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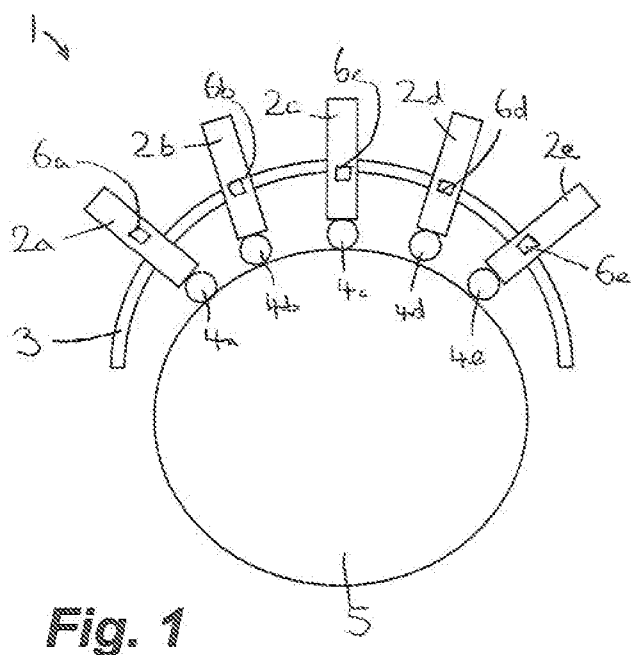
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(54) Title: ELECTRODE ASSEMBLY



(57) Abstract: An electrode assembly array for use in Elec-
trical Impedance Tomography (EIT), the electrode assembly
array (1) comprising a plurality of electrode assemblies (2a-e)
mounted to a frame (3), the electrode assemblies comprising
an electrode (4a-e) for contacting a subject and a drive ele-
ment (6a-e), the drive element adapted to drive the electrode
towards the subject from the frame for contacting the subject
and an abrasion element adapted to move the electrode such
that it abrades the subject.

ELECTRODE ASSEMBLY

[0001] This invention relates to an electrode assembly array that is suitable for use in Electrical Impedance Tomography (EIT). In particular, it relates to an electrode assembly array helmet. It also relates to an electrode assembly which forms part of the electrode assembly array. Further, it relates to an Electrical Impedance Tomography apparatus.

[0002] Electrical impedance tomography is a medical imaging technique that uses measurements of the electrical impedance of a body part to construct an image thereof. Typically, electrodes are used to apply an alternating current to the surface of the skin and the resulting potential is measured. Many measurements are made from different points on the skin and an image of impedance within the body is created using known reconstruction techniques. Thus, electrical impedance tomography provides imaging information regarding the internal electrical properties inside a body based on voltage measurements on its boundary.

[0003] For Electrical Impedance Tomography or Electroencephalography (EEG) source modelling of the brain, data is collected by electrodes placed on the scalp. Usually, there are between 16 and 256. It is important for the electrodes to have good electrical contact with the skin. This is usually achieved by manual abrasion of the skin. In clinical practice and most EIT studies, conventional EEG cup electrodes, about 1 cm across, have been used. A technician manually abrades the skin first and then electrodes are placed manually and held in place with a sticky paste or glue. This produces excellent skin-electrode contact but is time consuming and requires an expert technician.

[0004] For non-expert use, an electrode cap may be employed in which the electrodes are mounted at regular intervals within a flexible cap that fits on a subject's head. This may achieve skin contact without abrasion by using a gel or saline soaked sponges. Even using an electrode cap, manual skin abrasion under each electrode may be necessary to ensure a reliable contact between the electrodes and the subject.

[0005] Electrode caps are known but no design has been published for EIT of the head. Known cap designs have all been for EEG recording, in which electrode impedance is not as important. These all have the limitation that there is no consideration of electrode impedance.

[0006] According to a first aspect of the invention we provide an electrode assembly array for use in Electrical Impedance Tomography (EIT), the electrode assembly array comprising a plurality of electrode assemblies mounted to a frame, the electrode assemblies comprising an electrode for contacting a subject and a drive element, the drive element adapted to drive the electrode towards the subject from the frame for contacting the subject and an abrasion element adapted to move the electrode such that it abrades the subject.

[0007] This is particularly advantageous for EIT of brain function, as it could provide a robust application of 256 electrodes, for example, which could be used by unskilled personnel, and be able to automatically achieve and maintain good electrode skin contact.

[0008] Preferably the abrasion element is adapted to rotate the electrode as it is driven towards the subject to provide the abrasion for reliable electrode-subject contact. Alternatively the abrasion element may be arranged to vibrate the electrode to provide the abrasion as the electrode is driven into contact with the subject.

[0009] Preferably the electrode has a tip, which contacts the subject, that includes an abrasive material.

[00010] Preferably, the drive element is provided by an electric motor. Alternatively, the drive element may be provided by a spring. Preferably the abrasion element is provided by an electric motor.

[00011] Preferably, the electrode assembly includes a feedback device adapted to measure the electrode-subject impedance and control the drive element and/or abrasion element in response to those measurements. The feedback device may be arranged to control the drive means such that it drives the electrode more firmly

against the subject and/or maintain activation of the abrasion element until a target impedance is achieved. The target impedance may be <2 kOhms at 10 Hz. The feedback device may include a safety element to ensure that the drive element and/or abrasion element to not apply forces above a predetermined upper limit on the subject.

[00012] The apparatus may include a reference electrode. The target impedance may be determined in situ by the reference electrode that can be skilfully placed by an operator on the subject and then the feedback element of each electrode assembly controls the drive element and/or abrasion element to achieve the impedance of the reference electrode within predetermined bounds.

[00013] The feedback device may be adapted to monitor the electrode impedance after the target impedance has been achieved to ensure that the electrodes maintain a reliable contact with the subject. Accordingly, the feedback device may provide adjustment signals to the drive element and/or abrasion element to move the electrode to maintain the target impedance.

