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(54) Stress-at-work evaluating device and method

Verfahren und Vorrichtung zur Bewertung des Arbeitsstresses

Procédé et dispositif d'évaluation du stress au travail

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Description

[0001] The present invention relates to a stress-at-work evaluating device and method, and more particularly to a device for evaluating a stress of a subject at work based on activities of a muscle, which are independent of activities of right and left masseter muscles for opening and closing a jaw of the subject.

[0002] A method using biological information, such as an electromyogram (EMG) or brain wave, is known for a general technique for measuring a mental burden (stress) of a subject. The method using biological information frequently imparts some restriction on a subject in many cases and needs a relatively long recording time to analyze the acquiring data. For this reason, the method cannot be used for evaluating a mental stress of a subject if a subject is not in bed rest (for example, JP 11-19075 A).

[0003] A person frequently suffers from a large mental stress when he/she drives a vehicle (stress at work). A level of the stress and a situation where the person suffers from the stress vary from person to person. In a situation where vehicle ride is uncomfortable or controllability (steering performance) is poor, excessive strain is apt to occur in the person. Such excess strain is likely to hinder a smooth driving, possibly causing an accident.

[0004] In development and design for a vehicle etc., an electromyogram, which is easily measured and high in readiness, is obtained from myoelectric signals indicating activities of the muscles of parts of the human body whose loads are large during driving, such as the arms and the feet, and a mental stress of the subject at driving is directly evaluated.

[0005] When a human being is strained and suffers from a mental stress, an excessive strain as unintentional muscle activity generally appears in the muscle. Accordingly, such a mental stress can be measured by measuring an activity of the muscle.

[0006] Activities of the arms and the feet, which are largely engaged in work such as driving of a vehicle, are measured in the form of an electromyogram (EMG), movement of the muscles at work is measured, and a stress of a human body is judged in conventional cases. However, a method of objectively expressing a mental burden (mental stress) at work on the basis of the EMG has not been found yet.

[0007] In the EMG describing the activities of the muscles at work such as the arm and the foot, a myoelectric signal representing the muscle activities by work such as driving of a vehicle and a myoelectric signal representing the "excessive muscle strain" by the stress are superposed on each other. It is thus difficult to discriminate the muscle activity by driving from the muscle activity by the mental stress.

[0008] The method using biological information other than the EMG often imparts some restriction on a subject and needs a relatively long recording time to analyze the acquiring data. Therefore, it is difficult to correctly reproduce and evaluate a mental stress at work.

[0009] In conventional development and design for a vehicle etc., items relating to the mental burden (mental stress), such as riding comfort and controllability (steering performance), are merely described in terms of driver's drive feeling that is subjectively expressed in words. As a result, it is impossible to objectively judge the mental stress.

[0010] J.A. Healey ("J.A. Healey: "Wearable and Automotive Systems for Affect Recognition from Physiology, Ph. D. dissertation" May 2000 (2000-05), Massachusetts Institute of Technology, XP002318020) relates to systems and algorithms being designed and built to recognize effective patterns in physiological signals acquired from the masseter muscle. Healey discusses experiments conducted for evaluation of new systems and algorithms in three types of settings: a highly constrained laboratory setting, a largely unconstrained ambulatory environment and a less unconstrained automotive environment.

[0011] US patent US4667513 discloses a device for evaluating stress at work, comprising sensors for sensing myoelectric potentials of the right and left muscles of the subject, an external force level judging part, and an evaluating part for calculating normalised contraction intensity by normalising the contraction intensity by the level of the external force.

[0012] The present invention has been made in view of the above, and has an object to provide a stress-at-work evaluating device which particularly objectively judges a mental stress of a driver when he/she engages in work such as driving, by quantitatively measuring the "excessive muscle strain" that is generated in the masseter muscles for opening and closing the jaw of the subject as the result of the stress, and a stress-at-work evaluating method.

[0013] In order to attain the object described above, the present invention provides a stress-at-work evaluating device according to claim 1. In an example, there is described a stress-at-work evaluating device for evaluating a stress of a subject at a work based on measurement of activities of a muscle, which are independent of activities of right and left masseter muscles for opening and closing a jaw of the subject, the stress-at-work evaluating device comprising a sensor for sensing a myoelectric potential of at least one of the right and left masseter muscles, the potential being generated through the activities of the masseter muscle at the work; an amplifier for amplifying the myoelectric potential sensed by the sensor; a myoelectric-potential data processing part for processing time-series data of the amplified myoelectric potential of the masseter muscle, to thereby calculate intensity of the myoelectric potential of the masseter muscle; an external-force level judging part for judging a level of an external force acting on a head of the subject at the work; and an evaluating part for evaluating a level of stress of the subject at the work by using normalized intensity of the myoelectric potential of the masseter muscle by the external force level judged by the external-force level judging part.

