon, so that the underlying image 49 is not obscured. Since both the image 49 and the indicator 50 are displayed in the user's visual field, it is relatively easy for the user to guide, navigate and browse digital content using dedicated hand movements, without requiring the user to touch, or otherwise physically interact with, the NED 43. Since the image 49 and other content can be displayed and browsed effectively using on the NED 43, the user can view data with privately, even in public places, for example, when using public transport, in a public building or in a street.

[0053] Figures 12a, 13a, 14a and 15a depict the input device 37 is moved left, right, up and down respectively, causing stretching and/or flexing of the detection modules 30. In this particular example, the NED 43 is displaying an image. Figures 11b, 12b, 13b, 14b and 15b depict the image 49, 49', 49", 49"', 49"' and indicator 50, perceived by the user when viewing the NED 43 following the making of the gesture shown in Figure 11a, 12a, 13a, 14a and 15a respectively. In this particular example, the user can pan across an image in various directions by moving their hand 39 accordingly. In a similar manner, the input device 37 could be used to control a cursor in order to browse content and/or select items from a menu displayed on the NED 43.

[0054] Figures 12a, 13a, 14a and 15a demonstrate that the input device 27 can be used to generate command signals using a considerable number of gestures, such as moving the hand left, right, up or down. Alternatively, or additionally, a wrist-mounted input device may be arranged to generate control signals based on other gestures, such as turning the hand in various directions and/or rotating the hand clockwise or anti-clockwise.

[0055] Although the input devices 1, 25, 32, 37 of the above described embodiments comprise elastic sleeves 3, 28, 34, 38, input devices according to other embodiments of the invention may instead be provided on a stretchable sticker for temporary adhesion to a user's skin, as an "electronic plaster" or on a bandage, to provide a "smart bandage". Such an arrangement may be suitable for monitoring deformation of parts of a body for medical or veterinary purposes, such as patient recovery monitoring.

[0056] In the specific embodiments described hereinabove, the input devices 1, 25, 37 provide interfaces for a PDA or tablet pc 2, a laptop computer 26 or NED 43, while the input device 32 of Figure 10 was described as an interface for a number of electronic devices mounted on the sleeve 33, or integrated with, the input device 32. However, input devices according to embodiments of the invention may be used to control other external devices, including mobile telephones, audio-visual equipment and so on, or other devices mounted on, or integrated with, the input device, such as exercise monitors, a device for browsing through public information billboards, and so on.

[0057] Moreover, in some systems, such input devices may instead be used to track a user's movements. For instance, in an application where a user's hand movements are copied by a robotic apparatus to provide remote guidance and steering. Figure 16 depicts the input device 37 of Figure 11a when used in such an application.

[0058] In the example shown in Figure 16, the input device 37 generates a signal based on the movement of the user's hand 39 as described previously. In this particular example, the outputs from the sensors 30 are transmitted to a computer 51 via a wireless link 52. The computer 51 is arranged to reconstruct the movement of the user's hand 39 based on said outputs. The computer 51 then generates a corresponding control signal for transmission to a device 53 arranged to replicate the movement of the user, via a network 54. As the deformation of the skin of the user and, thus, the movement of the user's hand 39 can be mapped and monitored with high precision by the input device 37, such a system may be particularly suitable for teleoperation of a device 53 in applications requiring delicate movements.

Claims

1. Apparatus (1) comprising:

conformable material (3) arranged to, when placed adjacent to the skin of a user, undergo deformation conforming to deformation of the skin; and
a plurality of sensors (12a - 12i) arranged to provide respective outputs corresponding to the movement of said sensors with respect to one another in response to said deformation of the skin;
said sensors comprising flexure sensitive piezoelectric material configured to respond to flexural and/or stretching deformation of said sensors by generating an electrical charge,
a controller (10) connected to said sensors by conductors (7a-7c, 8a-8c) and arranged to monitor charges generated by said sensing material, and
the apparatus being **characterised by**
active feedback elements arranged to exert pressure on said skin in response to a control signal from the controller (10) supplied via the conductors
wherein said sensors are used as said active feedback elements, such that the sensors are operable in a first mode whereby said sensors act to sense flexural and/or stretching deformations of said sensors, when exposed to mechanical deformation, and the sensors are operable in a second mode whereby said sensors act as actuators for generating mechanical vibrations in accordance with the control signal from the controller.

2. Apparatus according to claim 1, wherein:

said conductors have a non-linear shape; and/or said conductors comprise a first set of conductors, connected at respective first surfaces of the sensing material of said sensors, and a second set of conductors, connected at respective second surfaces of said sensing material and said controller is arranged to address individual ones of said sensors using selected ones of said first set of conductors and said second set of conductors.

3. Apparatus according to claim 1 or 2, wherein:

said conformable material comprises a conformable substrate, said sensing material is mounted on said substrate and said conductors are connected to the sensing material of said sensors at respective first surfaces thereof; or
said conformable material comprises a conformable substrate, said sensing material is embedded in said substrate and said conductors are connected to the sensing material of said sensors at respective first surfaces thereof; or
at least one of said sensors comprise a layer of said sensing material, the controller is connected to said at least one sensor by four of said conductors, a first and second of said conductors being connected to a first surface of said layer and a third and fourth of said conductors being connected to a second surface of said layer opposite to said first surface, said controller being arranged to obtain readings from said sensor opposite surfaces of said layer and arranged to perform said monitoring by taking readings using multiple pairs of conductors selected from said first, second, third and fourth conductors.

4. Apparatus according to any preceding claim, wherein said sensors comprise lead-zirconate-titanate (PZT) or polyvinylidene fluoride (PVDF) material.

5. Apparatus according to any preceding claim, wherein the controller is arranged to generate a second signal to control an external device according to said outputs.

6. Apparatus according to claim 5, wherein said processor is arranged to generate said signal according to one or more time derivatives of said outputs.

7. A system comprising:

at least one apparatus according to claim 5 or 6; and
said external device.

8. A system according to claim 7, wherein:

said external device is arranged to determine a reconstruction of a movement of the user according to said outputs; or
said external device is configured to track movements of part of a body of the user according to the outputs of said sensors and to copy said movements; or
said external device is arranged to display content and said apparatus is arranged to control browsing of said content; or
said external device is arranged to display an image and to update said image periodically to correspond with said outputs.

9. A method comprising:

providing a plurality of sensors (12a - 12i) integrated on a conformable material (3), the sensors being arranged to provide respective outputs corresponding to movement of said sensors with respect to one another;
monitoring deformation of the conformable material, said deformations conforming to deformation of skin of a user to which the conformable material is adjacent, using said sensors,
generating an electrical charge by flexure sensitive piezoelectric sensors in response to flexural and/or stretching deformation of at least one of said sensors of the conformable material,
monitoring charges generated by the sensors integrated on the conformable material,
characterised by
applying active feedback to the skin in response to a control signal from a controller connected to said sensors via conductors,
wherein said sensors are used as said active feedback elements, such that said sensors are operable in a first mode whereby said sensors act to sense flexural and/or stretching deformations of said sensors, when exposed to mechanical deformation, and said sensors are operable in a second mode whereby said sensors act as actuators for generating mechanical vibrations in accordance with the control signal from the controller.

10. A method according to claim 9, comprising receiving an indication of a control signal associated with a predetermined set of outputs and responding to outputs meeting requirements of said predetermined set by generating the associated control signal.

