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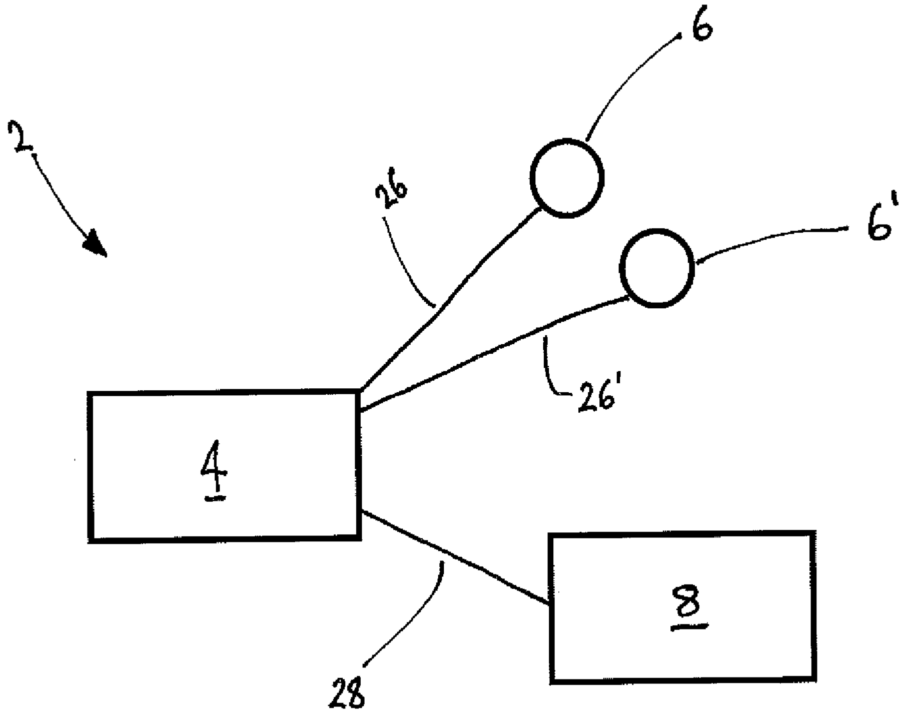