[00014] Preferably the electrode assembly includes an electrode position sensor arranged to measure the position of the electrode relative to the frame. This allows the shape of the subject to be determined for more accurate image reconstruction when using EIT. This information could be used to determine the shape of the head and skull which would inform the choice of numerical model used in image reconstruction.

[00015] Preferably the electrode assembly array includes 2, 16, 32, 64, 128 or 256 or more electrode assemblies. It will be appreciated that these figures are examples only and other numbers of electrode assemblies could be provided.

[00016] Preferably the electrodes include a conductivity liquid dispensing device for dispensing a liquid or gel at the electrode's tip to improve contact impedance with the subject.

[00017] According to a second aspect of the invention we provide an electrode assembly array for use in Electrical Impedance Tomography (EIT), the electrode assembly array comprising a plurality of electrode assemblies mounted to a frame, the

electrode assemblies comprising an electrode for contacting a subject and a drive element, the drive element adapted to drive the electrode towards the subject from the frame for contacting the subject, the electrode assemblies including an electrode position sensor arranged to measure the position of the electrode relative to the frame.

[00018] This allows the shape of the subject to be determined for more accurate image reconstruction when using EIT. This information could be used to determine the shape of the head and skull which would inform the choice of numerical model used in image reconstruction.

[00019] Preferably the electrode assemblies include an abrasion element adapted to move the electrode such that it abrades the subject.

[00020] It will be appreciated that the optional features disclosed in relation to the first aspect of the invention also apply to the second aspect of the invention.

[00021] According to a third aspect of the invention we provide an electrode assembly for forming an electrode assembly array having the features disclosed in the first and/or second aspects of the invention.

[00022] According to a fourth aspect of the invention we provide an electrical impedance tomography apparatus comprising an electrode assembly array according to the first and/or second aspect of the invention, a processing element for receiving and processing data from the electrodes to generate processed data and an image reconstruction element for producing an image of the subject from the processed data.

[00023] There now follows by way of example only a detailed description of the present invention with reference to the accompanying drawings, in which;

[00024] **Figure 1** shows a diagrammatical view of an electrode assembly array

[00025] **Figure 2** shows sectional view of a first embodiment of the electrode assembly with only the drive element visible;

[00026] **Figure 3** shows a diagram of an embodiment of the feedback element;

[00027] **Figure 4** shows a sectional view of a first embodiment of the electrode assembly with the drive element and abrasion element visible;

[00028] **Figure 5** shows a detailed view of the gear system of Figure 4;

[00029] **Figure 6** shows an embodiment of a rotary encoder that forms part of the feedback element;

[00030] **Figure 7** shows a slip ring of the electrode assembly;

[00031] **Figure 8** shows a detailed view of the electrode tip;

[00032] **Figure 9** shows a second embodiment of an electrode assembly;

[00033] **Figure 10** shows a third embodiment of an electrode assembly; and

[00034] **Figure 11** shows a diagram showing the functional parts of one of the electrode assemblies of the array.

[00035] Figure 1 shows a diagrammatical view of an electrode assembly array 1 comprising a plurality of electrode assemblies 2a-e mounted to a frame 3. Only five electrode assemblies are shown in figure 1 for simplicity. However, the exemplary embodiment described herein has 256 electrode assemblies. The electrode assembly array 1 is particularly suited for use with Electrical Impedance Tomography (EIT) apparatus, although it may be used with other technologies.

[00036] The electrode assemblies 2a-e each comprise an electrode 4a-e for contacting a subject 5 and a drive element 6a-e, the drive element adapted to drive the electrode 4a-e relative to the subject 5 from the frame 3 for contacting the subject 5. The electrode assemblies 2a-e also include an abrasion element adapted to move the

electrode 4a-e such that it abrades the subject 5 and, in particular, the skin of the subject 5.

[00037] The embodiment disclosed herein comprises a helmet with 256 electrode assemblies, although any number of assemblies may be provided. For example, the frame 3 may include 16 – 256 electrode assemblies in it, which forms the electrode assembly array. Each electrode assembly 2a-e is self-adjusting and connected to a feedback device micro-controller which would operate feedback loops to control force and contact impedance, and a position sensor to return the position of the electrode tip. In summary, each electrode assembly in the present embodiment contains the following elements:

- 1) A motor or motors for advancing and rotating the electrode to form the drive element and abrasion element.
- 2) Means to prevent excessive force on the electrode by limiting applied force in the motor or a mechanical breakpoint on the shaft or holder.
- 3) A control loop with optimised parameters for controlling applied linear force of the drive element, rotating torque of the abrasion element and contact impedance.
- 4) Means to record linear force applied or else a means to obviate this using a safety force ceiling coupled to a control by recording a set-point of skin impedance.

[00038] The electrode assemblies, mounted within a frame 3 of a helmet, operate without the need for expert supervision. Excellent electrode contact impedance would be achieved in several seconds with all adult head shapes and hair cuts and consistency.

[00039] In general, an electrode assembly for controlling a single electrode is disclosed with two independently controlled degrees of freedom: linear actuation/force control, and rotary actuation/impedance control. A linear actuator, which forms the drive element, advances the electrode towards a subject, and the force applied is measured by a load cell and controller, which forms the feedback device, and is used to maintain a constant force. The electrode is rotated by the abrasion element and is operated independently by a DC motor, which abrades the outer layer of the subject.

The contact impedance difference between the electrode and a predetermined reference is measured, and the abrasion is stopped when a threshold impedance is reached. A rotary encoder gives a measure of the speed of rotation, which is used to increase the torque output of the motor if the electrode has stalled due to the friction at the test object interface.

[00040] As each of the degrees of freedom are independent from each other, for clarity they can be described separately as in the following sections. Parts of the description below are that of a test set up rather than the electrode assemblies acting on a subject, such as a patient's head or scalp.

[00041] Drive element.

[00042] Figure 2 shows an embodiment of one of the electrode assemblies 2a-e and, in particular, electrode assembly 2a. It will be appreciated that in this embodiment all of the electrode assemblies have the same general structure. The electrode assembly includes the electrode 4a at one end of a spindle 10 and a drive element 6a at the other end of the spindle 10. The drive element 6a comprises a stepper motor 11 which acts on the spindle 10 through a thrust bearing 12. Actuation of the stepper motor 11 acts to move the spindle in a translational manner, and therefore the electrode 4a, relative to the subject 5.