11. A method according to claim 9 or claim 10, comprising:

providing a second apparatus, comprising a plurality of second sensors mounted on conformable material, the second sensors being arranged to provide respective outputs corresponding to movement of said second sensors with respect to one another;
monitoring deformation of the conformable material, said deformations conforming to deformation of the skin of the user, using said second sensors; and
transmitting a second signal corresponding to said outputs to said device.

Patentansprüche

1. Vorrichtung (1), umfassend:

formbares Material (3), das so ausgelegt ist, dass es, wenn es an der Haut eines Benutzers anliegend angeordnet wird, Verformung erfährt, die mit Verformung der Haut übereinstimmt; und
eine Mehrzahl von Sensoren (12a - 12i), die so ausgelegt sind, dass sie in Reaktion auf die Verformung der Haut jeweilige Ausgaben bereitstellen, die der Bewegung der Sensoren in Bezug auf einander entsprechen;
wobei die Sensoren biegungsempfindliches piezoelektrisches Material umfassen, das so konfiguriert ist, dass es auf Biege- und/oder Streckverformung der Sensoren durch Erzeugen einer elektrischen Ladung reagiert,
eine Steuerung (10), die durch Leiter (7a-7c, 8a-8c) mit den Sensoren verbunden und so ausgelegt ist, dass sie Ladungen überwacht, die vom Sensormaterial erzeugt wird, und
die Vorrichtung **gekennzeichnet ist durch**:

aktive Feedback-Elemente, die so ausgelegt sind, dass sie in Reaktion auf ein Steuersignal von der Steuerung (10), das über die Leiter zugeführt wird, Druck auf die Haut ausüben,

wobei die Sensoren als die aktiven Feedback-Elemente verwendet werden, derart dass die Sensoren in einem ersten Modus betrieben werden können, wodurch die Sensoren zum Erfassen von Biege- und/oder Streckverformungen der Sensoren dienen, wenn mechanischer Verformung ausgesetzt, und die Sensoren in einem zweiten Modus betrieben werden können, wodurch die Sensoren als Aktoren zum Erzeugen mechanischer Schwingungen gemäß dem Steuersignal von der Steuerung dienen.

2. Vorrichtung nach Anspruch 1, wobei:

die Leiter eine nichtlineare Form aufweisen; und/oder

die Leiter einen ersten Satz von Leitern, die an jeweilige erste Oberflächen des Sensormaterial der Sensoren angeschlossen sind, und einen zweiten Satz von Leitern umfassen, die an jeweilige zweite Oberflächen des Sensormaterials angeschlossen sind, und die Vorrichtung so ausgelegt ist, dass sie einzelne der Sensoren unter Verwendung ausgewählter des ersten Satzes von Leitern und des zweiten Satzes von Leitern ansteuert.

3. Vorrichtung nach Anspruch 1 oder 2, wobei:

das formbare Material ein formbares Substrat umfasst, das Sensormaterial auf dem Substrat montiert ist, und die Leiter an das Sensormaterial der Sensoren an jeweiligen ersten Oberflächen davon angeschlossen sind; oder

das formbare Material ein formbares Substrat umfasst, das Sensormaterial in das Substrat eingebettet ist, und die Leiter an das Sensormaterial der Sensoren an jeweiligen ersten Oberflächen davon angeschlossen sind; oder

mindestens einer der Sensoren eine Schicht des Sensormaterials umfasst, die Steuerung mit dem mindestens einen Sensor durch vier der Leiter verbunden ist, ein erster und ein zweiter der Leiter an eine erste Oberfläche der Schicht angeschlossen sind, und ein dritter und ein vierter Leiter an eine zweite Oberfläche der Schicht gegenüber der ersten Oberfläche angeschlossen sind, und die Steuerung so ausgelegt ist, dass sie Messwerte vom Sensor gegenüber Oberflächen der Schicht erhält, und so ausgelegt ist, dass sie das Überwachen durch Ablesen von Messwerten unter Verwendung mehrerer Paare von Leitern durchführt, die aus dem ersten, dem zweiten, dem dritten und dem vierten Leiter ausgewählt werden.

4. Vorrichtung nach einem der vorhergehenden Ansprüche, wobei die Sensoren Blei-Zirkonat-Titanat (PZT)- oder Polyvinylidenfluorid (PVDF)-Material umfassen.

5. Vorrichtung nach einem der vorhergehenden Ansprüche, wobei die Steuerung so ausgelegt ist, dass sie ein zweites Signal erzeugt, um ein externes Gerät gemäß den Ausgaben zu steuern.

6. Vorrichtung nach Anspruch 5, wobei der Prozessor so ausgelegt ist, dass er das Signal gemäß einer oder mehreren zeitlichen Ableitungen der Ausgaben erzeugt.

7. System, umfassend:

mindestens eine Vorrichtung nach Anspruch 5 oder 6; und

das externe Gerät.

8. System nach Anspruch 7, wobei:

das externe Gerät so ausgelegt ist, dass es eine Rekonstruktion einer Bewegung des Benutzers gemäß den Ausgaben bestimmt; oder

das externe Gerät so konfiguriert ist, dass es Bewegung eines Teils eines Körpers des Benutzers gemäß den Ausgaben der Sensoren verfolgt und die Bewegungen kopiert; oder

das externe Gerät zum Anzeigen von Inhalt ausgelegt ist, und die Vorrichtung zum Steuern des Durchsuchens des Inhalts ausgelegt ist; oder

das externe Gerät so ausgelegt ist, dass es ein Bild anzeigt und das Bild periodisch aktualisiert, damit es den Ausgaben entspricht.

9. Verfahren, umfassend:

Bereitstellen einer Mehrzahl von Sensoren (12a - 12i), die in ein formbares Material (3) integriert sind, wobei die Sensoren so ausgelegt sind, dass sie jeweilige Ausgaben bereitstellen, die Bewegung der Sensoren in Bezug aufeinander entsprechen;

Überwachen von Verformung des formbaren Materials unter Verwendung der Sensoren, wobei die Verformungen mit Verformung der Haut eines Benutzers übereinstimmen, an der das formbare Material anliegt,

Erzeugen einer elektrischen Ladung durch biegungsempfindliche piezoelektrische Sensoren in Reaktion auf Biege- und/oder Streckverformung mindestens eines der Sensoren des formbaren Materials,

Überwachen von Ladungen, die durch die Sensoren erzeugt werden, die in das formbare Material integriert sind,

gekennzeichnet durch

Anwenden aktiven Feedbacks auf die Haut in Reaktion auf ein Steuersignal von einer Steuerung, die über Leiter mit den Sensoren verbunden ist,

wobei die Sensoren als die aktiven Feedback-Elemente verwendet werden, derart dass die Sensoren in einem ersten Modus betrieben werden können, wodurch die Sensoren zum Erfassen von Biege- und/oder Streckverformungen der Sensoren dienen, wenn mechanischer Verformung ausgesetzt, und die Sensoren in einem zweiten Modus betrieben werden können, wodurch die Sensoren als Aktoren zum Erzeugen mechanischer Schwingungen gemäß dem Steuersignal von der Steuerung dienen.

10. Verfahren nach Anspruch 9, umfassend ein Empfangen einer Anzeige eines Steuersignals, das mit einem vorbestimmten Satz von Ausgaben assoziiert ist, und Reagieren auf Ausgaben, die Anforderungen des vorbestimmten Satzes erfüllen, durch Erzeugen des assoziierten Steuersignals.