FIGURE 1

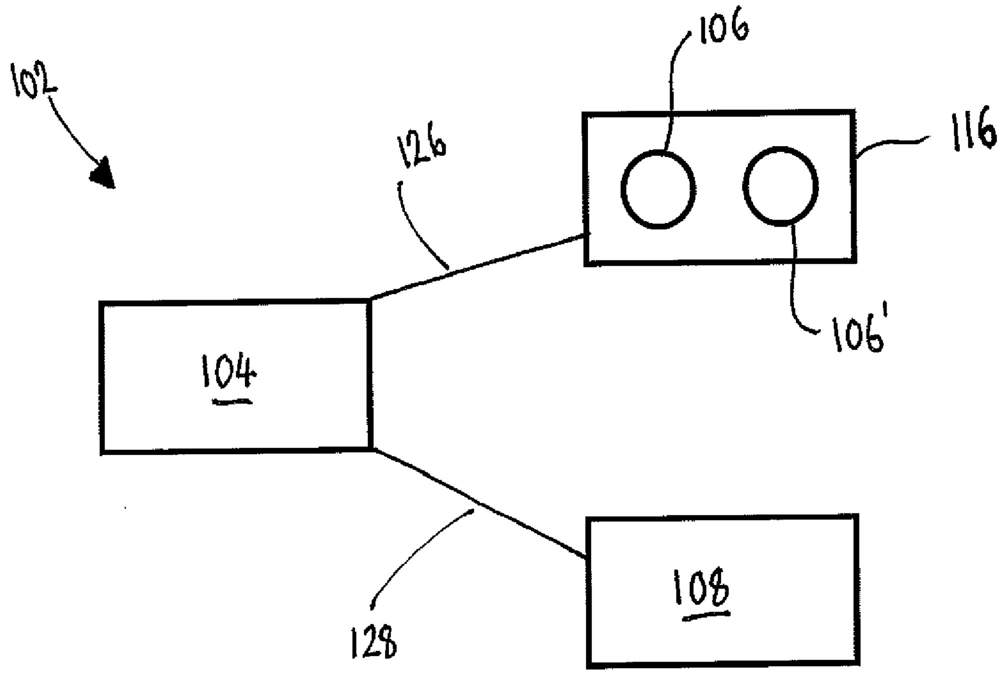

FIGURE 2

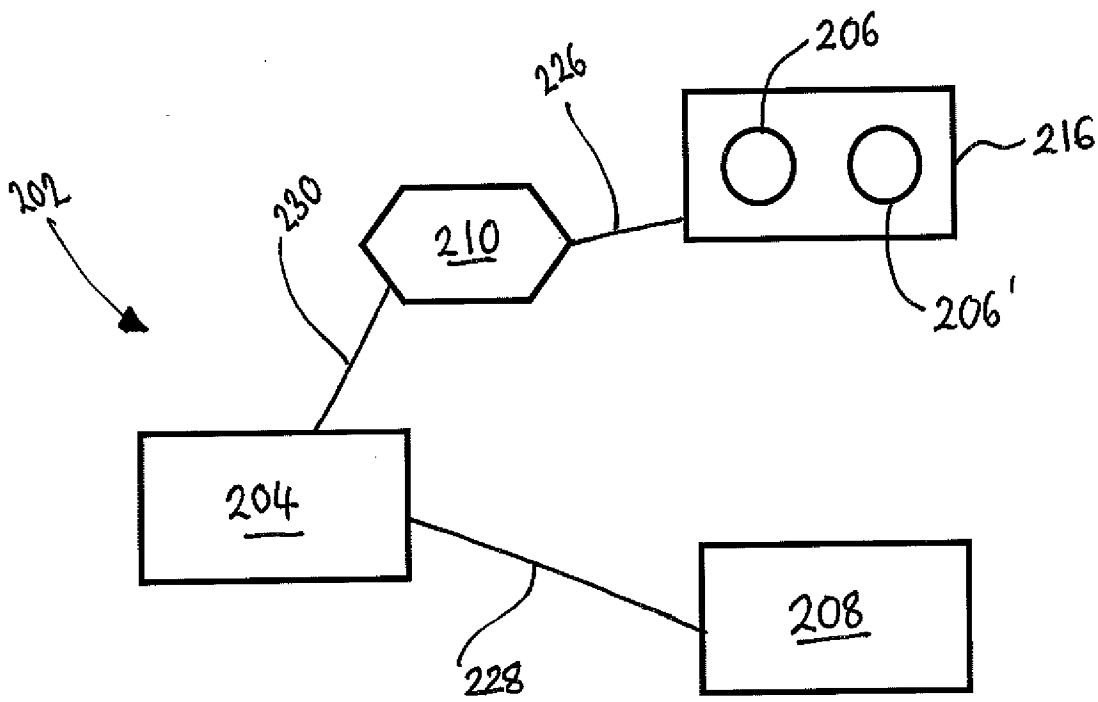

FIGURE 3

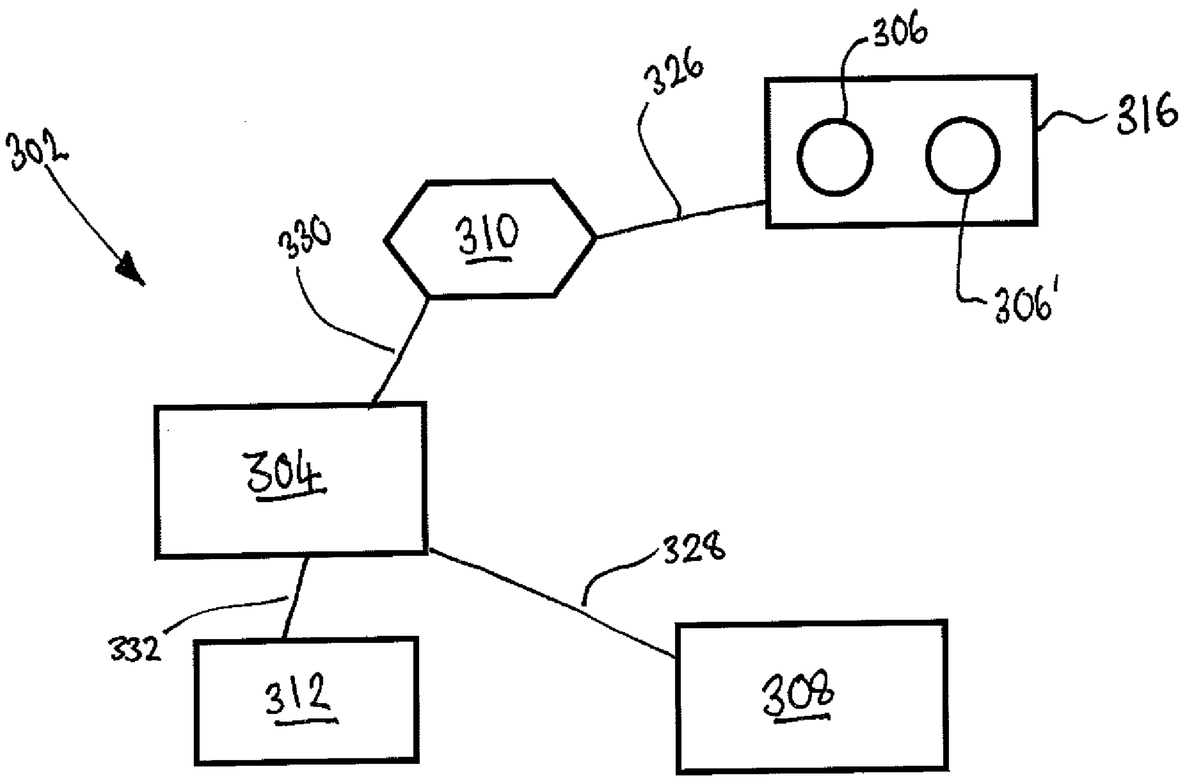

FIGURE 4

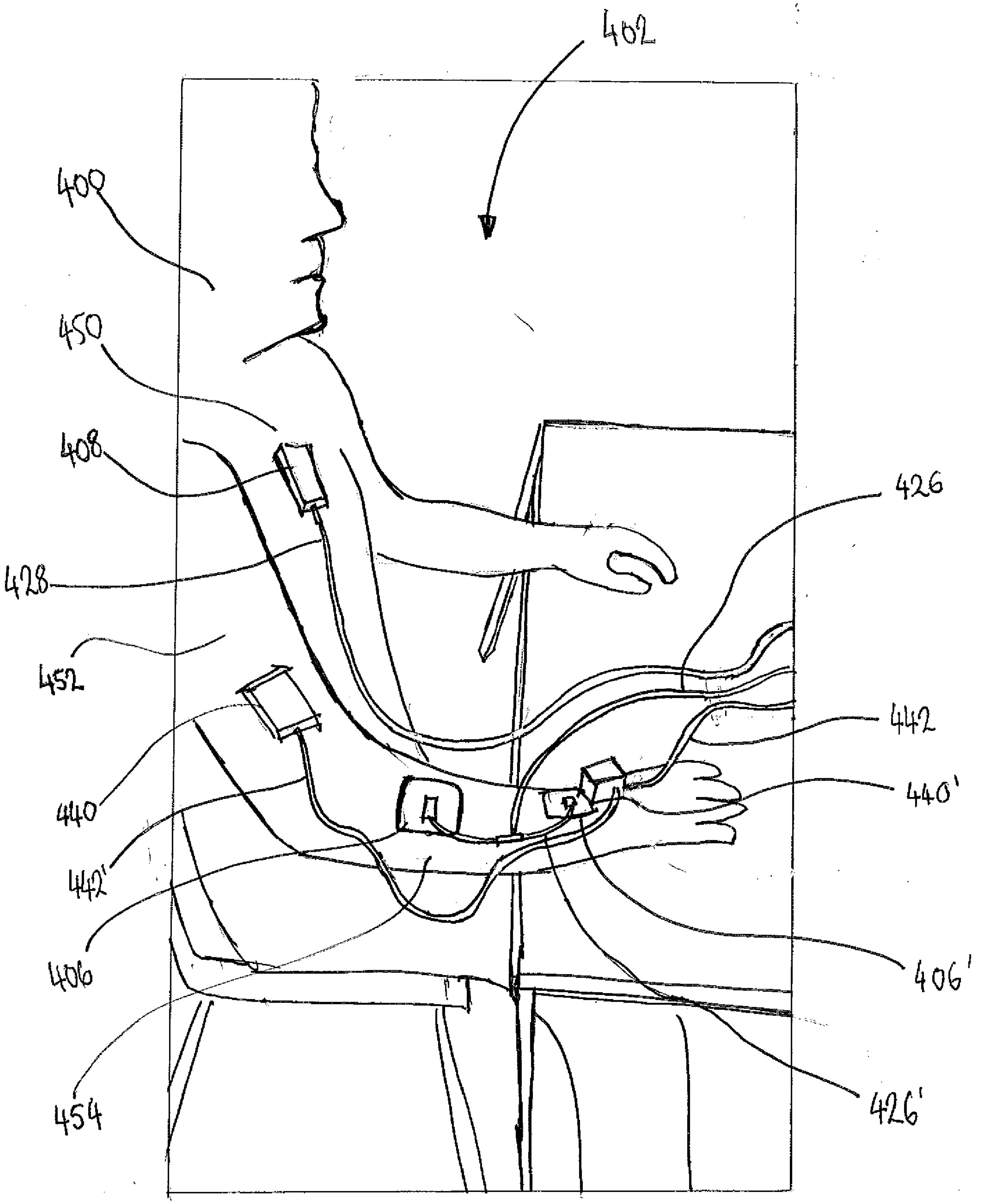

FIGURE 5

A System for Performing Functional Electrical Therapy

Technical Field of the Invention

The present invention relates to improvements in or relating functional electrical therapy.

Background to the Invention

Functional Electrical Therapy (FET) involves suppling an electrical pulse to specific muscles or nerves of a patient with a view to initiating movement of a limb or other body part of a patient . Commonly, FET involves using electrical stimulation of the muscles or nerves in a specific body part of a patient to assist in the practice of functional tasks undertaken in therapy sessions with a view to 're-educate' the movements so that the tasks may be performed without electrical stimulation at a later date. Functional Electrical Stimulation Therapy (FES) is similar to FET in that it involves suppling an electrical pulse to specific muscles or nerves of a patient with a view to initiating movement of a limb or other body part of a patient. The difference between the two is that in FES, the primary purpose is the immediate improvement in a specific functional movement as a direct result of stimulation, whereas FET also has an additional longer term goal of improvement of unassisted and general (not task-specific) functional movement. These types of therapy are particularly used on patients whose nervous system may be damaged resulting in partial or full paralysis of one or more body parts. Further information on FES and FET is described in Popovic, Dejan B. *et al.* "Neurorehabilitation of Upper Extremities in Humans with Sensory Motor Impairment"; Neurorehabilitation, Volume 5, Number 1, 2002, 54-67.

It is known in the art to incorporate into FET one or more motion sensors to monitor the movement of the stimulated body part and hence the effectiveness of the electrical stimulation. In these systems the FET is performed on a body part, such as an arm, and the motion sensor is connected to the same body part to which the FET is being applied. Known systems which incorporate such an idea include those described in WO2012003451A and WO2015044851A. In some known systems the motion data received by the motion sensor/s on the patient may be relayed to a user, enabling the user to adjust the stimulation levels in accordance with the movement observed in the stimulated body part. In further known systems, the motion data received by the motion sensor/s may be relayed to a computer, enabling automatic adaptation of the therapy session in accordance with the movement observed in the stimulated body part.

However, whilst such systems do provide information relating to the effectiveness of the FET on the stimulated body part, they do not provide any means to account for factors which may disguise the true effect of the stimulation, such as movement of other body parts which are independent to the stimulated body part. For example, where the stimulation is provided to a limb of a patient, a lack of movement of the limb may be compensated for by the patient by leaning his/her trunk. Such compensatory movements may significantly impact on the effectiveness of the therapy overall as a patient may continue to use the compensatory movements instead of re-learning the ‘correct’ movements for certain tasks.

It would therefore be advantageous to provide a system for performing FET which accounts for such additional factors and provides a means to monitor movement of unstimulated body parts or, movements of stimulated body parts in a in a direction which is not a result of stimulation, in order to reduce or eliminate compensatory movements by the patient.