[0014] In another example, there is described a stress-at-work evaluating device for evaluating a stress of a subject at a work based on measurement of activities of a muscle, which are independent of activities of the right and left masseter muscles for opening and closing a jaw of the subject, the stress-at-work evaluating device comprising sensors for sensing myoelectric potentials of the right and left masseter muscles, the potentials being generated through the activities of the masseter muscles at the work; an amplifier for amplifying the myoelectric potentials of the right and left masseter muscles sensed by the sensor;a myoelectric-potential data processing part for processing time-series data of the amplified myoelectric potentials of the right and left masseter muscles, to thereby calculate a simultaneous contraction intensity of the right and left masseter muscles from a simultaneous contraction waveform of the right and left masseter muscles generated from; and an evaluating part for evaluating a level of stress of the subject at the work by using the calculated simultaneous contraction intensity.

[0015] In this case, the stress-at-work evaluating device preferably comprises the external-force level judging part for judging a level of an external force acting on the head of the subject at the work, wherein the evaluating part calculates a simultaneous contraction intensity obtained by normalizing the calculated simultaneous contraction by the level of the external force, and evaluates the level of stress of the subject at the work by using the normalized simultaneous contraction intensity.

[0016] Preferably, the external-force level judging part judges the level of the external force acting on the head of the subject by using intensity of a myoelectric potential of a muscle acting for holding a posture of the head.

[0017] Preferably, the work causes a predetermined object to behave by processing the object to allow the resultant behavior to cause the external force acting on the head of the subject, and the external-force level judging part judges the level of the external force acting on the head by using a measured physical quantity representing the behavior of the object caused by the work.

[0018] As the work of the stress-at-work evaluating device of the present invention, steering operation done by the subject is mentioned.

[0019] Preferably, the evaluating part evaluates a level of stress of the subject at the work by comparing the normalized simultaneous contraction intensity with predetermined values.

[0020] Also, the present invention provides a stress-at-work evaluating method for evaluating a stress of a subject at a work based on measurement of activities of a muscle, which are independent of activities of right and left masseter muscles for opening and closing a jaw of the subject, the stress-at-work evaluating method comprising a myoelectric potential measurement step of sensing and amplifying a myoelectric potential of at least one of right and left masseter muscles, the potential being generated through the activities of the masseter muscle at the work; a processing step of processing time-series data of the measured myoelectric potential of the masseter muscle and calculating intensity information on the myoelectric potential of the masseter muscle; a judging step of judging a level of an external force acting on a head of the subject at the work; and an evaluating step of evaluating a level of stress of the subject at the work by using intensity on the myoelectric potential obtained by normalizing the intensity of the myoelectric potential of the masseter muscle by the external force level judged by the external-force level judging part.

[0021] In an example, there is described a stress-at-work evaluating method for evaluating a stress of a subject at an work based on measurement of activities of a muscle, which are independent of activities of right and left masseter muscles for opening and closing a jaw of the subject, the stress-at-work evaluating method comprising a measurement step of sensing and amplifying myoelectric potentials of the right and left masseter muscles, the potentials being generated through the activities of the masseter muscles at work; a processing step of processing time-series data of the amplified myoelectric potentials of the right and left masseter muscles thus measured and calculating a simultaneous contraction intensity of the right and left masseter muscles from a simultaneous contraction waveform of the masseter muscles; and an evaluating step of evaluating a level of stress of the subject at the work by using the simultaneous contraction intensity.

[0022] According to the present invention, the stress of a subject at objective work can be evaluated based on activities of a muscle, which are independent of the activities of the right and left masseter muscles for opening and closing the jaw of the subject, from myoelectric potentials of the masseter muscles when the subject is doing the work.

[0023] Therefore, according to the present invention, a mental stress of a subject at steering operation can be objectively evaluated by quantitatively expressing items appearing as a mental stress, such as riding comfort and controllability (steering performance), in the subject when the subject steers a vehicle.

[0024] This application claims priority on Japanese patent application No. 2003-325043 published as JP 2005087486.

[0025] In the accompanying drawings:

Fig. 1 is a diagram, in block and schematic form, showing a steering stress evaluating device 10, which is an embodiment of the present invention;

Fig. 2 is a diagram for explaining how to attach a sensor unit 12 of the steering stress evaluating device 10 shown in Fig. 1 to a driver;

Figs. 3A and 3B are graphs showing a relationship between an external force laterally applied to the head of a subject and myoelectric potential intensity of the sternocleidomastoids;

Fig. 4 is a diagram, in block and schematic form, showing a steering stress evaluating device 10 of a first embodiment of the present invention;

Fig. 5 is a flow chart for explaining a first embodiment of a method for evaluating a mental stress of a driver at steering, which is performed by using the steering stress evaluating device 10;

Fig. 6 is a diagram, in block and schematic form, showing a steering stress evaluating device 10 of a second embodiment of the present invention;