11. Verfahren nach Anspruch 9 oder 10, umfassend:

Bereitstellen einer zweiten Vorrichtung, die eine Mehrzahl von zweiten Sensoren umfasst, die auf formbarem Material montiert sind, wobei die zweiten Sensoren so ausgelegt sind, dass sie jeweilige Ausgaben bereitstellen, die Bewegung der zweiten Sensoren in Bezug aufeinander entsprechen;

Überwachen von Verformung des formbaren Materials unter Verwendung der zweiten Sensoren, wobei die Verformungen mit Verformung der Haut des Benutzers übereinstimmen; und

Senden eines zweiten Signals, das den Ausgaben entspricht, an das Gerät.

Revendications

1. Appareil (1) comprenant :

un matériau enrobant (3) agencé pour, lorsqu'il est placé au voisinage de la peau d'un utilisateur, subir une déformation épousant une déformation de la peau ; et

une pluralité de capteurs (12a - 12i) agencés pour fournir des sorties respectives correspondant au mouvement desdits capteurs les uns par rapport aux autres en réponse à ladite déformation de la peau ;

lesdits capteurs comprenant un matériau piézoélectrique sensible à la flexion configuré pour répondre à une déformation de flexion et/ou d'allongement desdits capteurs en générant une charge électrique,

un contrôleur (10) relié auxdits capteurs par des conducteurs (7a-7c, 8a-8c) et agencé pour surveiller des charges générées par ledit matériau de détection, et

l'appareil étant **caractérisé par**

des éléments de retour actif agencés pour exercer une pression sur ladite peau en réponse à un signal de commande provenant du contrôleur (10) fourni par le biais des conducteurs

dans lequel lesdits capteurs sont utilisés comme lesdits éléments de retour actif, de telle sorte que les capteurs sont utilisables dans un premier mode dans lequel lesdits capteurs agissent pour détecter des déformations de flexion et/ou d'allongement desdits capteurs, lorsqu'ils sont exposés à une déformation mécanique, et les capteurs sont utilisables dans un deuxième mode dans lequel lesdits capteurs agissent comme actionneurs pour générer des vibrations mécaniques en fonction du signal de commande provenant du contrôleur.

2. Appareil selon la revendication 1, dans lequel :

lesdits conducteurs ont une forme non linéaire ; et/ou

lesdits conducteurs comprennent un premier ensemble de conducteurs, branchés au niveau de premières surfaces respectives du matériau de détection desdits capteurs, et un deuxième ensemble de conducteurs, branchés au niveau de deuxièmes surfaces respectives dudit matériau de détection, et ledit contrôleur est agencé pour adresser des capteurs individuels parmi lesdits capteurs en utilisant des conducteurs sélectionnés dudit premier ensemble de conducteurs et dudit deuxième ensemble de conducteurs.

3. Appareil selon la revendication 1 ou 2, dans lequel :

ledit matériau enrobant comprend un substrat enrobant, ledit matériau de détection est monté sur ledit substrat et lesdits conducteurs sont reliés au matériau de détection desdits capteurs au niveau de premières surfaces respectives de ceux-ci ; ou

ledit matériau enrobant comprend un substrat enrobant, ledit matériau de détection est incorporé dans ledit substrat et lesdits conducteurs sont reliés au matériau de détection desdits capteurs au niveau de premières surfaces respectives de ceux-ci ; ou

au moins un desdits capteurs comprend une couche dudit matériau de détection, le contrôleur est relié audit au moins un capteur par quatre desdits conducteurs, un premier et un deuxième desdits conducteurs étant reliés à une première surface de ladite couche et un troisième et un quatrième desdits conducteurs étant reliés à une deuxième surface de ladite couche à l'opposé de ladite première surface, ledit contrôleur étant agencé pour obtenir des lectures depuis des surfaces opposées de ladite couche dudit capteur et agencé pour effectuer ladite surveillance en prenant des lectures au moyen de multiples paires de conducteurs sélectionnés parmi lesdits premier, deuxième, troisième et quatrième conducteurs.

4. Appareil selon une quelconque revendication précédente, dans lequel lesdits capteurs comprennent un matériau à base de titanozirconate de plomb (PZT) ou de polyfluorure de vinylidène (PVDF).

5. Appareil selon une quelconque revendication précédente, dans lequel le contrôleur est agencé pour générer un deuxième signal pour commander un dispositif externe en fonction desdites sorties.

6. Appareil selon la revendication 5, dans lequel ledit processeur est agencé pour générer ledit signal en fonction d'une ou plusieurs dérivées temporelles desdites sorties.

7. Système comprenant :

au moins un appareil selon la revendication 5 ou 6 ; et
ledit dispositif externe.

8. Système selon la revendication 7, dans lequel :

ledit dispositif externe est agencé pour déterminer une reconstruction d'un mouvement de l'utilisateur en fonction desdites sorties ; ou
ledit dispositif externe est agencé pour suivre des mouvements d'une partie d'un corps de l'utilisateur en fonction des sorties desdits capteurs et pour copier lesdits mouvements ; ou
ledit dispositif externe est agencé pour afficher du contenu et ledit appareil est agencé pour contrôler le survol dudit contenu ; ou
ledit dispositif externe est agencé pour afficher une image et pour actualiser ladite image périodiquement pour qu'elle corresponde auxdites sorties.

9. Procédé comprenant :

l'obtention d'une pluralité de capteurs (12a - 12i) intégrés sur un matériau enrobant (3), les capteurs étant agencés pour fournir des sorties respectives correspondant à un mouvement desdits capteurs les uns par rapport aux autres ;
la surveillance d'une déformation du matériau enrobant, lesdites déformations épousant une déformation de la peau d'un utilisateur à laquelle le matériau enrobant est adjacent, au moyen desdits capteurs,
la génération d'une charge électrique par des capteurs piézoélectriques sensibles à la flexion en réponse à une déformation de flexion et/ou d'allongement d'au moins un desdits capteurs du matériau enrobant,
la surveillance de charges générées par les capteurs intégrés sur le matériau enrobant,
caractérisé par
l'application d'un retour actif à la peau en réponse à un signal de commande provenant d'un contrôleur relié auxdits capteurs par le biais de conducteurs,
dans lequel lesdits capteurs sont utilisés comme lesdits éléments de retour actif, de telle sorte que lesdits capteurs sont utilisables dans un premier mode dans lequel lesdits capteurs agissent pour détecter des déformations de flexion et/ou d'allongement desdits capteurs, lorsqu'ils sont exposés à une déformation mécanique, et lesdits capteurs sont utilisables dans un deuxième mode dans lequel lesdits capteurs agissent comme actionneurs pour générer des vibrations mécaniques en fonction du signal de commande provenant du contrôleur.

10. Procédé selon la revendication 9, comprenant la réception d'une indication d'un signal de commande associé à un ensemble prédéterminé de sorties et la réponse à des sorties respectant des exigences dudit ensemble prédéterminé par génération du signal de commande associé.

11. Procédé selon la revendication 9 ou la revendication 10, comprenant :

l'obtention d'un deuxième appareil, comprenant une pluralité de deuxièmes capteurs montés sur un matériau enrobant, les deuxièmes capteurs étant agencés pour fournir des sorties respectives correspondant à un mouvement desdits deuxièmes capteurs les uns par rapport aux autres ;
la surveillance d'une déformation du matériau enrobant, lesdites déformations épousant une déformation de la peau de l'utilisateur, au moyen desdits deuxièmes capteurs ; et
la transmission d'un deuxième signal correspondant auxdites sorties audit dispositif.