It is an aim of an embodiment or embodiments of the present invention to overcome or mitigate at least some of the drawbacks of the prior art.

Summary of the Invention

According to a first aspect of the invention there is provided a system for performing functional electrical therapy comprising: one or more electrodes operable in use to stimulate one or more muscles or nerves associated with a given body part of a patient by supplying an electrical impulse thereto; one or more motion sensors operable to monitor the movement of at least one further part of the patient's body, the at least one further part of the patient's body being independent of the stimulated body part; and a computation unit, operably connected to the one or more motions sensors, for receiving and analysing data obtained from the one or more motion sensors relating to the movement of the at least one further body part of the patient to determine whether the patient is moving the stimulated body part only, through observation by the patient or a user of the system or through monitoring movement of the stimulated body part via one or more motion sensors, or is compensating for lack of movement in the stimulated body part by moving the at least one further, unstimulated part of the body.

In this way, the system of the invention allows for the motion of one or more independent body parts to be monitored each time an electrical stimulation impulse or a series of impulses is supplied (hereinafter referred to as a "stimulation event") to determine whether the overall physical motion observed is due to the movement of the stimulated body part or another, unstimulated part of the patient's body. This is particularly advantageous to assess the effectiveness of each stimulation event. Specific examples where the system of the present invention may be utilised include monitoring the overall motion of a patient when asked to reach for an object at a distance away from them, ensuring that the observed motion is due to the stimulated movement of the patient's arm, rather than the patient leaning towards the object.

Whilst the invention is defined above and hereinafter with reference to its application in Functional Electrical Therapy (FET), it should be understood that the invention may be utilised equally in performing Functional Electrical Stimulation Therapy (FES), the differences between which are described above.

In some embodiments the one or more electrodes of the system may be operable in use to supply an electrical stimulation impulse to one or more muscles or nerves within a limb of a patient, which may be a leg, for example. In such embodiments, the one or more electrodes may be operable to cause movement in a limb of the patient who would otherwise not be able to move the limb sufficiently due to partial or full paralysis of the associated muscles. In presently preferred embodiments the one or more electrodes may be operable in use to supply an electrical stimulation impulse to one or more muscles or nerves within the arm of a patient. In further embodiments the one or more electrodes may be operable in use to supply an electrical stimulation impulse to one or more muscles or nerves within the hand, foot, finger/s or toe/s of a patient.

In some embodiments at least one of the one or more motion sensors may be operable to monitor the movement of a patient's trunk and therefore may be adapted to connect to a user's trunk, such as to a patient's stomach, chest, back, shoulder or neck, for example. In such embodiments, the one or more electrodes may operable to provide an electrical stimulation impulse to the nerve/s and/or muscle/s within a patient's limb.