Fig. 7 is a flow chart for explaining a second embodiment of a method for evaluating a stress of a driver at steering, which is carried out by using the steering stress evaluating device 10;

Fig. 8 is a diagram, in block and schematic form, showing a steering stress evaluating device 10 of a third embodiment of the present invention;

Fig. 9 is a flow chart for explaining a third embodiment of a method for evaluating a mental stress during steering of a vehicle, which is performed by using the steering stress evaluating device 10;

Fig. 10 is a schematic diagram showing a traveling path along which the vehicle runs in stress comparison tests conducted for each vehicle characteristic when a driver steers the vehicle;

Figs. 11A and 11B are graphs showing values of normalized myoelectric potential intensities obtained when a driver D1 steers vehicles having different vehicle characteristics in predetermined subsections;

Figs. 12A and 12B are graphs showing values of normalized myoelectric potential intensitiess obtained when a driver D2 steers vehicles having different vehicle characteristics in predetermined subsections;

Figs. 13A and 13B are graphs showing sensory values of steering stability and response sharpness obtained when the driver D1 steers vehicles having different vehicle characteristics in predetermined subsections; and

Figs. 14A and 14B are graphs showing sensory values of steering stability and response sharpness steering stability obtained when the driver D2 steers vehicles having different vehicle characteristics in the predetermined subsections.

[0026] A preferred stress-at-work evaluating device and a stress-at-work evaluating method, which are believed to be the best modes of the present invention, will be described with reference to the accompanying drawings.

[0027] Fig. 1 is a diagram, in block and schematic form, showing a steering stress evaluating device 10 (referred to as an evaluating device 10) in which a stress-at-work evaluating device of the present invention is applied to steering operation done by a driver as a subject.

[0028] The evaluating device 10 evaluates a mental stress of a driver for driving a vehicle when he/she steers the vehicle. The evaluating device is made up of a sensor unit 12 for detecting a time-series myoelectric potential of one or both of the right and left masseter muscles of the driver, an amplifier 16 for amplifying the myoelectric potential detected by the sensor unit 12, and a processor unit 20 for evaluating the mental stress of the driver when he/she steers the vehicle by using the time-series data of the amplified myoelectric potential of the masseter muscle, and a level of an external force acting on the head of the driver.

[0029] When an external force is applied to the head of a worker (subject) who is doing an objective work, the muscles of the worker contract for supporting his head to hold his posture. The level of the external force corresponds to a level of a force to hold a posture of the worker. The level can be judged by using a myoelectric potential of the head supporting muscle, which is generated at this time.

[0030] In the objective work, for example, a steering operation of a vehicle, an subject operates to cause an object to behave. When this behavior causes an external force to be applied to the head of the worker at the objective work, a level of the external force can be judged by using a physical quantity featuring the behavior of the object (e.g., vehicle) (evaluation for the level of the external force will be described in detail later.).

[0031] The sensor unit 12 contains a sensor for detecting a myoelectric potential of one or both of the right and left masseter muscles of the driver. Fig. 2 is a diagram for explaining how to attach the sensor unit 12 to a driver. The sensor unit 12 includes a couple of electrodes 12a and 12b, which are attached while being spaced away from each other by about 5mm, and an earth electrode 12c for a reference potential. As shown in Fig. 2, the electrodes 12a and 12b are stuck to a skin of an upper part of a masseter muscle X (enclosed by a broken line) of a face F. The earth electrode 12c is stuck to an earlobe. Those sensors 12a, 12b, and 12c may be Ag/AgCl dish-like electrodes, Ag electrodes, or stainless electrodes.

[0032] Before the electrodes of those detecting sensors are stuck onto the skin surface of the driver, each electrode is scrubbed with a suitable means, and cleaned by using alcohol, and then are attached to the skin surface by using electrode paste. In this case, the cleaning operation is continued until electric resistance of each electrode is reduced to 30 kΩ (preferably 5 kΩ). The paired electrodes are attached onto a venter of the muscle such that those electrodes are arranged in parallel with the muscular fiber.

[0033] The electrode 12c is an earth electrode to be attached to an earlobe of the driver, which is an electrically inactive position, in order to hold a potential of the driver constant. Use of the earth electrode ensures an exact measurement carried out by the potential detecting sensors 12a and 12b. In Fig. 2, the sensor unit 12 is stuck so as to measure a myoelectric potential of the right masseter muscle. When a myoelectric potential of the left masseter muscle is measured, the sensor unit is struck as in the right masseter case.

[0034] The earth electrode 12c connected to the amplifier 16 is earthed through the amplifier 16. The amplifier 16 is a known amplifier for amplifying a myoelectric potential detected by the sensor unit 12.