[00043] The components related to controlling the applied force are shown in Figure 2. The stepper motor 11 pushes the spindle 10 via the thrust bearing 12, thus enabling the spindle to be rotated freely whilst being translated. The output of the stepper motor 11 is a fixed displacement per step. This is converted into a force output via a spring 13. The spring constant k of spring 13 was chosen to be approximately 150 N/m, which results in a force range of 0-20N for the length of stable travel for the stepper motor.

[00044] This was confirmed by measuring the force transmitted through a test object 16 via a load cell 15 in a full Wheatstone bridge configuration. A custom amplifier was used to amplify the differential signal, the gain of which was chosen to maximise the dynamic range for the expected forces and DC power level.

[00045] The electrode 4a is slidably mounted within a retaining bush 14. The spring 13 is mounted within the bush 14 between the electrode 4a and the spindle 10.

[00046] The electrode assembly 2a includes a feedback device (not shown in Figure 2). The feedback device assists in controlling the drive element 6a. The feedback device measures either the impedance between the electrode 4a and the subject 5 or the force applied by the drive element 6a or both and provides control signals to the drive means 6a. The impedance between the electrode 4a and the subject may be measured using an appropriate impedance measurement device. The applied force may be measured using a force measurement device located adjacent the electrode 4a or spring or elsewhere in the electrode assembly 2a.

[00047] The feedback device receives measurements from the impedance measurement device and/or force measurement device and compares the measurement to a predetermined set point. If the force measurement is lower than the set point or the impedance measurement is higher than the set point, the feedback device may instruct the stepper motor 11 to advance to increase the force/decrease the impedance. If the force measurement is higher than the set point or the impedance measurement is lower than the set point, the feedback device may instruct the stepper motor 11 to recede to decrease the force/increase the impedance. The force sensor may be located behind electrode and may be a force sensitive resistor, or a spring loaded potentiometer.

[00048] The operation of the feedback device 30 or control loop is shown in figure 3. The stepper motor 11 moved at a constant step rate, with the direction changing based on the error between the set point and the measurement(s). A deadband is used to prevent limit cycling, which is set at a level so that the steady state error was within a single step of the stepper motor 11. Therefore, provided that the measurements received by feedback device are within bounds, the feedback device will maintain the electrode position. Control of the drive element in this way is advantageous, as the position of the electrode can be adjusted to ensure a consistent force and/or impedance is maintained between the electrode assembly 2a and the subject 5.

[00049] The feedback device 30 or the electrode assembly may include a safety element to ensure that a force beyond a safety threshold is not applied to the subject. The safety element may inhibit further signals to the motor 11, provide instructions to recede the electrode 4a or the safety element may comprise a mechanical connection that yields when a threshold force is applied thereto, thereby relieving the force applied by the electrode to the subject 5.

[00050] Abrasion Element and Rotary Actuation

[00051] The rotary actuation is achieved through the components shown in figure 4. Rotary actuation is used by an abrasion element to abrade the subject 5. A DC motor 40, via a drive gear 42, intermediate gears 41 and a keyed joint 43, rotates the spindle 10. The keyed joint 43 includes key 45 to engage the spindle 10. The gear assembly is shown in more detail in Figure 5. The rotational speed of the spindle is set at approximately 1 Hz or 60 RPM, so the gear ratio of the gears 41, 42 was chosen to bring the output of the motor 40 to within this range. In the embodiment shown the gear ratio used was 640:1, which also served to greatly amplify the torque output of the motor 40. Pulse Width Modulation (PWM) is used to control the speed of the motor without significantly impacting the torque output.

[00052] A rotary encoder 44 (shown in more detail in Figure 6) may be used to measure the speed of rotation of the electrode spindle 10. The rotary encoder 44 includes a bearing 46 between it and the keyed joint 43. The output of which served two purposes: to measure if the electrode rotation had stalled, and if so increase the PWM duty cycle to increase the output torque, and to record the speed and total angle rotated.

[00053] The impedance between the actuated electrode 4a and the subject 5 is measured continuously. The electrode 4a is electrically connected to the central spindle 10, which is connected to the feedback device via a slip ring 70.

[00054] The abrasion element comprises the motor and gears 40 to 45 for rotating the spindle as well as the surface of the electrode 4a, which is described in more detail below. The abrasion element is implemented as follows; the abrasion is controlled in a simple closed loop on/off fashion. As the electrode 4a is rotated it will abrade the

subject 5 and, generally, the impedance will decrease. The feedback device measures the impedance and when the impedance reaches a predetermined threshold value, rotation of motor 40 is suspended and therefore abrasion is stopped. If the impedance between the electrode 4a and the subject 5 increases. The feedback device may cause the motor 40 to rotate once again such that the electrode 4a abrades the subject further.

[00055] Figure 6 shows the rotary encoder for measuring the speed of rotation of the spindle and the total angle rotated. It is of conventional design and will only be described briefly herein. The rotary encoder comprises a code wheel 60 having a plurality of apertures of known spacing therein connected to the spindle 10. An infrared LED 61 is placed on the front side of the code wheel 60 and a quadrature encoder 62 is placed behind the code wheel 60 for measuring when light from the LED 61 is received through the apertures. This enables the speed of rotation and the angle of rotation to be determined.

[00056] Figure 7 shows a more detailed view of the electrode assembly 2a including the electrode 4a, a slip ring 70 and clearance bearing 71. The slip ring 70 provides an interface to allow the electrical signal from the electrode to be read by the feedback device and EIT system. Figure 7 also shows a test object 72 and reference electrode 73 used for testing the electrode assembly. It will be appreciated that the reference electrode could alternatively be positioned on a subject 5, when the array is in use.