In such embodiments, the system may be operable in use to monitor the motion of a patient's trunk during a stimulation event. In this way, the system provides a means to determine whether the patient is moving the stimulated limb itself, or the patient leaning his/her trunk to compensate for a lack of movement in the stimulated limb.

In some embodiments at least one of the one or more motion sensors may be operable to monitor the movement of a user's upper arm during a stimulation event. In such embodiments, the one or more electrodes may operable to provide an electrical stimulation impulse to the nerve/s and/or muscle/s within a patient's forearm. In this way, the system may be operable in use to monitor the motion of a patient's upper arm during a stimulation event to determine how the patient's arm is moving about the patient's shoulder joint. For example, the at least one motion sensor may be operable to be used to determine about which axis the patient's arm is moving with respect to the shoulder joint. In such embodiments, movement about one or more axes, e.g. shoulder abduction, may be indicative of compensatory movements by a patient whereas movement about one or more further axes, e.g. shoulder flexion, may be deemed to be 'correct' or 'expected' for the task being performed during a stimulation therapy session.

The system may comprise two or more motion sensors which may be operable in use to monitor the movement of the same further body part. In other embodiments the system may comprise two or more motion sensors operable in use to monitor the movement of both a first further body part and a second further body part, both the first and second further body parts being independent of the body part to which the electrical impulse is provided. For example, in some embodiments the system may be operable in use to monitor both the movement of the trunk of the patient, and also the movement of the upper arm/bicep of the patient. In such embodiments, the system may be operable to provide an electrical stimulation impulse to the forearm of the patient. In this way, the system may be used to determine whether the patient is moving his/her forearm, or whether the patient is compensating for a lack of movement in the his/her forearm by leaning his/her trunk and/or rotating his/her upper arm in a given direction about his/her shoulder joint, said rotation being about a different axis or axes to that expected for the task being performed. In further embodiments the system may comprise three or more motion sensors which may be operable in use to monitor the movement of three or more further body parts of a patient, each of the three or more further body parts being independent of the stimulated body part.

In some embodiments the one or more motion sensors may be operable in use to monitor the movement of the stimulated body part in addition to at least one further body part, the at least one further body part being independent of the stimulated body part. In this way, the system provides a means of monitoring both the direct effect of the electrical stimulation, and also the overall movement of the patient.

In embodiments wherein the system comprises one or more motion sensors which are operable to monitor the movement of the stimulated body part, the one or more sensors may additionally or alternatively be operable to monitor the movement of the stimulated body part prior to any stimulation event taking place. In this way, the system of the invention may be operable to monitor the movement of a body part of a patient without any external stimulation. In further embodiments, the one or more electrodes may be operable in use to provide an electrical impulse upon detection of movement of the stimulated body part by the one or more motion sensors. In this way, the system provides a means to encourage the patient to initiate movement of the body part before any electrical stimulation takes place. In embodiments which additionally comprise one or more motion sensors operable to monitor the movement of one or more independent parts of the patient's body, the system may provide a means to monitor the movement of the independent body parts and only provide an electrical stimulation impulse to the desired body part when, firstly, movement in said body part has been initiated by a patient, and secondly, where no compensatory movements have been detected by the motion sensors positioned on independent body part/s.

In some embodiments the or each motion sensor may be operable in use to monitor linear movement of a body part along a given axis. Additionally or alternatively, the or each motion sensor may be operable in use to monitor rotation movement of a body part about a given axis. In some embodiments at least one of the or each motion sensor may be operable in use to monitor movement of a body part along or about two or more separate axes. For example, in some embodiments the or each motion sensor may be operable to monitor rotational or linear movement of a body part about or along two orthogonal axes. In further exemplary embodiments the or each motion sensor may be operable to monitor rotational movement of the body part about a first axis and linear movement of the same body part about a second axis.

In some embodiments the system may comprise a means for informing the patient, or a therapist providing the FET therapy to the patient, of the results obtained from the one or more motion sensors in "real time", i.e. during or immediately after a stimulation event. In this way, the system is able to provide the patient or therapist with information on the movement of themselves/the patient during each stimulation event. This enables the system to be used to evaluate the FET therapy routine being undertaken using the system and alter the routine if necessary during the therapy session which provides a means of giving real time feedback on the effectiveness of each stimulation event.

The or each electrode of the system may be operable in use to be placed directly onto a patient's skin in close proximity to the muscles and/or nerves to which the electrical impulse is being supplied. In other embodiments the or each electrode of the system may be operable in use to be located internally, underneath a patient's skin. In such embodiments, the or each electrode may be operable to be placed directly onto the muscles and/or nerves to which the electrical impulse is to be supplied.

The one or more motion sensors may comprise any sensor operable in use to determine the direction and/or speed at which the body part to which it is connected, in use, has moved. The one or more motion sensors may, for example, comprise an accelerometer or a gyroscope, which may comprise a rate gyroscope, for example. In embodiments wherein the system comprises more than one motion sensor, there may be provided at least two different types of motion sensor.

In addition to receiving and analysing data obtained from the one or more motion sensors, the computation unit may also be operable to control the operation of the one or more electrodes. For example, the computation unit may be operable in use to control when and to what extent an electrical impulse is supplied to the nerves/muscles of a patient.

The computation unit may be operable to communicate with at least one of the one or more electrodes and/or the one or more motion sensors through a wired connection. In some embodiments the computation unit is operable to communicate with each of the one or more electrodes and/or each of the one or more motion sensors through a wired connection.

In presently preferred embodiments the computation unit may be operable to communicate with at least one of the one or more electrodes and/or the one or more motion sensors through a wireless connection. The wireless connection may comprise an infrared connection, or Bluetooth (RTM) connection, for example. In some embodiments the computation unit is operable to communicate with each of the one or more electrodes and/or each of the one or more motion sensors through a wireless connection.

The computation unit may be operable to communicate with the one or more electrodes either directly or indirectly. In embodiments wherein the computation unit is communicable with the one or more electrodes indirectly, such a communication may be performed via a stimulator. The stimulator may be operable in use to control the operation of the or each electrode to determine when and to what extent each electrical impulse is supplied to the muscle/s and/or nerve/s within a patient. In such embodiments, the stimulator may be operable in use to control the operation of the or each electrode under instruction from the computation unit.