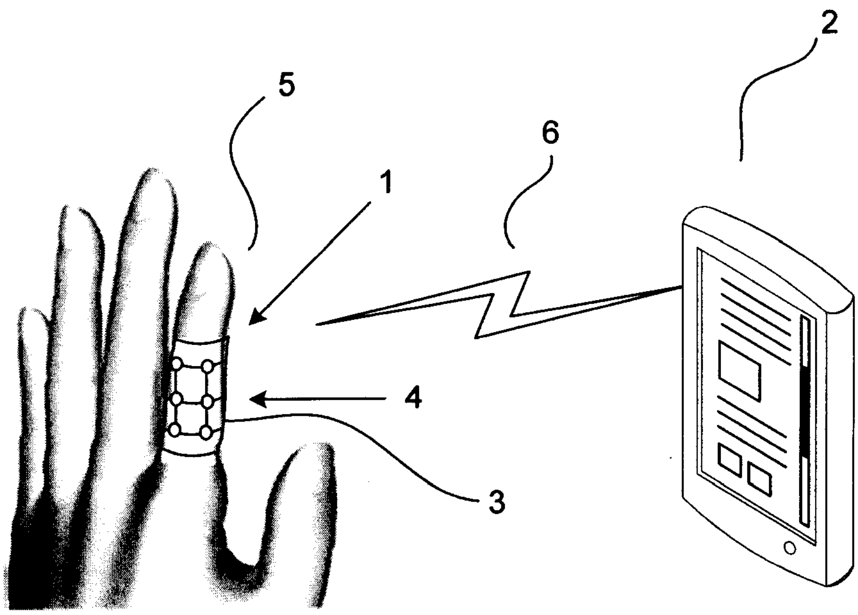

Figure 1a

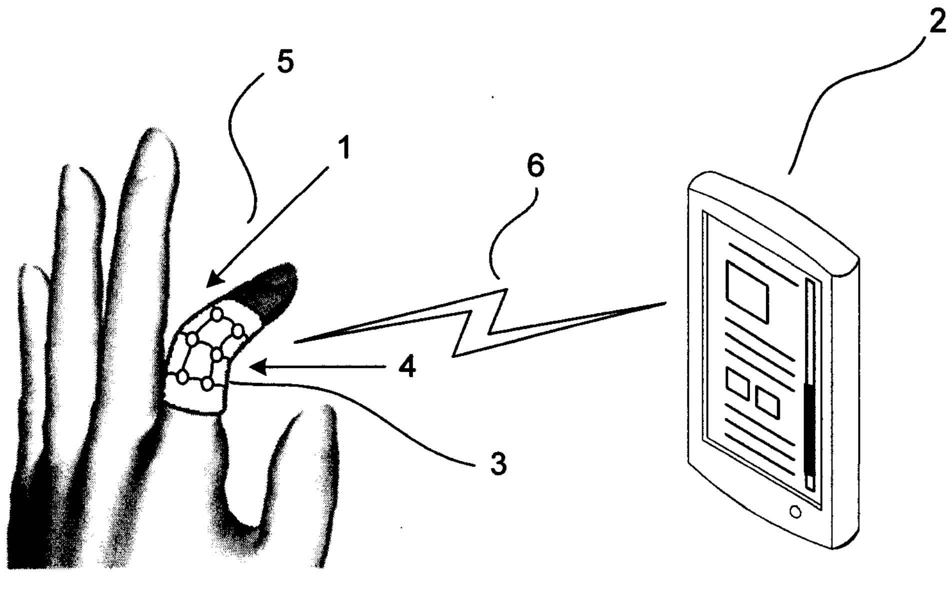

Figure 1b

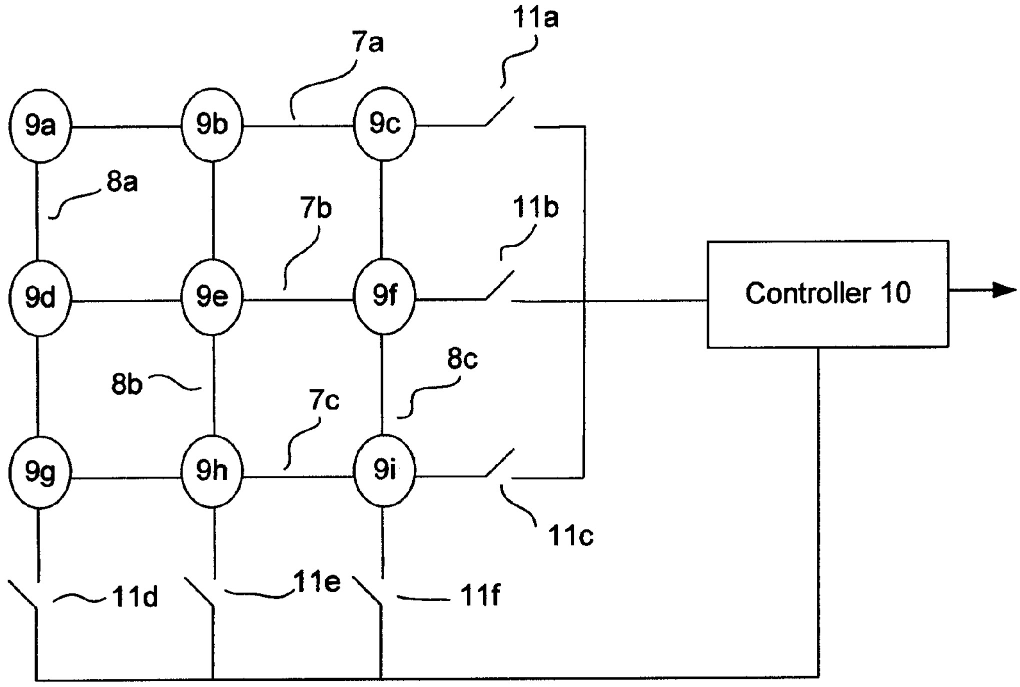

Figure 2

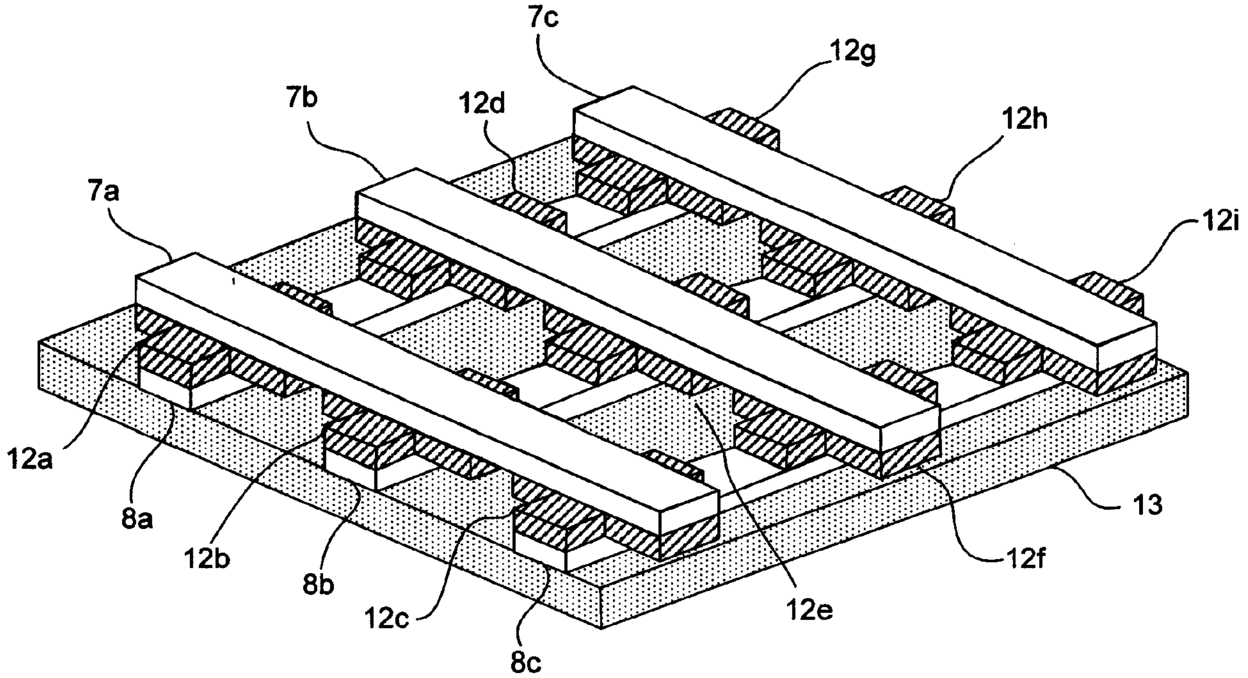

Figure 3