[0035] The masseter muscles are large muscles located on the sides of the face, and the muscles and the temporalis are both called mastication muscles. The masseter muscles act to close the jaw of the subject, for example, to masticate and speak. Accordingly, the masseter muscles do not act during driving work, which is normally done using the muscles of the arms and the feet. When a stress is placed on the subject, the subject unconsciously performs "teeth clenching" as the result of stress generation. Accordingly, the masseter muscles actively act. The evaluating device 10 evaluates a level of mental stress of the driver by measuring a myoelectric potential of the masseter muscle and evaluating a "teeth clenching" intensity of the driver.

[0036] The processor unit 20 contains a myoelectric-potential data processing part 22, an external-force level judging part 24, a normalizing part 26, an evaluating part 28, a CPU 30, a memory 32, and a monitor 34. The myoelectric-potential data processing part 22 processes, as designed, time-series data of the myoelectric potential of the masseter muscle output from the amplifier 16 to thereby generate a waveform (referred to as a myoelectric potential waveform), smoothly shaped, of the myoelectric potential of the masseter muscle. Then, the myoelectric-potential data processing part 22 calculates from the myoelectric potential waveform a myoelectric potential intensity (the myoelectric potential intensity will be described in detail later) as intensity information on the myoelectric potential of the masseter muscle in a predetermined time region. The external-force level judging part 24 evaluates a level of an external force acting on the head of the subject during the objective work, from external force physical quantity data, which is data indicating a level of an external force acting on the head of a worker already separately measured. The normalizing part 26 normalizes the myoelectric potential intensity calculated in the myoelectric-potential data processing part 22 by using the external force level judged by the external-force level judging part 24. The evaluating part 28 evaluates a level of stress at work by using the normalized myoelectric potential intensity. The CPU 30 controls and manages operations of the respective parts. The memory 32 stores data obtained in the respective parts and calculation results. The monitor 34 outputs the processing results output from the related parts and the evaluation results. The external force physical quantity will subsequently be described in detail.

[0037] The processor unit 20 may be realized by a hardware arrangement in which the respective parts of the unit are circuitries so designed as to have related functions, or a software arrangement configured to exercise the functions of the related parts by programs on a computer.

[0038] In a first embodiment of a method of evaluating a mental stress of a driver when he/she steers a vehicle, which will be described later, the myoelectric-potential data processing part 22 samples the time-series data of a myoelectric potential of one of the right and left masseter muscles during the objective work, performs full-wave rectification on the sampled data, smoothes the rectified one to thereby generate a myoelectric potential waveform, and finally calculates a myoelectric potential intensity from this myoelectric potential waveform in a predetermined time region for output.

[0039] The "myoelectric potential intensity in a predetermined time region" means, for example, a root mean square (RMS) (effective value) of the myoelectric potential waveform, and an integrated electromyogram (IEMG) thereof, which are calculated in a predetermined time region.

[0040] In a second embodiment of the stress evaluating method, which will also be described later, the myoelectric-potential data processing part samples the time-series data of myoelectric potentials of both the right and left masseter muscles during the objective work, performs full-wave rectification on both the sampled data, smoothes the rectified ones to thereby generate smooth myoelectric potential waveforms, calculates a simultaneous contraction waveform in a predetermined time region from the myoelectric potential waveforms of those masseter muscles, and finally calculates a simultaneous contraction intensity from the simultaneous contraction waveform.

[0041] The term "simultaneous contraction waveform" is a waveform obtained by calculating a geometric average of the myoelectric potentials of the right and left masseter muscles at the same time point or a waveform generated by selecting a myoelectric potential which is the smaller in value of the myoelectric potentials of the right and left masseter muscles at the same time point.

[0042] The external-force level judging part 24 judges a level of an external force applied to the head of the driver during the driving work.

[0043] The judgment of the external force level will be described below. In a process of judging the external force level, the external-force level judging part performs full-wave rectification on time-series data of an acceleration having a lateral direction with respect to the vehicle (the acceleration will be referred to as a lateral acceleration, and corresponds to an input external force physical quantity (which will be discussed in detail later)). Then, the external-force level judging part smoothes the rectified one to form a smooth waveform (referred to as an external force physical quantity waveform) representing the external force physical quantity (lateral acceleration). The external-force level judging part, thereafter, calculates an external force physical quantity, which is an RMS value (or an integrated value) of the external force physical quantity waveform in a predetermined time region, and sets the external force physical quantity as a level of the external force.

[0044] The lateral acceleration as the external force physical quantity is measured by a sensor and an amplifier (not shown) fixed to a console of the vehicle, and acquired data is input to the external-force level judging part 24.

[0045] If a vehicle moves during driving, or in a state where a driver sits on a seat of the vehicle, a driver's body receives a force from the vehicle through the seat and moves together with the vehicle.

[0046] During driving, the head of the driver is held at substantially fixed position and angle with respect to the driver's body by a plurality of muscles (temporalis, sternocleidomastoids, trapezius and masseter muscles, and the like). When the driver turns the steering wheel to change a behavior of the vehicle, the driver receives an acceleration at his head. At this time, those muscles contract and relax in directions to hold a relative position of the head to the body, that is, the muscles act for holding the posture, so that the head holds its position while resisting an external force.