In some embodiments the computation unit may comprise a user interface. In such embodiments the user interface may be operable in use to display information relating to the data obtained from the one or more motion sensors. For example, the user interface may be operable to display or convey information relating to the direction or distance the further body part/s has moved during a stimulation event. In some embodiments the user interface may be operable to display a visual or convey an audible warning/notification when a patient is determined to have moved the at least one further body part during a stimulation event. In some embodiments the user interface may be operable to display to a user instructions relating to a pre-determined FET therapy routine. In some embodiments the pre-determined routine may be interrupted if and when a patient is determined to have moved the at least one further body part during a stimulation event. Additionally or alternatively, the user interface may also be operable to receive input/s from the patient and/or a therapist providing FET therapy relating to the operation of the one or more electrodes, such as to control the extent of the electrical impulse supplied to the patient, for example.

The computation unit may comprise a personal computer or the like. In some embodiments the computation unit may be portable and may comprise a laptop or tablet computer, for example.

In further embodiments the system comprises a control unit. The control unit may be separate from the computation unit. In some embodiments the control unit is operable to receive input/s from the patient and/or a therapist providing FET therapy relating to the operation of the one or more electrodes, such as to control the extent of the electrical impulse supplied to the patient, for example. Providing a separate control unit may enable the remainder of the system to be used independent from the computation unit, if desired.

The one or more electrodes may be contained within a housing. In such embodiments the housing may comprise a means to attach the housing to the body part of the patient which is to be stimulated. In some embodiments the electrode housing may comprise a wearable garment. In embodiments wherein at least one of the one or more electrodes may communicate with the computation unit through a wireless connection, the electrode housing may additionally comprise a wireless transmitter therein to which each of the one or more electrodes are connected. Alternatively, each of the one or more electrodes which may communicate through a wireless connection with the computation unit may comprise an individual wireless transmitter.

The one or more motion sensors may be contained within a housing. In such embodiments the housing may comprise a means to attach the housing to the further body part of the patient whose movement is to be monitored. In some embodiments the motion sensor housing may comprise a wearable garment. In embodiments wherein at least one of the one or more motion sensors may communicate with the computation unit through a wireless connection, the motion sensor housing may additionally comprise a wireless transmitter therein to which each of the one or more motion sensors are connected. Alternatively, each of the one or more motion sensors which may communicate through a wireless connection with the computation unit may comprise an individual wireless transmitter. In embodiments wherein the system may be used to monitor the movement of two or more further body parts during a stimulation event, the system may comprise two separate motion sensor housings, each comprising one or more motion sensors therein.

According to a second aspect of the present invention there is provided a kit forming part of a system for performing functional electrical therapy, the kit comprising: one or more electrodes operable in use to stimulate one or more muscles or nerves associated with a given body part of a patient by supplying an electrical impulse thereto; and one or more motion sensors operable to monitor the movement of at least one further part of the patient's body, the at least one further part of the patient's body being independent of the stimulated body part, wherein each component of the kit is operably connectable via a wired or wireless connection to an independent computation means configured to determine, based on data obtained by the one or more motion sensors relating to the movement of the at least one further body part of the patient, whether the patient is moving the stimulated body part only, through observation by the patient or a user of the system or through monitoring movement of the stimulated body part via one or more motion sensors, or is compensating for lack of movement in the stimulated body part by moving the at least one further, unstimulated part of the body.

The kit of the second aspect of the invention may incorporate any or all of the features of the system of the first aspect of the invention as desired or appropriate.

The independent computation means may be a personal computer of a user, for example. In some embodiments the kit may be connectable to a computation means in the form of a laptop computer, or may be connectable to a tablet computer or smartphone, for example. In use, the operational use of the kit may be controlled using the independent connected computation means. In such embodiments, the kit may additionally comprise a software package or the like which may be downloadable onto the computation means enabling the independent computation means to control the operation of the components of the kit, in use.

In further embodiments the kit comprises a control unit. In some embodiments the control unit is operable to receive input/s from the patient and/or a therapist providing FET therapy relating to the operation of the one or more electrodes, such as to control the extent of the electrical impulse supplied to the patient, for example. In some embodiments the control unit may be connectable to an independent computation means in addition to, or as an alternative to, each further component of the kit. In this way, the operational state of the control unit may be able to be controlled using the independent computation means. Alternatively, the control unit may provide the only means to control the operation of each component of the kit. Providing a separate control unit may enable the kit to be used independent from an independent computation means.

Also described is an example method of performing functional electrical therapy not forming part of the claimed invention, which includes the steps of: supplying an electrical stimulation impulse to one or more muscles or nerves associated with a given body part of a patient; and using one or more motion sensors to monitor the movement of at least one further part of the patient's body, the at least one further part of the patient's body being independent of the stimulated body part.

The example method may comprise supplying an electrical stimulation impulse to one or more muscles or nerves within a limb of a patient, which may be a leg, for example. The method may be utilised to cause movement in a limb of the patient who would otherwise not be able to move the limb sufficiently due to partial or full paralysis of the associated muscles. The electrical stimulation impulse may be supplied to one or more muscles or nerves within the arm of a patient.

The method may comprise monitoring the movement of a patient's trunk using the one or more motion sensors. The body part of the patient associated with the one or more muscles and/or nerves to which the electrical stimulation impulse is supplied may be a patient's limb, and the method may comprise monitoring the motion of a patient's trunk during a stimulation event. In this way, the method provides a means to determine whether the overall observed movement of the patient is due to the movement of the limb itself, or the patient leaning his/her trunk disguising the movement of the limb (or lack thereof).

Where the method comprises the use of more than one motion sensor, each of the plurality of motion sensors may be placed on the same further body part, or in some embodiments one or more motion sensors may be placed on a first further body part and one or more motion sensors may be placed on a second further body part, both the first and second further body parts being independent of the body part to which the electrical impulse is provided. For example, the method may comprise using one or more motion sensors placed on the trunk of the patient, and one or more motion sensors placed on the upper arm/bicep of the patient. In such instances the electrical stimulation impulse may be provided to the forearm of the patient. In this way, the method provides a means to determine whether the overall observed movement of the patient is due to the movement of the forearm of the patient, or the patient leaning his/her trunk and/or his/her upper arm disguising the movement of the forearm (or lack thereof). The method may comprise placing one or more motion sensors of three or more separate further body parts, each of the three or more further body parts being independent of the stimulated body part.