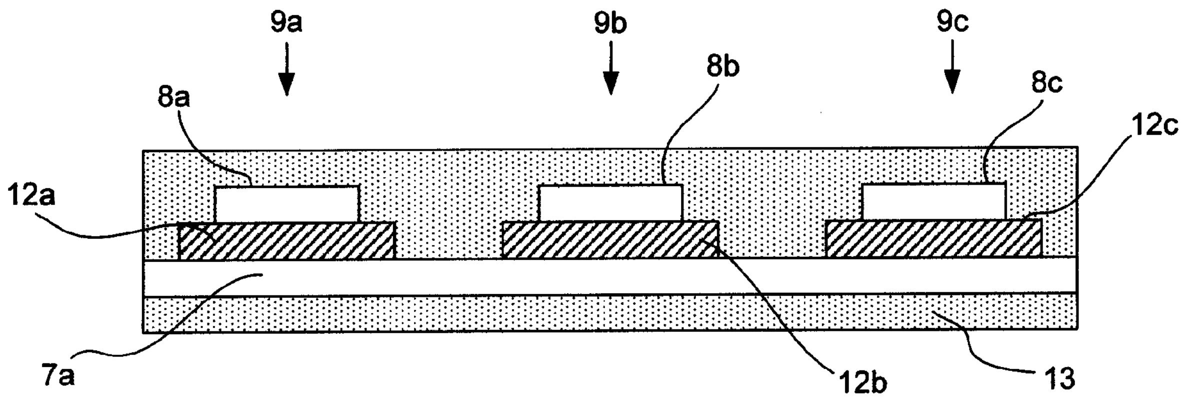

Figure 4

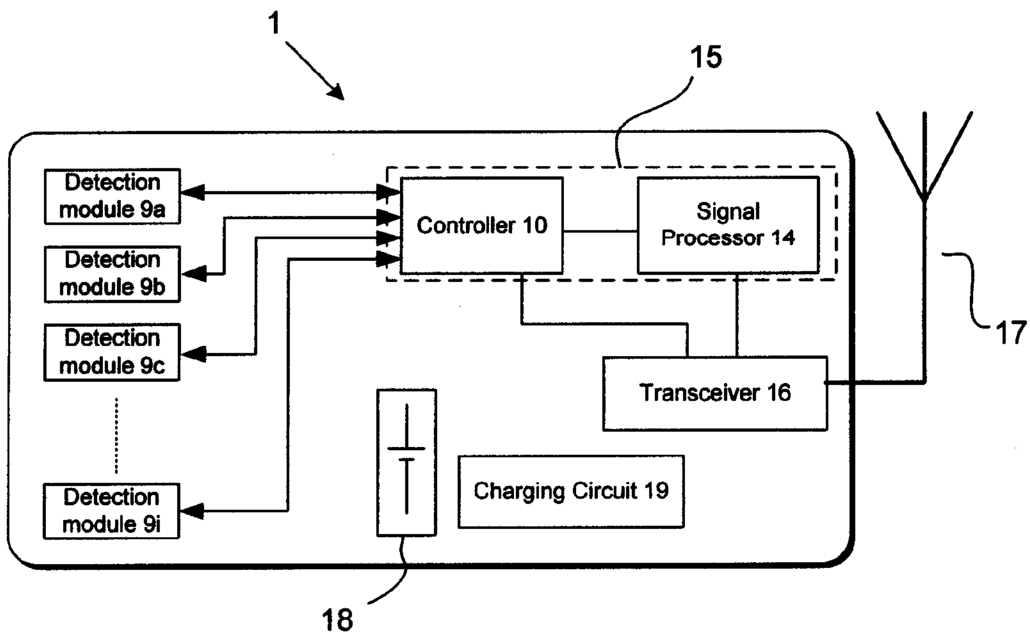

Figure 5

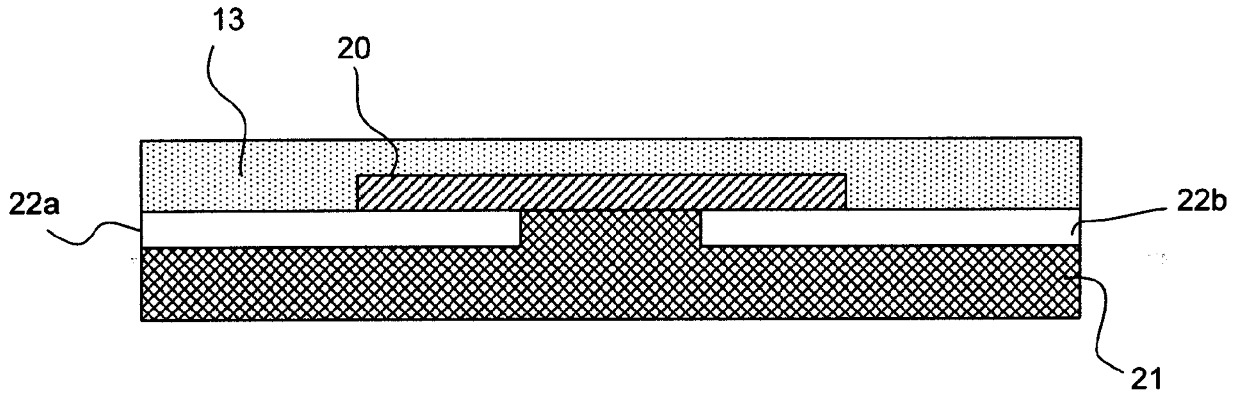

Figure 6

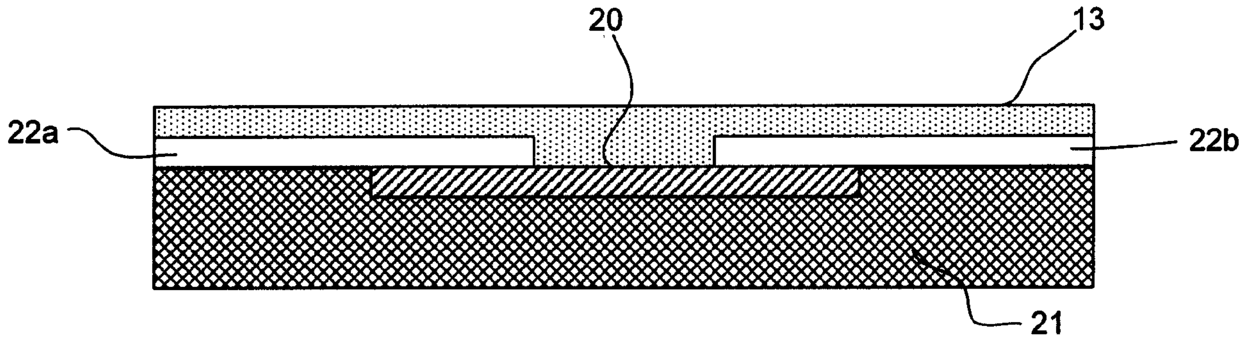

Figure 7

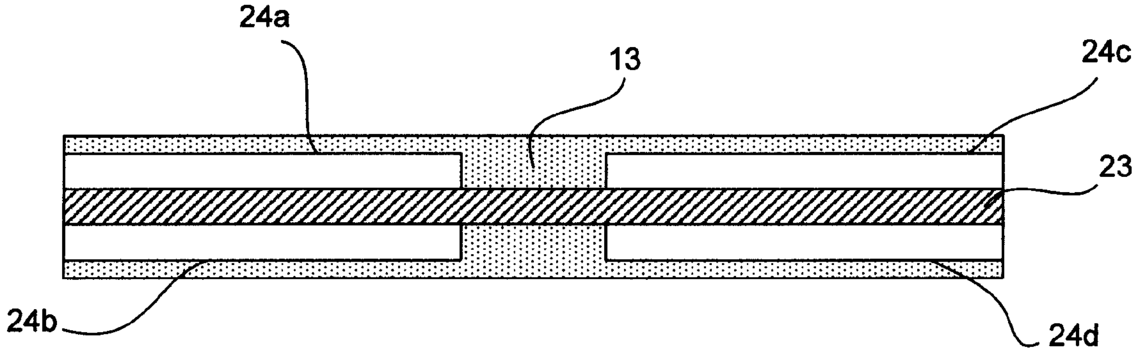