[00057] With reference to Figure 8, the electrode 4a is constructed out of brass, and has a grid of pyramidal extrusions 80. This creates an abrasive surface, which more readily removes the top layer of skin of the subject 5. The electrode tip thus provides for skin abrasion by rotation and may, if needed, be coated in a conductive paste gel or hydrogel. The abrasive surface greatly aids the abrasion when using traditional abrasive paste. The electrode 4a may be detachable from the electrode assembly such that it can be replaced or sterilised. Abrasive gel could also be coated onto the surface.

[00058] In addition or alternatively, the electrode may include a dispensing device for dispensing a conductivity liquid to improve electrical contact between the electrode and the subject 5. The dispensing device could dispense the abrasive gel. The dispensing device may comprise an electrically controlled pump having an outlet in or adjacent to the electrode 4a. Alternatively, the dispensing device may comprise a liquid containing bladder and outlet, wherein the force applied by the drive element compresses the bladder to expel the liquid from the bladder out through the outlet.

[00059] In the above embodiment a first motor 11 is described as providing motive power for the drive element and the motor 40 for providing motive power for the abrasion element. However, a single motor with lead-screw to convert motor rotation into rotation and translation could be provided.

[00060] The impedance between the electrode 4a and the subject received by the feedback device may be measured using a reference electrode on the patient's scalp, which can be placed manually and shared between all the electrode assemblies.

[00061] One alternative embodiment of the design is shown in Figure 9. The major differences are disclosed below;

[00062] Impedance control algorithm

[00063] The feedback device of the first embodiment used a simple threshold control scheme for the abrasion element. However, in an alternate embodiment a different control scheme is used. It has been found that the impedance decreases logarithmically with the abrasion until the majority of the outer layer of skin is removed. Therefore, the feedback device is configured to measure the derivative of the impedance and control the motor 40 accordingly. In this way, the abrasion element can be controlled robustly and effectively. As the derivative of the impedance reaches an approximately constant value, then further abrasion has little effect, so the feedback device will stop rotation of the spindle 10 by way of motor 40.

[00064] Figure 9 shows an embodiment with passive translation and active rotation. In this embodiment, the electrode 4a is mounted to the spindle 10. A load spring 90, covered by a sleeve 91, acts between a flange 92 and the electrode 4a to

bias it towards an extended position. The linear translation of the electrode 4a is passive in that the spring 90 is compressed by the act of placing the unit on the subject. The spring is preloaded to ensure that the force exerted across the whole displacement range is within a predetermined force range. The electrode 4a is rotated to effect abrasion in the same fashion as the previous embodiment – via a geared motor 94 and keyed joint system 93. Impedance and abrasion can be controlled automatically in the same fashion, with real time impedance measurements received by the feedback device. As with the previous embodiment, a rotary encoder or potentiometer records the spindle 10 translation, to give a measure of the speed of rotation, angle rotated and electrode position.

[00065] Figure 10 shows an embodiment with passive translation and manual rotation. This embodiment is similar to that of Figure 9 except that the motor 94 is replaced by a manual rotation handle 100. The rotation of the electrode could be performed manually by the clinician, via the handle 100 which provides sufficient leverage to abrade the skin. In this case there is no automatic control, rather the user rotates the handle by a predetermined amount. Impedance is measured and fed back to the clinician, such as by way of a display or indicator. The clinician can read the display or indicator and can rotate the abrasion element and thereby the electrodes further should more abrasion be required. The clinician therefore uses the feedback to determine whether or not further abrasion is required.

[00066] Figure 11 shows an overview of the electrode assembly 1100. The translational movement of the electrode 1101 is controlled by a drive element 1102. The rotational movement (although it may be vibratory movement) of the electrode 1101 is controlled by an abrasion element 1103. The drive element 1102 and abrasion element 1103 are controlled to move the electrode 1101 to ensure reliable electrical contact with a subject 5. The assembly includes a feedback device 1104 to receive feedback from sensors to assist in controlling the drive element 1102 and abrasion element 1103. Thus, the assembly further includes a force sensor 1105 and an impedance sensor 1106. The force sensor 1105 is mounted behind the electrode to measure the force applied to the subject. The impedance sensor 1106 uses a reference electrode, placed by a clinician on the subject 5, to obtain a measure of the impedance between the electrode 4a and the subject 5. The reference electrode may

be common to all of the electrode assemblies in the array. The feedback device may use the measurement of the force sensor and/or impedance sensor to control the drive element 1102 and/or abrasion element 1103. The feedback device 1104 may provide control signals to effect further abrasion. The feedback device may provide control signals, in addition or alternatively, to control the position of the electrode 4a relative to the subject 5 and therefore the force with which the electrode is applied to the subject 5. The assembly further includes an electrode position sensor 1107 for measuring the position of the electrode 1101 relative to the frame. This information can be used by an EIT system 1108 to derive the shape of the subject, which can assist in image reconstruction. The electrode position sensor is configured to determine the electrode tip position using a position sensor of conventional design that measures light or conductance to evaluate distance and therefore the position of the electrode tip. The EIT system 1108 also receives the data measured by the electrodes in use.

[00067] Embodiments of the electrode assembly array 1 described herein may be in the form of a helmet and may have the following features;

- A lightweight helmet with up to 256 electrodes (or more)
- Each electrode 4a-e has a conducting tip to be used as an electrode
- The electrodes are self-advancing and abrading. They would advance and rotate until good mechanical contact and a low skin impedance were produced
- This would be achieved using rotation and advancement of the electrode by a motor or motors and abrasion would be accomplished by rotation of an abrasive tip. The effect on skin-electrode impedance and applied force would be monitored and used in a feedback loop to achieve and maintain a low skin impedance (say < 2 kOhm at 10 Hz).
- The positions of each of the electrode tips are calculated using a position sensor in the electrode assembly.

[00068] Applications of the electrode assembly array include, among others;

(1) EIT of acute stroke or head injury. The application of the electrode assembly array helmet would be by nurses or paramedical staff and require good electrode contact over circa 20 minutes. This could be in a hospital bed, casualty ward or in an ambulance which might be moving. The present embodiment provides a self-regulating assembly array (through a drive element, abrasion element and feedback device) for

electrode application which can achieve excellent skin-electrode contact without the need for expert technicians with application in a few seconds which also returns the position of electrodes (using a electrode position sensor).