[0047] The "external force physical quantity" is a physical quantity that enables one to indirectly estimate a level of an external force applied to the head. In this embodiment, for the external force physical quantity, the following quantities may be enumerated: a physical quantity featuring a motion of the vehicle, a physical quantity featuring a motion of the driver's body, a physical quantity featuring a motion of the driver's head, and an activity intensity of the muscles of the driver that act to hold the posture of the head. The acceleration that is lateral with respect to the vehicle is involved in the external force physical quantity.

[0048] Figs. 3A and 3B are graphs showing myoelectric potential intensity (RMS values) of the sternocleidomastoids of a subject wearing a helmet when forces are laterally applied to the helmet for a predetermined time. In other words, Fig. 3A is a graph showing activities of the right and left sternocleidomastoids when a force is applied to the right side of a subject, that is, it is applied to the subject in such a direction as to turn his neck to the right. Fig. 3B is a graph showing activities of the right and left sternocleidomastoids when a force is applied to the left side of a subject, that is, it is applied to the subject in such a direction as to turn his neck to the left.

[0049] As seen from Figs. 3A and 3B, as the external force is larger, the myoelectric potential intensity of the muscle located on the opposite side to the side to which the head is bent, more increases. This fact indicates that the sternocleidomastoid located on the side opposite to the side to which the head is bent contracts so as to stop the bending of the head, that is, the sternocleidomastoid acts to hold the posture of the head while resisting the external force. From this fact, it is confirmed that a myoelectric potential intensity of the sternocleidomastoid, in particular a myoelectric potential intensity of the sternocleidomastoid located on the opposite side as viewed in the direction of the force applied to the head corresponds to the external force acting on the helmet. Therefore, the myoelectric potential intensity is the external force physical quantity. The present invention can describe a magnitude of the external force acting on the head by using the myoelectric potential intensity of the muscles acting to hold the posture of the head.

[0050] In the present invention, the external force physical quantity may be any physical quantity if it enables one to estimate a level of the external force applied to the head. For the external force physical quantity, a yaw angle value of the vehicle and a slip angle value, which feature the vehicle motion are additionally enumerated. A steering torque generated when the steering wheel of the vehicle is turned, and a steering operation load as the product of the steering torque and a steering angular velocity are further enumerated for the external force physical quantity. Time-series data of the myoelectric potentials of the masseter muscles, temporalises, sternocleidomastoids and trapezius, and the like, which are the muscles acting for holding the posture of the head of the driver during driving, are also enumerated.

[0051] A physical quantity representative of a motion of the driver's head, which is obtained by directly measuring a motion of the driver's head by, for example, a motion capture, is also enumerated for the external force physical quantity. There is no special limitation on the external force physical quantity and the judging means for judging the external force level.

[0052] The normalizing part 26 normalizes a myoelectric potential intensity in a predetermined time region that is output from the myoelectric-potential data processing part 22 by, for example, dividing the same by an external force physical quantity intensity in the same time region as that set when the myoelectric potential intensity is calculated, which is output from the external-force level judging part 24, and outputs the normalized myoelectric potential intensity to the evaluating part 28.

[0053] The evaluating part 28 evaluates a level of stress placed on a worker at work by, for example, comparing a value of the normalized myoelectric potential intensity with set values of respective stages previously set for stagewise evaluation on levels of stress of the worker at work.

[0054] The evaluation result thus obtained, together with the myoelectric potential waveforms and the myoelectric potential intensity, is sent to the monitor 34 for display.

[0055] A stress-at-work evaluating method carried out in the thus arranged evaluating device 10 will be described in detail by using a method for evaluating stress levels during steering, which is one form of the stress-at-work evaluating method.

[0056] Fig. 4 is a diagram, in block and schematic form, showing a steering stress evaluating device 10 of a first embodiment of the present invention. Fig. 5 is a flow chart for explaining a first embodiment of a method for evaluating a stress of a driver at steering, which is carried out by using the steering stress evaluating device 10.

[0057] In the first embodiment of the stress-at-steering evaluating method, time-series myoelectric potential data of the right and left masseter muscles of the driving during steering are acquired by measurement, and a myoelectric potential intensity in a predetermined time region when the vehicle runs is obtained. Also in the evaluating method, time-series lateral acceleration of the vehicle as the external force physical quantity is measured, and an external force physical quantity intensity in a predetermined time region when the vehicle runs is obtained. The first embodiment of the stress-at-steering stress evaluating method normalizes a myoelectric potential intensity in the predetermined time region by dividing the same by the external force physical quantity in the predetermined time region, and evaluates a stress of the driver when he/she steers the vehicle.