The method may comprise using one or more motion sensors to monitor the movement of the stimulated body part in addition to at least one further body part, the at least one further body part being independent of the stimulated body part. In this way, the method provides a means of monitoring both the direct effect of the electrical stimulation, and also the overall movement of the patient to give a better indication of the effectiveness of the stimulation therapy.

The method may comprise informing the patient, or a therapist providing the FET therapy to the patient, of the results obtained from the one or more motion sensors in “real time”, i.e. during or immediately after a stimulation event. In this way, the patient or therapist is provided with information on the movement of themselves/the patient during each stimulation event so the FET therapy routine may be evaluated and altered if necessary during the therapy session, giving real time feedback on the effectiveness of each stimulation event.

Where the method comprises monitoring the motion of a patient's trunk during stimulation of a patient's limb, the real time feedback from the motion sensors may be used to identify instances where the patient is leaning his/her trunk disguising the movement of the limb. In such instances, the patient may take it upon themselves, or be instructed by a therapist, to then (during subsequent stimulation events) attempt to reduce the amount by which they are leaning. In this way, the method provides a means of encouraging the patient to move the stimulated body part with a view to increasing the effectiveness of the FET therapy. In instances whereby a patient shows no overall movement as they have not moved his/her trunk nor shown any movement of the stimulated limb, the real time feedback may be used to determine whether changes in the FET therapy routine are necessary, such as an increase in the magnitude of the electrical impulse supplied during subsequent stimulation events.

The method may comprise supplying the electrical impulse using one or more electrodes. The or each electrode may be placed directly onto a patient's skin in close proximity to the muscles and/or nerves to which the electrical impulse is being supplied. In other examples the or each electrode may be located internally, underneath a patient's skin, and may be placed directly onto the muscles and/or nerves to which the electrical impulse is to be supplied.

The one or more motion sensors used may comprise any sensor operable in use to determine the direction and/or speed at which the body part to which it is connected, in use, has moved. The one or more motion sensors may, for example, comprise an accelerometer or a gyroscope, which may comprise a rate gyroscope. Where the method comprises using more than one motion sensor, there may be provided at least two different types of motion sensor.

The method may comprise communicating the information generated by each of the one or more motion sensors and/or controlling the operation of the one or more electrodes using a computation unit. In such examples, the method may comprise communicating the information generated by each of the one or more motion sensors and/or controlling the operation of the one or more electrodes over a wired or wireless connection.

<u>Detailed Description of the Invention</u>

In order that the invention may be more clearly understood embodiments thereof will now be described, by way of example only, with reference to the accompanying drawings, of which:

Figure 1 is a schematic overview of a first embodiment of a system of the present invention.

Figure 2 is a schematic overview of a second embodiment of a system of the present invention.

Figure 3 is a schematic overview of a third embodiment of a system of the present invention.

Figure 4 is a schematic overview of a fourth embodiment of a system of the present invention.

Figure 5 is a perspective view of a patient illustrating the operational use of a system in accordance with the present invention.

Figures 1 to 5 illustrate a number of embodiments of a system of the present invention for performing FET therapy, each of which will be described hereinbelow. Where different embodiments comprise substantially the same components as other illustrated embodiments, like reference numerals are used.

The system 2 illustrated in Figure 1 comprises a computation unit in the form of computer 4, electrodes 6, 6` for supplying an electrical impulse, and a motion sensor 8, which may be an accelerometer or a gyrometer, for example. Each electrode 6, 6` is connected to the computer 4 through respective connections 26, 26`. Connections 26, 26` may be wired connections or may be wireless. Similarly, motion sensor 8 is connected to the computer 4 through connection 28, which again may be wired or wireless. In instances where connections 26, 26`, 28 are wireless, the respective component of the system 2 may additionally comprise a wireless transmitter or the like enabling data to be transferred over the wireless connection to the computer 4.

Figure 1 illustrates the electrodes 6, 6` being connected directly to the computer 4 which includes a stimulator. However, it should be understood that computer 4 may communicate indirectly with electrodes 6, 6` (as is described below with reference to Figures 3 and 4) via an intermediary component, which may be an external stimulator or the like which controls the operation of the electrodes 6, 6` under instruction from the computer 4.

The system 2 illustrated in Figure 1 is used to perform FET therapy on a patient. In use, the electrodes 6, 6` are placed either upon the skin of a patient, or in some cases may be placed under the skin of a patient, and positioned with a view to encouraging movement of a body part of a patient by supplying an electrical impulse to nerves and/or muscles of a patient within the body part which are in the vicinity of, or in contact with the electrodes 6, 6`. The operational state of the electrodes 6, 6` is controlled by the computer 4. At the same time, the motion sensor 8 is used to monitor the movement of a further body part of the patient, wherein the further body part is independent of the stimulated body part. Information obtained by the motion sensor 8 is transferred via connection 28 to computer 4 where it is collated and analysed.

By monitoring the movement of a further body part which is independent of the stimulated body part, the system provides a means to determine whether the patient is moving the stimulated body part only, or is compensating for a lack of movement in the stimulated body part by moving another, unstimulated part of the body. By obtaining this information, during a therapy session a patient may be encouraged to attempt to reduce movement of the unstimulated body part and increase movement of the stimulated body part.

In an exemplary use of the system 2 of the invention, the system 2 may be used whilst a patient is performing a conventional "coin brush" task, as is described below. In this task, a patient may be required to reach for and subsequently drag a coin or coins across a surface. In such instances, the electrodes 6, 6` are commonly placed onto the arm of a patient to stimulate muscles and/or nerves within the arm of a patient to cause movement of the arm initially towards the coin/s and subsequently in a given direction. The impulse or impulses may be provided, for example, to the triceps and/or forearm extensors of the patient's arm. The system 2 of the present invention additionally utilises a motion sensor 8 which would be placed for example on the trunk of the patient operable to monitor the movement of the patient's trunk whilst performing the task. In this way, the extent to which a patient leans to reach for the coin/s may be determined. By monitoring the extent to which the patient is leaning, this may be used to provide real time feedback to the patient to discourage them from leaning, and thereby encouraging them to maintain an upright posture and use their arm to reach for the coin/s, rather than compensating for lack of movement from their arm by leaning forward to reach for the coin/s.

Figure 1 illustrates an embodiment of the system 2 wherein the electrodes 6, 6` are independent of each other and may be placed at different points on a patient's body. However, it is common to group electrodes 6, 6` to target a certain area on a patient's body as an increased number of electrodes provides greater control over the electrical impulse supplied to a given body part. Therefore, as illustrated in Figure 2, the electrodes 106, 106` may be grouped together.