(2) EIT of stroke, head injury or epileptic seizures requiring monitoring over hours or tens of hours in a hospital setting. In this case, the electrode assembly array helmet would have the advantages as set out above but also has the advantage of continual adjustment of electrode-skin impedance to be optimal. This is advantageous over previous methods of manual repeated inspection of conventional EEG electrodes by expert EEG technicians.

[00069] The purpose of this device is to apply electrodes automatically and rapidly to the scalp of the patient, and reduce and maintain the contact impedance at a level low enough to produce high quality impedance or EEG data. The positions of the electrodes are also returned, for use in generating numerical models (such as FEM – finite element modelling) of the head for use in EIT image reconstruction or EEG inverse source modelling.

[00070] Other modifications that are considered;

- ✧ Shielded wires/coaxial wires for electrode – most EIT systems use active shielding, so it would be advantageous to include this in the embodiments
- ✧ Electrodes design – pyramidal design has been demonstrated to work, but the design in terms of shape/size could be developed further. Other patterns such as spiral or rough sand paper like surfaces could also be used
- ✧ The electrode is currently orthogonal to the axis of rotation, in reality the scalp surface will not be parallel with the electrode mounting so the electrode will be at an angle with the scalp. Therefore connections such as a universal joint or a ball joint could be placed between the electrode and the spindle to align the electrode with the surface.
- ✧ Fail safe mechanisms for actuated embodiments, limitations on torque output can prevent motor travelling too far. Other mechanisms to disengage the motors or disconnect parts could also be included to prevent dangerous forces being applied to a subject

- ✧ Data rejection based on accelerometer readings – large patient movement could lead to large motion artefact during recording. Reading the patients head movement could allow for removal of bad data and repeat recordings. Thus, the electrode assembly array may include an accelerometer to interface with an electrode impedance tomography apparatus so that data is captured only when the subject is sufficiently still.
- ✧ Visual feedback of contact impedance – good contact indicator (such as a Green LED) when electrode has good contact, allows clinician to know which electrodes have good contact.

CLAIMS

1. An electrode assembly array for use in Electrical Impedance Tomography (EIT), the electrode assembly array comprising a plurality of electrode assemblies mounted to a frame, the electrode assemblies comprising an electrode for contacting a subject and a drive element, the drive element adapted to drive the electrode towards the subject from the frame for contacting the subject and an abrasion element adapted to move the electrode such that it abrades the subject.
2. An electrode assembly array according to claim 1, in which the abrasion element is adapted to rotate the electrode as it is driven towards the subject to provide the abrasion for reliable electrode-subject contact.
3. An electrode assembly array according to claim 1, in which the abrasion element is arranged to vibrate the electrode to provide the abrasion as the electrode is driven into contact with the subject.
4. An electrode assembly array according to any preceding claim, in which the electrode has a tip, which contacts the subject, which includes an abrasive material.
5. An electrode assembly array according to any preceding claim, in which the drive element is provided by an electric motor.
6. An electrode assembly array according to any one of claims 1 to 4, in which the drive element is provided by a spring.
7. An electrode assembly array according to any preceding claim, in which the abrasion element is provided by an electric motor.
8. An electrode assembly array according to any preceding claim, in which the electrode assembly includes a feedback device adapted to measure the electrode-subject impedance and control the drive element and/or abrasion element in response to those measurements.

9. An electrode assembly array according to claim 8, in which the feedback device is arranged to control the drive means such that it drives the electrode more firmly against the subject and/or maintain activation of the abrasion element until a target impedance is achieved.
10. An electrode assembly array according to claim 9, in which the target impedance is $<2 \text{ k}\Omega$ at 10 Hz.
11. An electrode assembly array according to any one of claims 8 to 10, in which the feedback device includes a safety element to ensure that the drive element and/or abrasion element do not apply forces above a predetermined upper limit on the subject.
12. An electrode assembly array according to any one of claims 8 to 11, in which the feedback device includes a reference electrode that can be placed on the subject by an operator.
13. An electrode assembly array according to claim 9 or claim 10, in which the feedback device is adapted to monitor the electrode impedance after the target impedance has been achieved to ensure that the electrodes maintain a reliable contact with the subject.
14. An electrode assembly array according to claim 13, in which the feedback device provides adjustment signals to the drive element and/or abrasion element to move the electrode to maintain the target impedance.
15. An electrode assembly array according to any preceding claim, in which the electrode assembly includes an electrode position sensor arranged to measure the position of the electrode relative to the frame.
16. An electrode assembly array according to claim 1, in which the electrodes include a conductivity liquid dispensing device for dispensing a liquid or gel at the electrode's tip to improve contact impedance with the subject.

17. An electrode assembly array according to any preceding claim, in which the electrode assembly includes a feedback device adapted to measure the force applied by the electrode to the subject and control the drive element and/or abrasion element in response to those measurements.

18. An electrode assembly array according to any preceding claim, in which the electrode assembly array forms part of an electrical impedance tomography apparatus comprising a processing element for receiving and processing data from the electrodes to generate processed data and an image reconstruction element for producing an image of the subject from the processed data.

19. An electrode assembly array for use in Electrical Impedance Tomography (EIT), the electrode assembly array comprising a plurality of electrode assemblies mounted to a frame, the electrode assemblies comprising an electrode for contacting a subject and a drive element, the drive element adapted to drive the electrode towards the subject from the frame for contacting the subject, the electrode assemblies including an electrode position sensor arranged to measure the position of the electrode relative to the frame.

20. An electrode assembly array according to claim 19, in which the electrode assemblies include an abrasion element adapted to move the electrode such that it abrades the subject.

21. An electrode assembly array according to claim 19, in which the electrode position sensor comprises a light sensor for determining the position of the electrode

22. An electrode assembly array according to claim 19, in which the electrode position sensor comprises a conductance sensor for determining the position of the electrode.