[0058] In the first embodiment of the stress-at-work evaluating method described above, as shown in Figs. 4 and 5, the sensor unit 12 is stuck to a driver as a subject as shown in Figs. 1 and 2, the driver starts to drive and steers the vehicle, and a myoelectric potential of one of the right and left masseter muscles of the driver is constantly measured (step S100).

[0059] In the myoelectric potential measurement, the sensor unit 12 acquires a myoelectric potential of the masseter muscle at steering, and amplifies it by the amplifier 16, and time-series data of the myoelectric potential is output to the myoelectric-potential data processing part 22 of the processor unit 20.

[0060] The myoelectric-potential data processing part 22 rectifies and smoothes the time-series data of the myoelectric potential of the masseter muscle that is obtained to thereby generate a myoelectric potential waveform. Then, the myoelectric-potential data processing part calculates a myoelectric potential intensity in a predetermined time region corresponding to a predetermined running section, from the myoelectric potential waveform (step S102).

[0061] Specifically, the time-series data of the myoelectric potential of the masseter muscle that is measured by the sensor unit 12 and amplified by the amplifier 16, is rectified to form a signal waveform whose values are all equal to or higher than 0, and the signal waveform is smoothed by a filtering process of a low-pass filter to provide a smooth myoelectric potential waveform containing a little noise. The myoelectric-potential data processing part 22, thereafter, calculates an RMS value (effective value), as a myoelectric potential intensity, of a myoelectric potential waveform in a given time region corresponding to a running section, from the myoelectric potential waveform.

[0062] During driving, time-series data of a lateral acceleration as the external force physical quantity is measured (step S104).

[0063] The lateral acceleration of the vehicle is measured by an acceleration pickup attached to a console of the vehicle, and recorded by a recorder mounted on the vehicle, such as data logger.

[0064] To measure a myoelectric potential of the muscle used for holding the posture of the driver, the sensor unit 12 and the amplifier 16 shown in Fig. 2, which are used when the myoelectric potential of the masseter muscle are measured, are used. Then the electrodes 12a and 12b of the sensor unit 12 are stuck to a surface of a skin covering the muscle to be measured, and a myoelectric potential is measured and recorded by a recorder mounted on the vehicle, such as a logger.

[0065] Then, the time-series data of the measured external force physical quantity is supplied to the external-force level judging part 24 of the evaluating device 10, and a level of an external force is measured in the external-force level judging part 24.

[0066] Specifically, the time-series data of the lateral acceleration as the measured external force physical quantity, like the time-series data of the myoelectric potential already stated, is rectified and smoothed to generate an external force physical quantity waveform. An RMS value (effective value), serving as the external force physical quantity intensity, of the external force physical quantity waveform in a predetermined time region is calculated, and the resultant is set as an external force level (step S106).

[0067] Next, the normalizing part 26 normalizes the myoelectric potential intensity in the predetermined time region which is obtained in step S102 by using the external force physical quantity intensity (external force level) in the predetermined region which is obtained in step S106, and the normalized myoelectric potential intensity is output to the evaluating part 28 (step S108). The evaluating part 28 compares the normalized myoelectric potential intensity with set values of respective stages previously set for stagewise evaluation on levels of stress of the driver at steering to thereby evaluate a level of stress of the driver at steering, and the evaluation result is sent to the monitor 34 (step S110).

[0068] The first embodiment of the stress-at-steering evaluating method according to the present invention is as described above.

[0069] The masseter muscles of the driver act also to hold the posture of the driver against an external force acting on the driver's head. Accordingly, myoelectric potentials of the masseter muscles measured contain the myoelectric potential resulting from the activity of the muscles for holding the posture. In the first embodiment of the present invention, the myoelectric potential intensity normalized by the external force level (external force physical quantity intensity) is used. Therefore, the myoelectric potential intensity of the masseter muscle, which is generated as the result of the "teeth clenching" due to the stress, can be evaluated under less influence of the activities of the masseter muscles in holding the posture.

[0070] During the "teeth clenching" due to the stress, the right and left masseter muscles concurrently act. Therefore, when a stress is placed on the driver, the myoelectric potentials of both masseter muscles increase. In the activities of the masseter muscles for holding the posture, the right and left masseter muscles independently act. Accordingly, only the myoelectric potential of one of the right and left masseter muscles increases as illustrated by the sternocleidomastoid in Figs. 3A and 3B. For this reason, the myoelectric potential intensity of the masseter muscle, which is generated as the result of the "teeth clenching" due to the stress, can be evaluated under less influence of the activities of the masseter muscles in holding the posture.

[0071] A second embodiment of a method for evaluating a stress of a driver during driving will be described. Fig. 6 is a diagram, in block and schematic form, showing a steering stress evaluating device 10 of the second embodiment of the present invention. Fig. 7 is a flow chart for explaining a second embodiment of a method for evaluating a stress of a driver at steering, which is carried out by using the steering stress evaluating device 10. In the second embodiment of the stress-at-steering evaluating method, time-series data of the myoelectric potentials of the right and left masseter muscles of the driver as he/she steers the vehicle are measured, and a simultaneous contraction intensity in a predetermined time region at steering is obtained, and a stress placed on the driver at steering is evaluated by using the simultaneous contraction intensity.