Figure 8

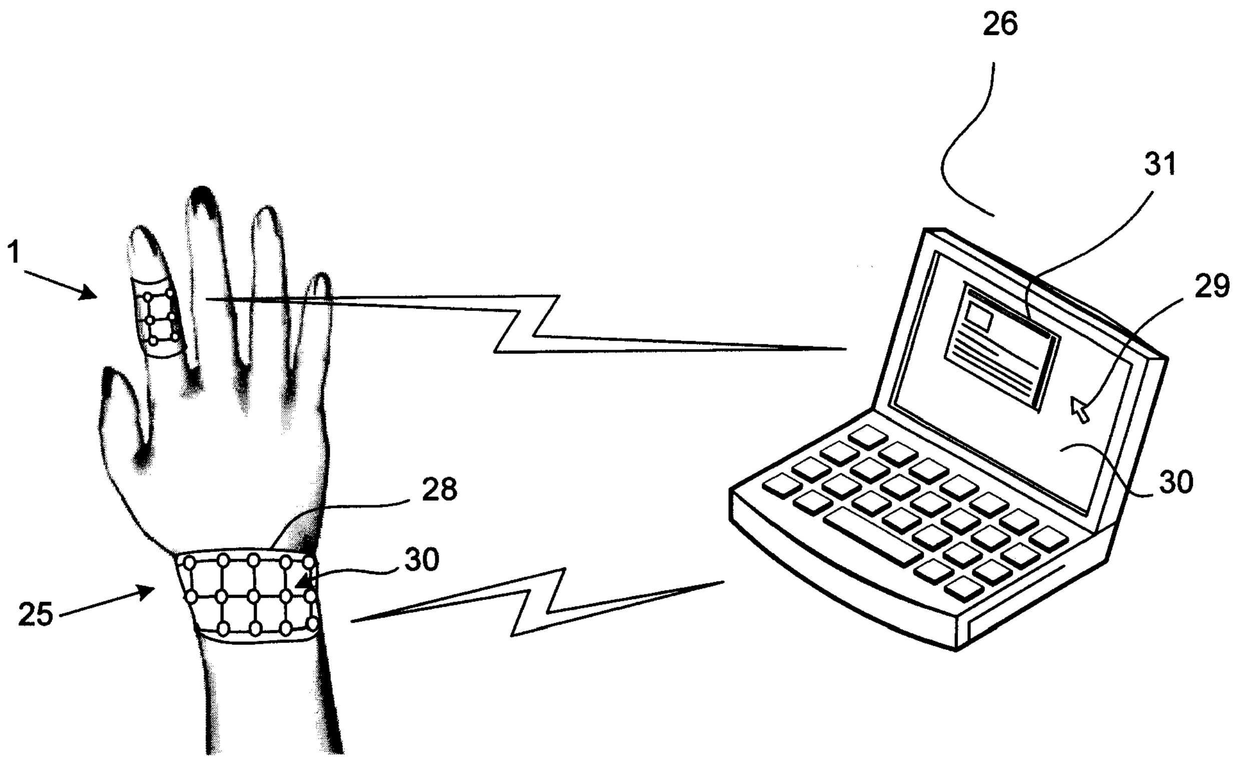

Figure 9

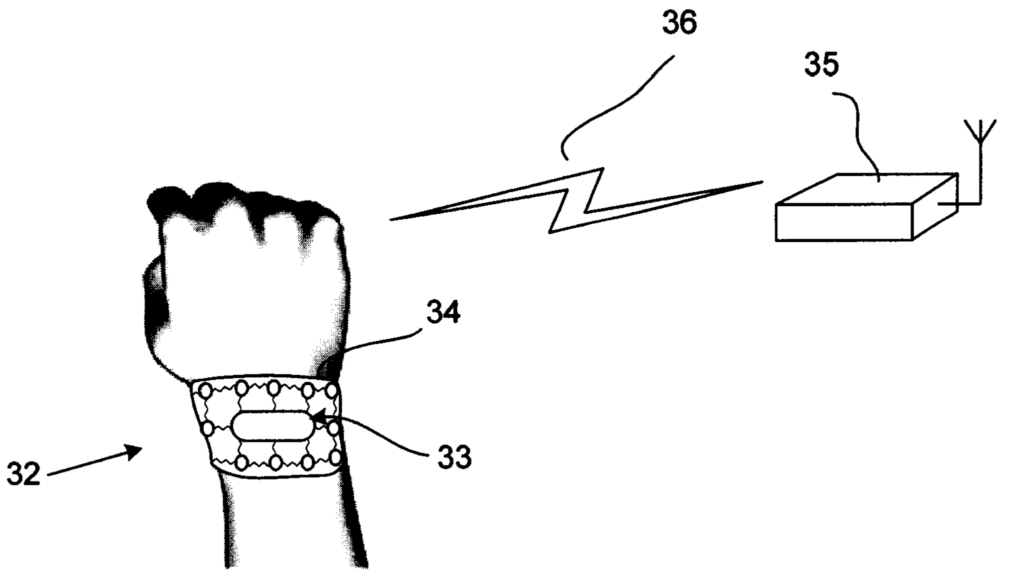

Figure 10

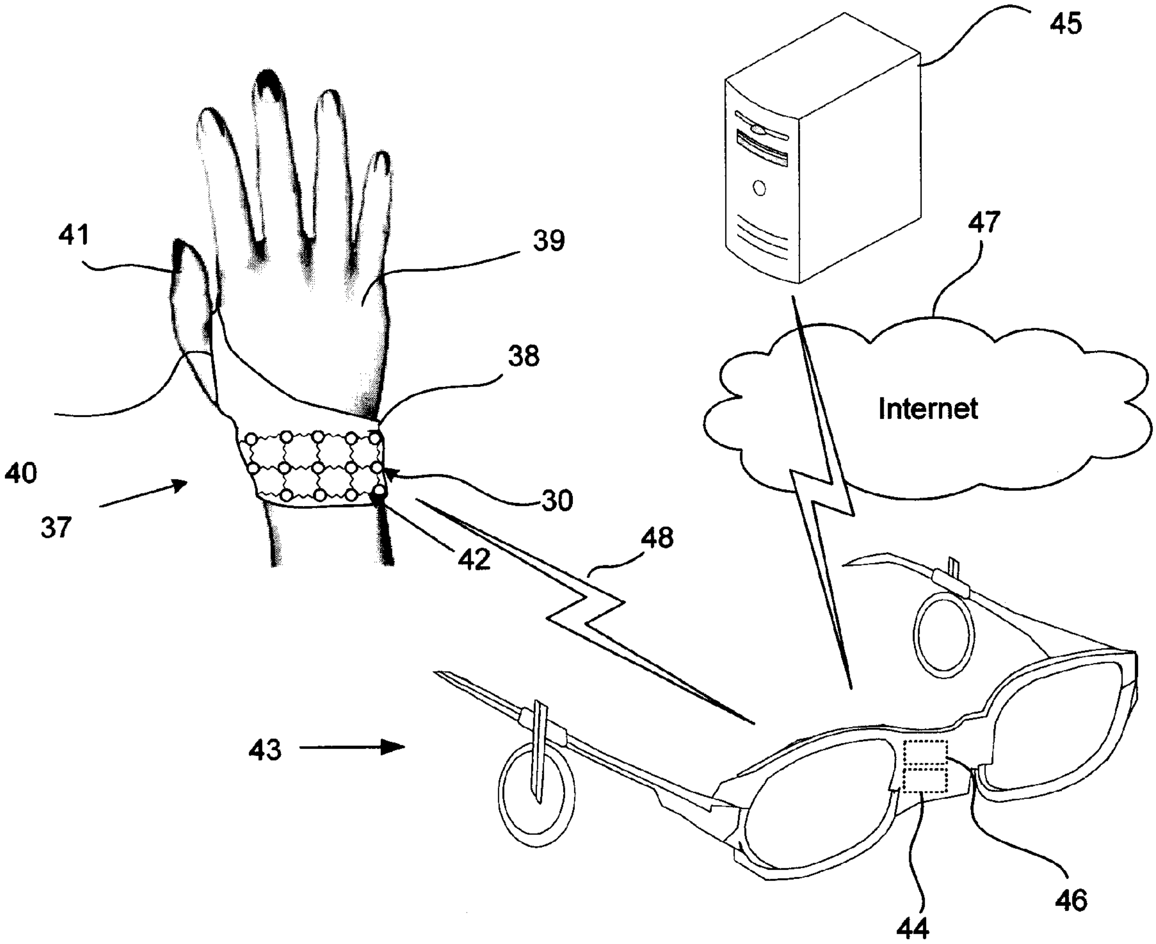

Figure 11a

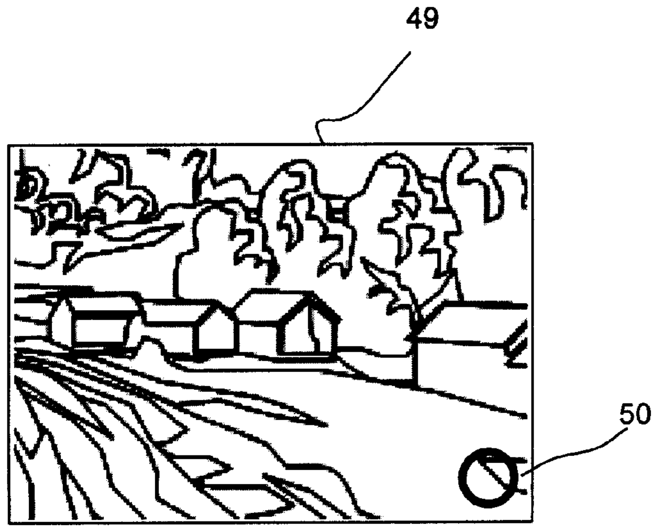

Figure 11b