23. An electrode assembly array according to any one of claims 19 to 22, in which the electrode assembly array forms part of an EIT apparatus and the electrode position sensors are configured to be used by the EIT apparatus in generating numerical models for use in EIT image reconstruction.

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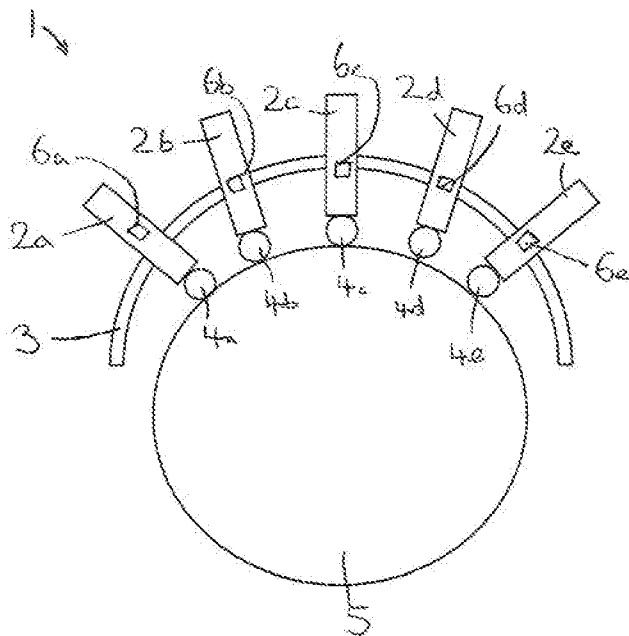


Fig. 1

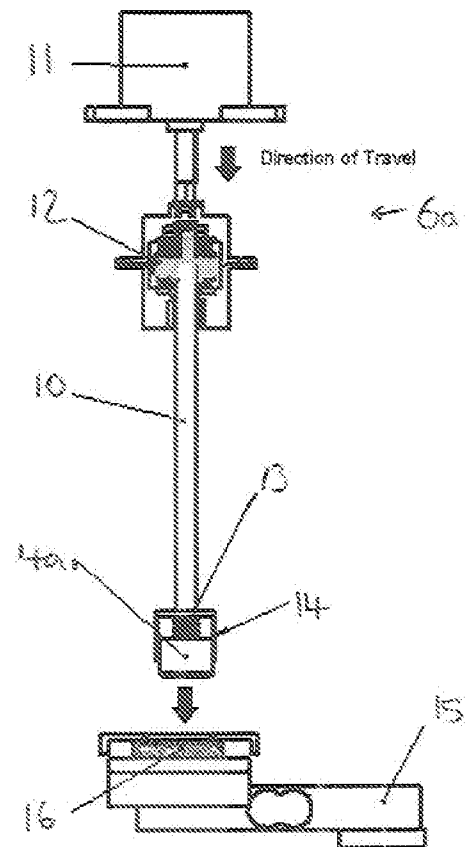


Fig. 2

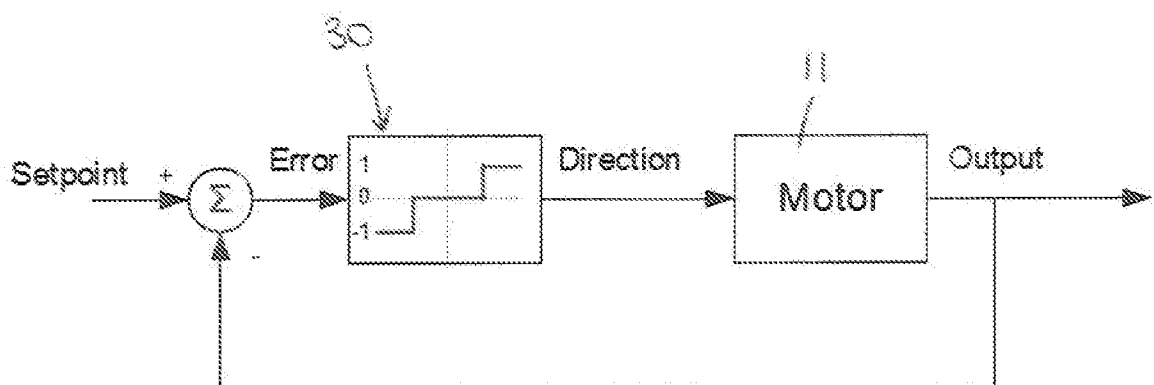


Fig. 3

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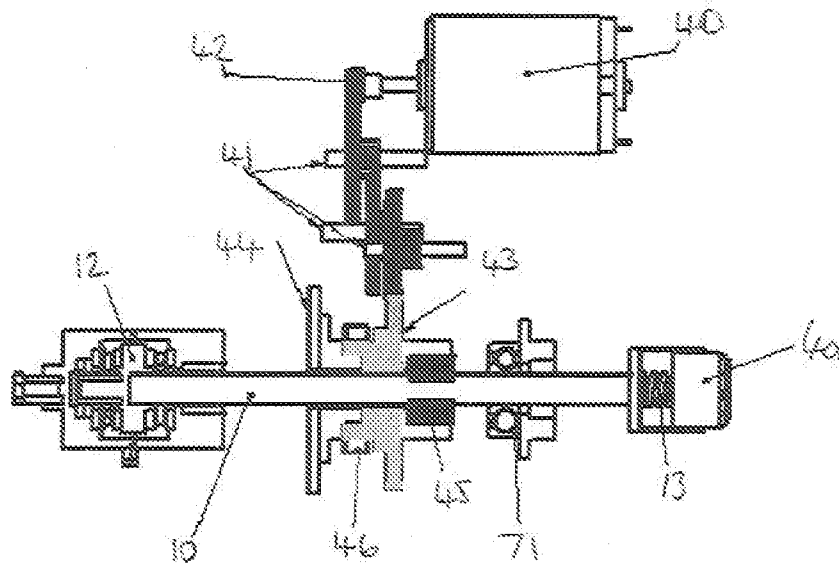