[0072] In the second embodiment of the stress-at-steering evaluating method, as shown in Figs. 6 and 7, as in the first embodiment, the sensor unit 12 is attached to the driver as a subject. In this state, the driver starts driving and steering of a vehicle, a myoelectric potential of one of the right and left masseter muscles of the driver is constantly measured, and time-series data of the myoelectric potential of the masseter muscle when the driver steers the vehicle is acquired by the sensor units 12 (step S200).

[0073] In this myoelectric potential measurement, the sensor unit 12 acquires a myoelectric potential of the right and left masseter muscles generated when the driver steers the vehicle, the amplifier 16 amplifies the myoelectric potential, and time-series data of the myoelectric potentials of the right and left masseter muscles are output to the myoelectric-potential data processing part 22 of the processor unit 20.

[0074] The myoelectric-potential data processing part 22 rectifies and smoothes the time-series data of the myoelectric potentials of the right and left masseter muscles to generate myoelectric potential waveforms. The myoelectric-potential data processing part 22 then calculates from the myoelectric potential waveforms a geometric average of the myoelectric potentials of the right and left masseter muscles at the same time point to generate a simultaneous contraction waveform, and calculates a simultaneous contraction intensity as an RMS value of the simultaneous contraction waveform at a fixed time interval. (step S202).

[0075] In the present invention, the simultaneous contraction intensity in a predetermined time region may be calculated in such a manner that, by using a waveform, which is generated by selecting the smaller of the two values of the myoelectric potentials of the right and left masseter muscles at the same time point, for the simultaneous contraction waveform, an RMS value of the simultaneous contraction waveform generated is calculated. A specific example of the method of generating the simultaneous contraction waveform and calculating the simultaneous contraction intensity is described in Japanese Patent Application No. 2002-212683, filed by the applicant of the present patent application. In this patent application, a synchronous contraction waveform (simultaneous contraction waveform) based on the right and left deltoid muscles of a subject is generated, and a comfort at work felt by worker is evaluated based on intensity information (simultaneous contraction intensity) of the synchronous contraction waveform calculated from the same waveform. Also in the present invention, the myoelectric potentials of the masseter muscles may be processed in a manner similar to the processing of the myoelectric potentials of the deltoid muscles in the invention of the above patent application.

[0076] In the second embodiment, the calculated simultaneous contraction intensity is output to the evaluating part 28 without undergoing any processing in the normalizing part 26. In the evaluating part, it is compared with set values of respective stages previously set for stagewise evaluation on levels of stress of the driver at steering to thereby evaluate a level of stress of the driver at steering (step S204).

[0077] The second embodiment of the present invention can evaluate intensities of myoelectric potentials generated when both the right and left masseter muscles simultaneously act as the result of the "teeth clenching" of the driver, by using the simultaneous contraction intensity. Therefore, it is possible to evaluate a stress of the driver at work under less influence of the activities of the muscles for holding the posture, without normalizing the external force acting on the head by the external force level, as in the first embodiment.

[0078] However, the intensity information on the myoelectric potentials generated when the right and left muscles independently act are not perfectly removed from the simultaneous contraction intensity. Accordingly, to more accurately obtain the myoelectric potential intensity caused by the "teeth clenching" resulting from the stress, it is preferable to normalize the simultaneous contraction intensity by the external force level.

[0079] A stress of the subject can be evaluated more accurately by normalizing the simultaneous contraction intensity by a level of the external force acting on the head. A stress-at-steering evaluating method based on such a technique will be described as a third embodiment of the present invention. Such a stress evaluating method according to the third embodiment will be described hereunder.

[0080] Fig. 8 is a diagram, in block and schematic form, showing a steering stress evaluating device 10 of the third embodiment of the present invention. Fig. 9 is a flow chart for explaining the third embodiment of a method for evaluating a mental stress during steering of a vehicle, which is performed by using the evaluating device 10.

[0081] First, a driver drives a vehicle, as in step S200 in the second embodiment. Time-series myoelectric potential data of the right and left masseter muscles of a driver who is driving the vehicle are measured (step S300). As in step S202 in the second embodiment, a simultaneous contraction intensity of the right and left masseter muscles is calculated from the time-series myoelectric potential data of the right and left masseter muscles (step S302).