In the illustrated embodiment, the system 102 comprises a housing 116 in which the electrodes 106, 106` are contained. The housing 116 is generally able to be fixed onto a body part of a patient, which may be via straps or other connections (not shown), but may comprise a wearable garment which a patient may place over a body part to be stimulated.

The electrodes 106, 106` are electrically connected within the housing 116 and are jointly connected to the computer 104 through connection 126. Again, the connection 126 may be wired or wireless, and in instances where the connection 126 is wireless, the housing 116 itself may include a transmitter connected to each electrode 106, 106` for communicating with the computer 104.

Figure 3 shows a further embodiment of a system 202 for performing FET therapy. The system 202 is substantially the same as system 102 illustrated in Figure 2, however, the system 202 additionally comprises a stimulator 210. The stimulator 210 is operable to control the operation of the electrodes 206, 206` as opposed to the computer 4, 104 controlling the operation of the electrodes 6, 6`, 106, 106` as in the preceding Figures. In use, the stimulator 210 is operable to control the operation of the electrodes 206, 206` under instruction from the computer 204.

The stimulator 210 is connected to an electrode housing 216 which contains electrodes 206, 206` via connection 226, which, as with previously illustrated embodiments may be wired or wireless. The stimulator 210 is further connected via wired or wireless connection 230 to the computer 204. In use, this connection 230 may be used to transmit instructions between the electrodes 206, 206` and the computer 204, with the stimulator 210 providing the electrical signals to the electrodes 206, 206` to initiate stimulation events with the computer 204 instructing the stimulator 210 to provide said electrical signals.

A further embodiment of a system 302 for performing FET therapy is shown in Figure 4. The system 302 is substantially identical to the system 302 illustrated in Figure 3, but additionally comprises a graphical user interface (GUI) 312 which is used to display or convey information to a user of the system 302, who may be the patient but alternatively may be a therapist providing the treatment to the patient. Such information may be displayed visually by the GUI 312, but may additionally or alternatively be conveyed to a user by an audible sound or sounds. For example, where the system 302 detects an unwanted movement of one or more independent (unstimulated) body parts, the GUI 312 may display a warning message or may convey an audible alarm. Preferably, the GUI 312 is operable to display or convey information to the user in real time, i.e. during or shortly after a stimulation event.

The GUI 312 is connected to the computer 304 through connection 332 and is operable to display or communicate any or all of the following.

The GUI 312 may communicate information relating to the data obtained by the motion sensor 308 to a user. For example, where the motion sensor determines that the connected body part has moved during a stimulation event, the GUI 312 may display a warning/alert which states this fact. This may be used to encourage the patient to minimise the movement of the further body part thereby encouraging movement of the stimulated body part.

The GUI 312 may display information relating to the operational state of the electrodes 306, 306` informing a user of when an electrical impulse is being supplied. Additionally or alternatively, the GUI 312 may be used to input instructions relating to the operational state of the electrodes 306, 306` such as controlling when and to what extent the electrical impulse is supplied. This may be used during a therapy session where it may be required to increase or decrease the magnitude of the electrical impulse.

The GUI 312 may display information relating to a task to be completed by the patient during a stimulation event. For example, the GUI 312 may display a series of instructions to the patient.

The embodiments illustrated in Figures 1 to 4 comprise a single motion sensor 8 which is used to determine the movement of a single further body part of the patient. However, it is envisaged that any number of separate motion sensors may be used. For example, there may be provided motion sensors to determine any movement of two or more separate further body parts. In further developments of the system of the invention it is envisaged that one or more motion sensors may be used as in the prior art where the movement of the stimulated body part is measured directly by placing one or more motion sensors on the stimulated body part.

Figure 5 illustrates the operational use of a system 402 in accordance with the invention showing how the components of the system 402 may be positioned on a patient 400, in use. The system 402 is substantially similar to those illustrated in the preceding Figures, and like reference numerals have been used to illustrate like components.

As shown, the system 402 includes a pair of electrodes 406, 406` positioned on a forearm 454 of the patient 400. The electrodes 406, 406` are connected together by wired connected 426` and subsequently with an external component via wired connection 426. The external component may be a computer or stimulator in the same way as described in the preceding Figures. The electrodes 406, 406` are operable in use to supply an electrical stimulation impulse to the muscle/s and/or nerve/s within the forearm 454 of the patient 400. In addition, the system 402 includes a motion sensor 408 located on the chest 450 of the patient 400. In use, the motion sensor 408 may be used to monitor the movement of the patient’s trunk during stimulation events, as is described above with reference to Figure 1. Motion sensor 408 is connected to an external component, which may be a computer or control unit (not shown) via wired connected 428 as discussed above.

The system 402 additionally comprises a pair of secondary motion sensors 440, 440`, with the first secondary motion sensor 440 being located on the upper arm

452 of the patient 400, and the second secondary motion sensor 440` being located on the forearm 454 of the patient 400. In the illustrated embodiment, the secondary motion sensors 440, 440` are connected to one another via wired connection 442` and subsequently to an external component, which may be a computer or control unit (not shown) via wired connected 442 as with motion sensor 408 as is described above.

In use, the second secondary motion sensor 440` may be operable to monitor directly how the forearm 454, i.e. the stimulated body part of the patient 400, moves during a stimulation event. In some embodiments the secondary motion sensor 440` may be operable in use to monitor movement of the stimulated body part before a stimulation event takes place. In this way, the motion sensor 440` may be used to detect instances where the patient is moving the stimulated body part of their own accord. In such instances, the system 402 may be configured that an electrical impulse is only supplied to a patient when movement of the stimulated body part, or in this case the body part to be stimulated, is initiated by the patient 400. In this way, the system 402 provides a means to encourage the patient 400 to use said body part without any external stimulation.

The first secondary motion sensor 440, as with motion sensor 408, monitors movement of an independent (unstimulated) body part during a stimulation event. However, in this case, secondary motion sensor 440 monitors the movement of the patient's upper arm 452 which may be indicative of specific motion of the patient's upper arm 452 about his/her shoulder. For example, motion sensor 440 may be operable to detect the direction of rotation of the patient's upper arm 452 about his/her shoulder. In this way, the system 402 is operable to identify instances wherein the rotation of the patient's upper arm 452 is about a different axis or axes to that/those expected for the task being performed which may be indicative of a compensatory movement by the patient 400.The embodiments illustrated in Figures 1 to 4 comprise a computation unit in the form of a computer 4, 104, 204, 304. Whilst the computer 4, 104, 204, 304 will commonly comprise a personal desktop computer, it should be understood that it may comprise a portable computer which may be a laptop or tablet computer, for example. In this way, the system 2, 102, 202, 302 is entirely portable.