Fig. 4

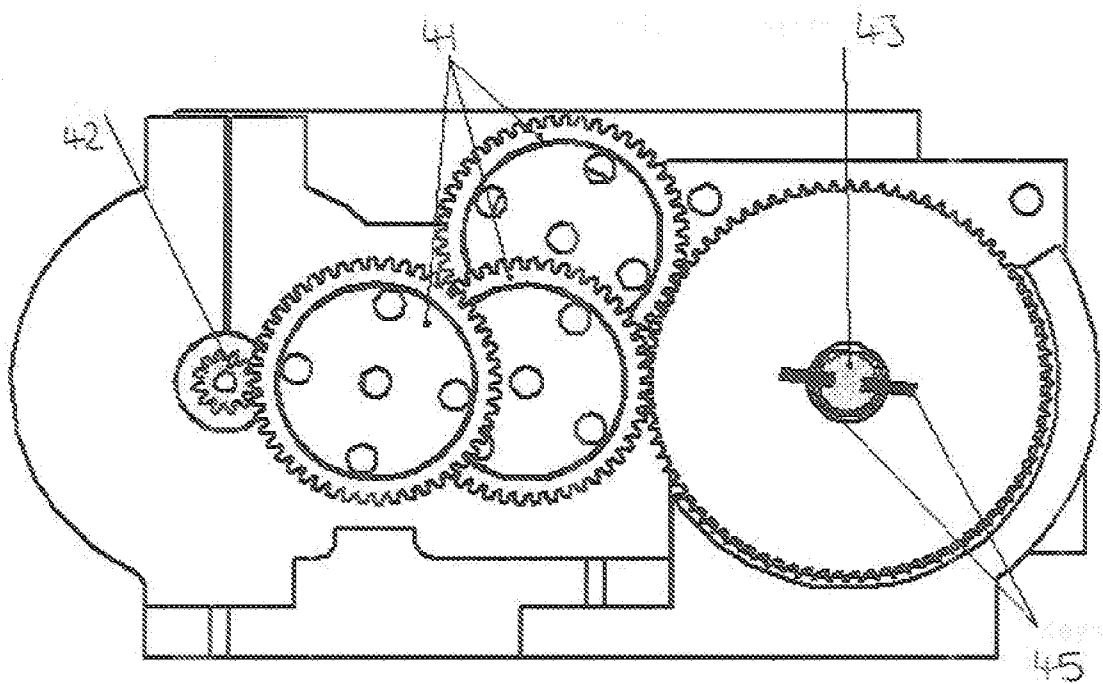


Fig. 5

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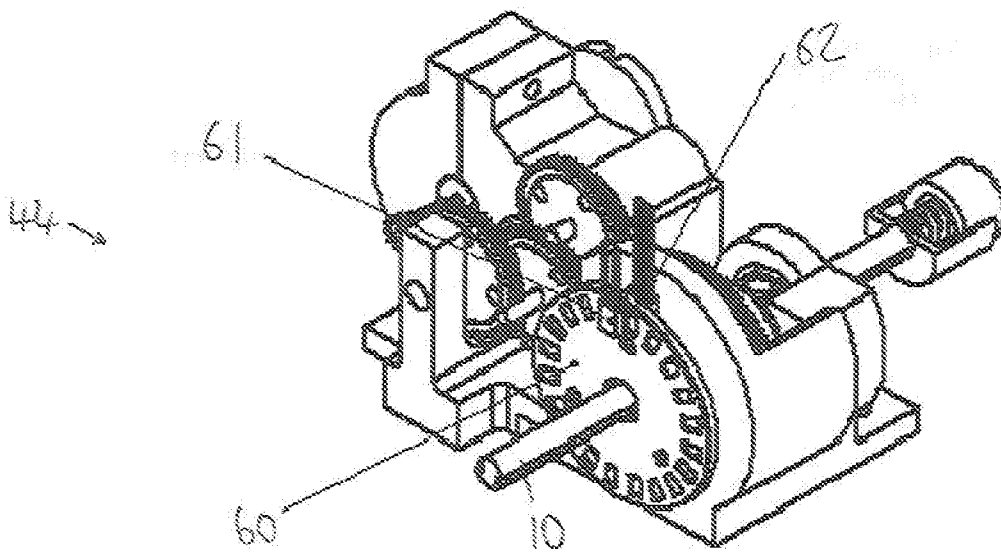