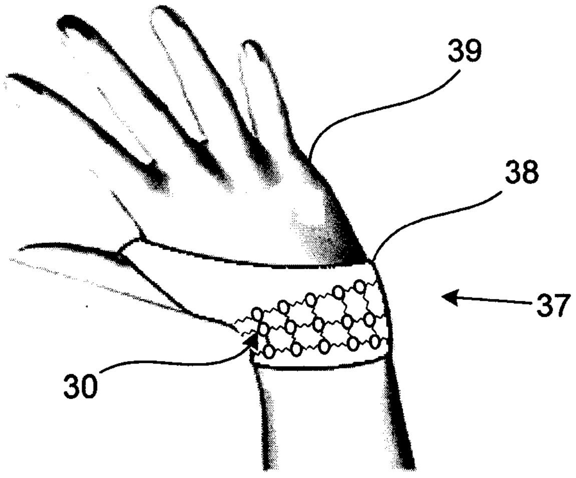

Figure 12a

Figure 12b

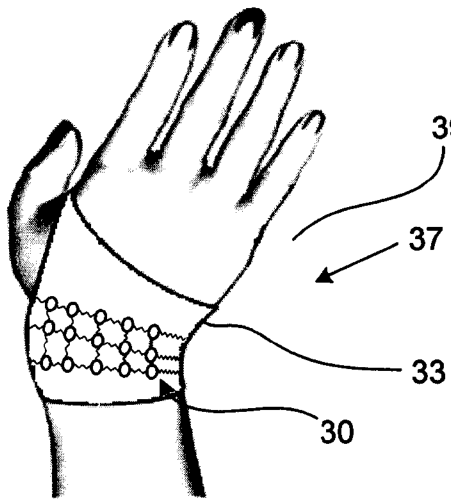

Figure 13a

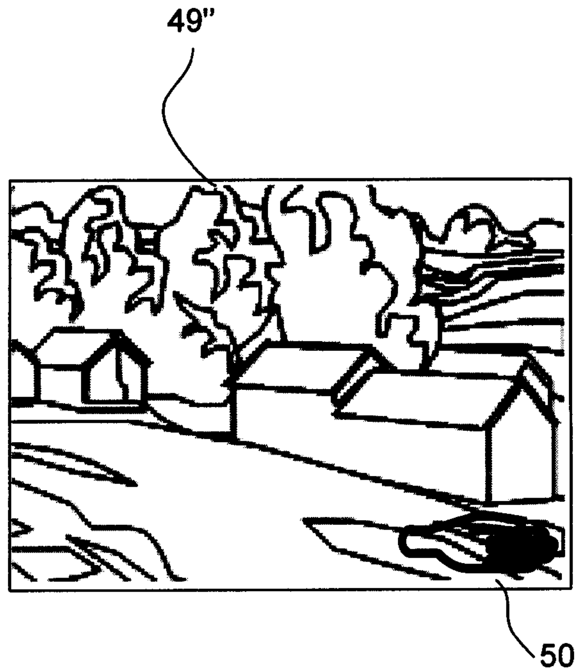

Figure 13b

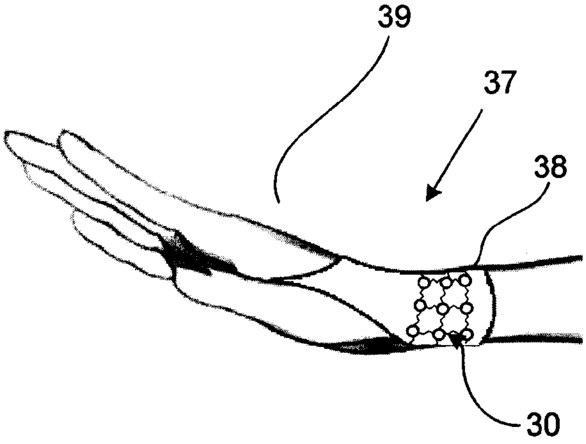

Figure 14a