The above embodiments are described by way of example only. Many variations are possible without departing from the scope of the invention as defined in the appended claims.

CLAIMS

1. A system for performing functional electrical therapy comprising: one or more electrodes operable in use to stimulate one or more muscles or nerves associated with a given body part of a patient by supplying an electrical impulse thereto; one or more motion sensors operable to monitor the movement of at least one further part of the patient's body, the at least one further part of the patient's body being independent of the stimulated body part; and a computation unit, operably connected to the one or more motion sensors, for receiving and analysing data obtained from the one or more motion sensors relating to the movement of the at least one further body part of the patient to determine whether the patient is moving the stimulated body part only, through observation by the patient or a user of the system or through monitoring movement of the stimulated body part via one or more motion sensors, or is compensating for lack of movement in the stimulated body part by moving the at least one further, unstimulated part of the body.

2. A system as claimed in claim 1 wherein the one or more electrodes of the system are operable in use to supply an electrical stimulation impulse to one or more muscles or nerves within a limb of a patient.

3. A system as claimed in claim 2 wherein the one or more electrodes are operable in use to supply an electrical stimulation impulse to one or more muscles or nerves within the arm of a patient.

4. A system of any preceding claim wherein the one or more motion sensors are operable to monitor the movement of a patient's trunk.

5. A system as claimed in claim 4 wherein the one or more motion sensors are adapted to connect to a patient's trunk.

6. A system as claimed in claim 1 wherein the one or more motion sensors are operable to monitor the movement of a patient's upper arm.

7. A system as claimed in claim 6 wherein the one or more motion sensors are operable to determine how the patient's arm is moving about the patient's shoulder joint during a stimulation event.

8. A system as claimed in any of claims 1 to 7 comprising two or more motion sensors operable in use to monitor the movement of the same further body part.

9. A system as claimed in any of claims 1 to 7 comprising two or more motion sensors operable in use to monitor the movement of a first further body part and a second further body part, both the first and second further body parts being independent of the body part to which the electrical impulse is provided.

10. A system of any preceding claim wherein the one or more motion sensors are operable in use to monitor the movement of the stimulated body part in addition to at least one further body part, the at least one further body part being independent of the stimulated body part.

11. A system of claim 10 wherein the one or more motion sensors are operable to monitor the movement of the stimulated body part prior to any stimulation event taking place.

12. A system of claim 11 wherein the one or more electrodes are operable in use to provide an electrical impulse upon detection of movement of the stimulated body part by the one or more motion sensors.

13. A system as claimed in any preceding claim wherein the or each motion sensor is operable in use to monitor linear movement of a body part along a given axis and/or rotational movement of a body part about a given axis.

14. A system of claim 13 wherein at least one of the or each motion sensor is operable in use to monitor movement of a body part along or about two or more separate axes.

15. A system as claimed in any preceding claim wherein the one or more motion sensors comprise an accelerometer or a gyroscope.

16. A system as claimed in any preceding claim comprising at least two different types of motion sensor.

17. A system of any one of claims 1 to 16 wherein the computation unit is operable to control the operation of the one or more electrodes.

18. A system as claimed in claim 17 comprising a stimulator operable in use to control the operation of the or each electrode under instruction from the computation unit.

19. A system as claimed in claim 17 or claim 18 wherein the computation unit is operable to communicate with at least one of the one or more electrodes directly, or indirectly via the stimulator, and/or the one or more motion sensors through a wired or wireless connection.

20. A system as claimed in any one of claims 1 to 19 wherein the computation unit comprises a user interface.

21. A system as claimed in claim 20 wherein the user interface is operable in use to display or convey information relating to the data obtained from the one or more motion sensors.

22. A system as claimed in claim 21 wherein the user interface is operable to display or convey a visual or audible warning/notification when a patient is determined to have moved the at least one further body part during a stimulation event.

23. A system as claimed in any of claims 20 to 22 wherein the user interface is operable to display or convey to a user instructions relating to a pre-determined FET therapy routine.

24. A system as claimed in any of claims 20 to 23 wherein the user interface is operable to receive input/s from the patient and/or a therapist providing FET therapy relating to the operation of the one or more electrodes.

25. A system as claimed in any preceding claim comprising a control unit.

26. A system as claimed in claim 25 wherein the control unit is separate from the computation unit.

27. A system as claimed in claim 25 or claim 26 wherein the control unit is operable to receive input/s from the patient and/or a therapist providing FET therapy relating to the operation of the one or more electrodes.

28. A system as claimed in any preceding claim wherein the one or more electrodes may be contained with a housing.

29. A system as claimed in claim 28 wherein the housing comprise a means to attach the housing to the body part of the patient which is to be stimulated.

30. A system as claimed in claim 28 or 29 wherein the electrode housing comprises a wearable garment.

31. A kit forming part of a system for performing functional electrical therapy, the kit comprising: one or more electrodes operable in use to stimulate one or more muscles or nerves associated with a given body part of a patient by supplying

an electrical impulse thereto; and one or more motion sensors operable to monitor the movement of at least one further part of the patient's body, the at least one further part of the patient's body being independent of the stimulated body part, wherein each component of the kit is operably connectable via a wired or wireless connection to an independent computation means configured to determine, based on data obtained by the one or more motion sensors relating to the movement of the at least one further body part of the patient, whether the patient is moving the stimulated body part only, through observation by the patient or a user of the system or through monitoring movement of the stimulated body part via one or more motion sensors, or is compensating for lack of movement in the stimulated body part by moving the at least one further, unstimulated part of the body.

32. A kit as claimed in claim 31 wherein, in use, the operational use of the kit is controllable using the independent connected computation means.

33. A kit as claimed in any one of claims 31 to 32 comprising a control unit.

34. A kit as claimed in claim 33 wherein the control unit is operable to receive input/s from the patient and/or a therapist providing FET therapy relating to the operation of the one or more electrodes.

35. A kit as claimed in claim 33 or 34 wherein the control unit is connectable to an independent computation means in addition to, or as an alternative to, each further component of the kit.