Fig. 6

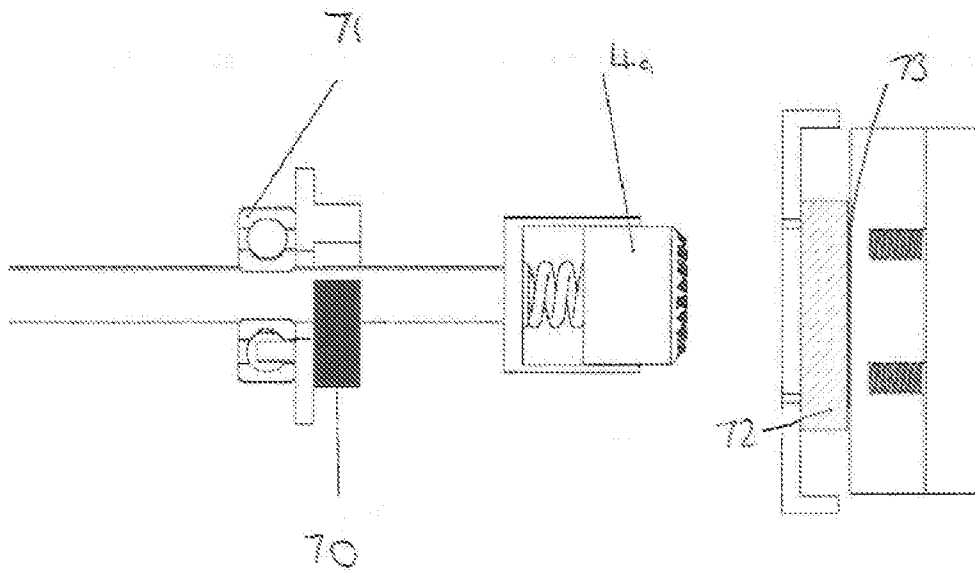


Fig. 7

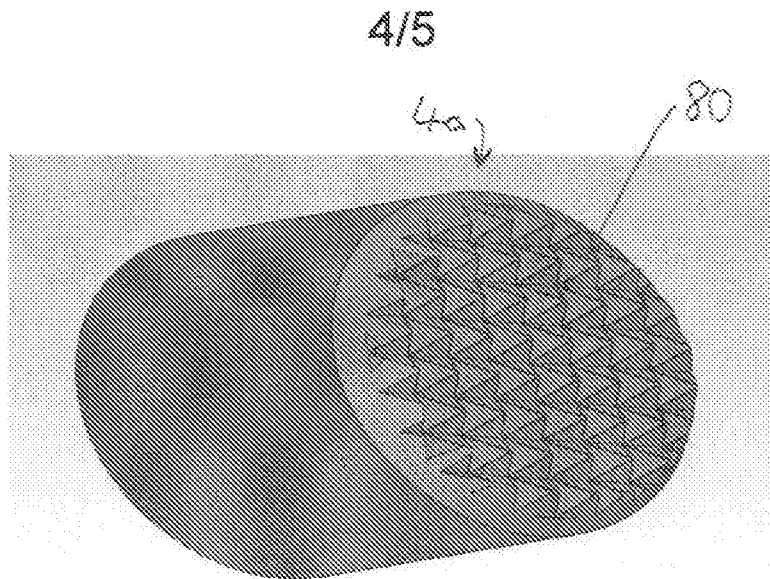


Fig. 8

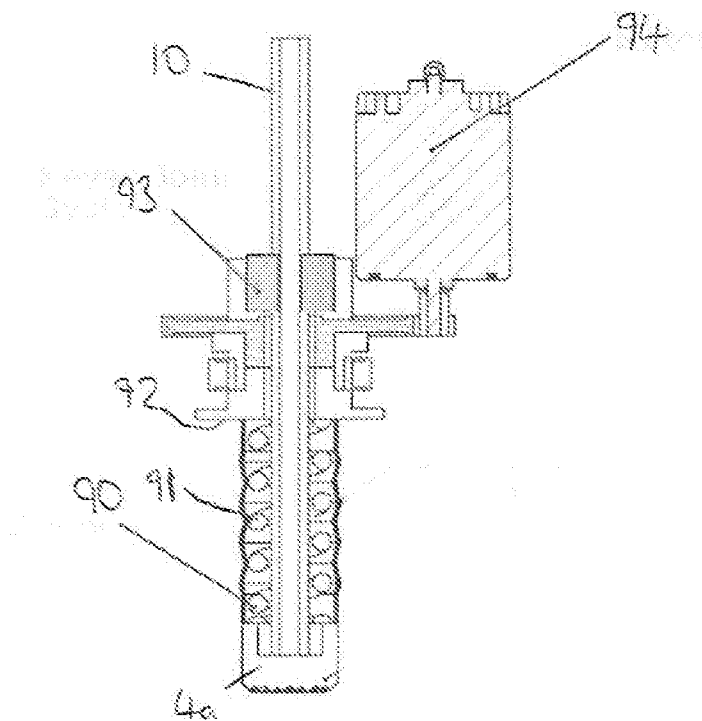


Fig. 9

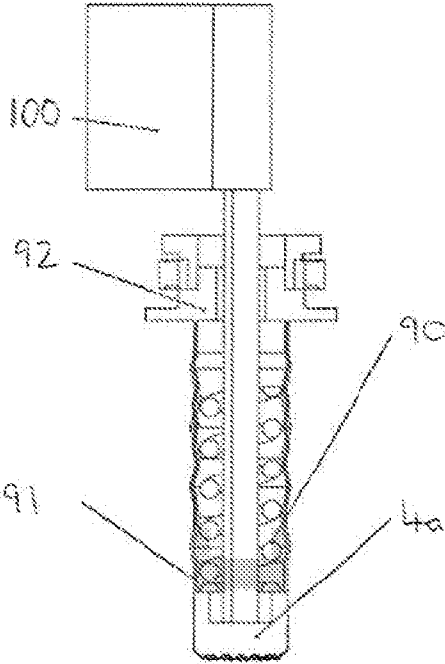


Fig. 10

1100x

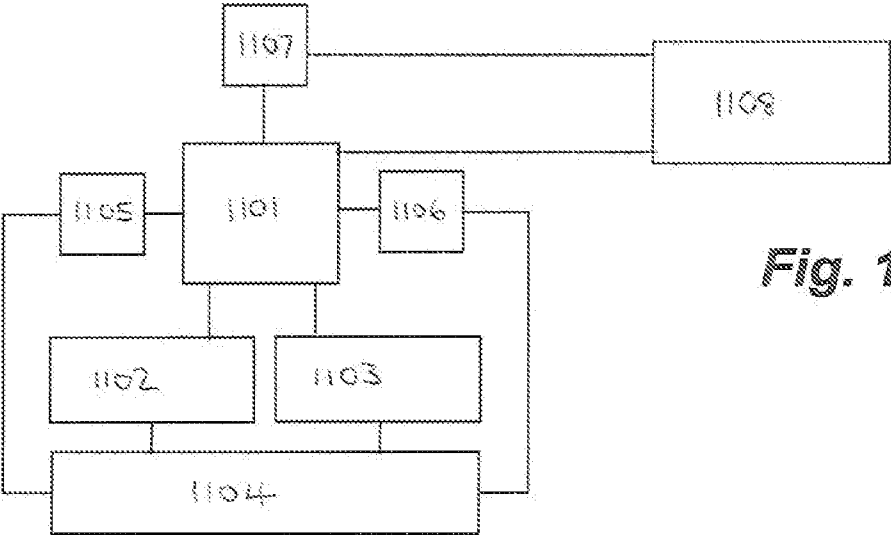


Fig. 11