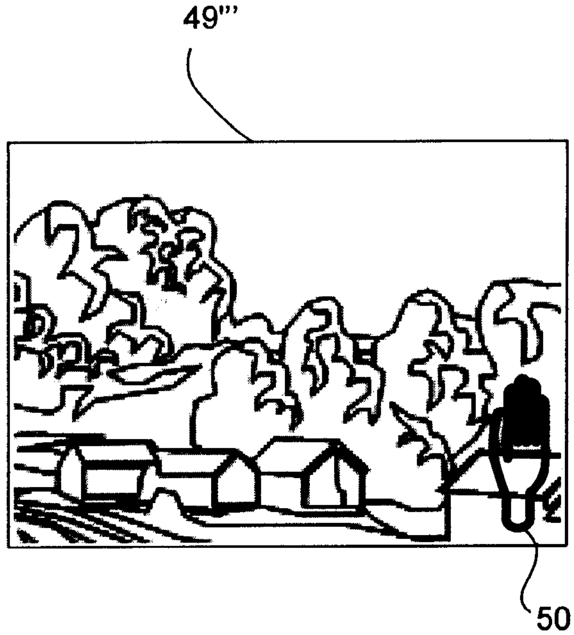

Figure 14b

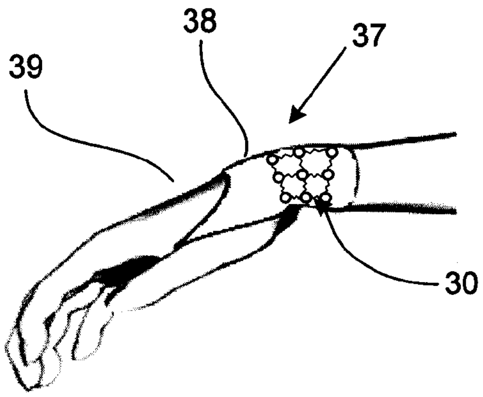

Figure 15a

Figure 15b

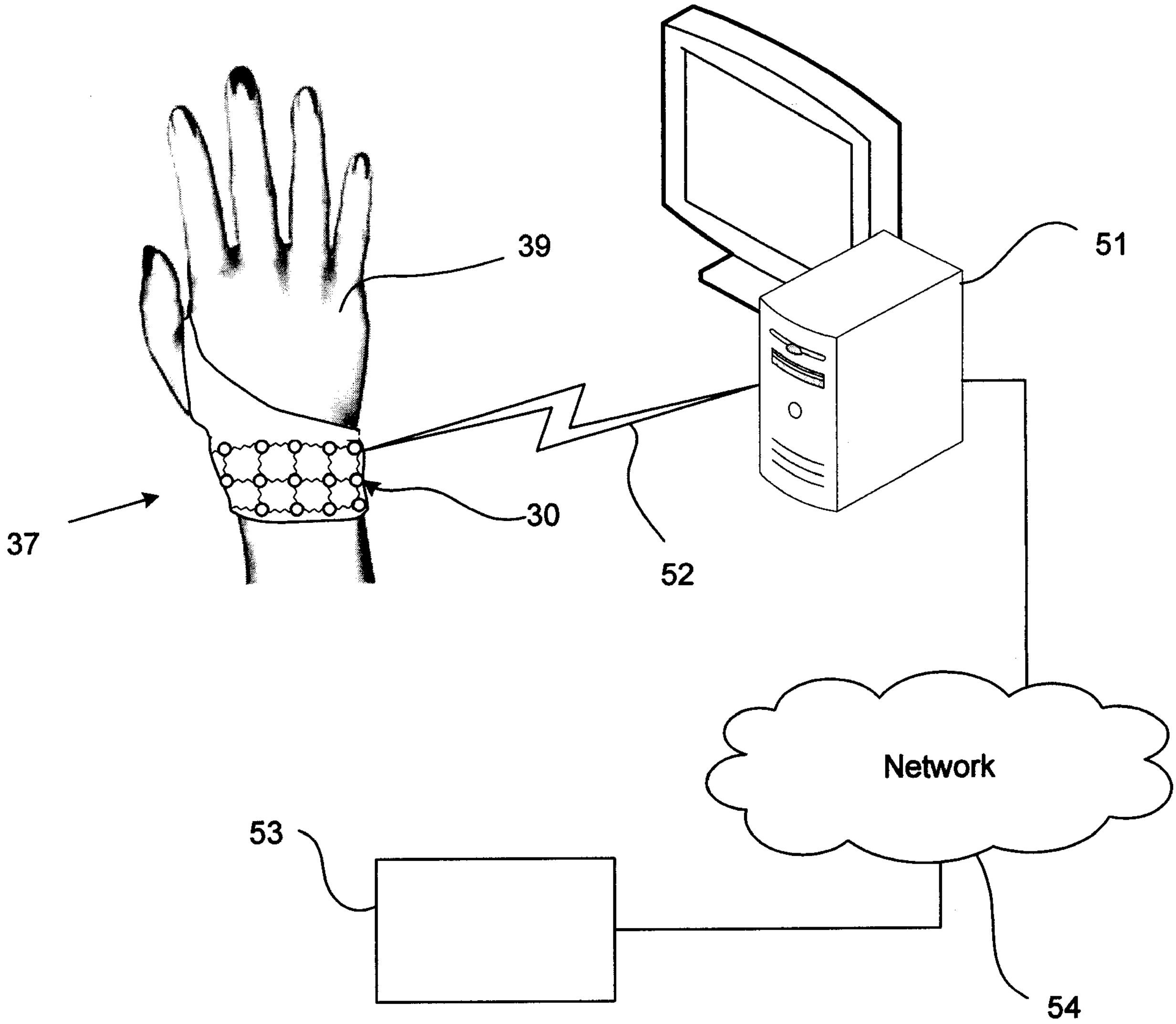

Figure 16

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