[0082] During driving, time-series data of an external force physical quantity is measured (step S304) in the same manner as in step S104 of the first embodiment, and a level of an external force is set based on the time-series data (step S306) as in step S106 of the first embodiment. Subsequently, in the normalizing part 26, the simultaneous contraction intensity calculated in step S302 is divided by the external force level set in step S306 to be normalized (step S308). A stress of the driver at work is evaluated by using the normalized simultaneous contraction intensity (step S310) as in step S204 of the second embodiment. In this way, the influence of the external force when the subject is doing work is further removed, and in this condition, myoelectric potentials of the masseter muscle of the subject caused by the stress can be evaluated. Hence, the stress of the subject can be evaluated more precisely.

[0083] The data processing method in each of the first, second, and third embodiments of the invention may be modified as follows. A first normalizing process is carried out as follows. In the process, waveforms obtained by rectifying time-series data of the measured myoelectric potentials are normalized by using a maximum myoelectric potential that is previously measured and retained by recording to thereby compute indices. A normalized myoelectric potential waveform obtained by the first normalizing process is generated. A stress of the subject is evaluated using the normalized myoelectric potential waveform as a myoelectric potential waveform.

[0084] The influence of electric resistance of the electrodes 12a and 12b, which varies every time the sensor unit 12 is stuck to the subject, is lessened by normalizing the time-series data of the myoelectric potential by using the maximum myoelectric potential (first normalizing process). When the electrodes 12a and 12b are stuck plural times, to evaluate the stress of the subject more precisely, it is preferable to use the normalized myoelectric potential waveform as the myoelectric potential waveform.

[0085] In the first, second, and third embodiments of the invention, a myoelectric potential intensity or a simultaneous contraction intensity in a predetermined time region is calculated from time-series myoelectric potential data of one or both of the right and left masseter muscles.

[0086] In the present invention, a myoelectric potential intensity or a simultaneous contraction intensity may be calculated in a time region obtained by removing, from a given time region, a time region where the subject does desired work involving the masseter muscles independently of the objective work, such as mastication or conversation, by recognizing the desired work involving the masseter muscles independently of the objective work from motion picture data that is obtained by photographing the desired work involving the masseter muscles independently of the objective work or voice data recording the conversation during the work.

[0087] In a case where, in the myoelectric potential measurement, the subject may do desired work involving the masseter muscles independently of the objective work, such as mastication or conversation, a stress placed on the subject during the objective work can be highly precisely evaluated by calculating a myoelectric potential intensity or a simultaneous contraction intensity in a time region which excludes a time region where the subject does desired work involving the masseter muscles independently of the objective work such as mastication or conversation. [Example]

[0088] Comparison tests were conducted by using the steering stress evaluating device 10 according to the present invention. In the tests, stress evaluations were performed as follows. The stress-at-driving evaluating method of the first embodiment of the present invention was used for the evaluation. Vehicles having different vehicle characteristics were used. Stress of a driver was measured for each vehicle characteristic when he/she steers the vehicles. The test results will be presented below.

[0089] Fig. 10 schematically illustrates a vehicle traveling path in this example. To evaluate the stress, in this example, a lane change section was divided into four subsections of approaching (I_1), steering-start (I_2), turning (I_3), and corrective steering (I_4). Each driver as a subject was instructed to drive the vehicle along the traveling path at constant speed.

[0090] Five vehicles S1 to S5 having different vehicle characteristics were used. Differences in the kind of tires mounted and in the combination of the kind of tires that were mounted on the front wheels and the rear wheels accounted for the difference in the vehicle characteristics.

[0091] In this example, two drivers D1 and D2 each drove the five vehicles having different specifications five times along the traveling path shown in Fig. 10. Time-series myoelectric potential data of the masseter muscles and time-series data of lateral acceleration as external force physical quantity data were measured for each vehicle running. A myoelectric potential intensity and an external force physical quantity intensity were calculated from the time-series myoelectric potential data and time-series data of lateral acceleration, which were obtained by the measurement, and were normalized by dividing the myoelectric potential intensity by the external force physical quantity intensity.

[0092] Figs. 11A and 11A are graphs showing values of normalized myoelectric potential intensities obtained when the driver D1 steers the vehicles having vehicle characteristics defined by specifications S1 to S5 in the subsections I_2 and I_3. The graph of Fig. 11A and the graph of Fig. 11B show the values of the normalized myoelectric potential intensities for the subsection I_2 and the subsection I_3, respectively.

[0093] Figs. 12A and 12B are graphs showing values of normalized myoelectric potential intensities obtained when a driver D2 steers vehicles having vehicle characteristics defined by specifications S1 to S5 in the subsections I_2 and I_3, respectively. The graph of Fig. 12A and the graph of Fig. 12B show the values of the normalized myoelectric potential intensities for the subsection I_2 and the subsection I_3, respectively.

[0094] In the subsections I_2 and I_3, the driver steers the steering wheel to actively change an advancing direction of the vehicle. In those subsections, the steering operation is difficult and a stress of the driver is large as compared with those in the subsections I_1 and I_4 where the vehicle travels straight ahead.

[0095] As seen from Figs. 11A and 11B and 12A and 12B, the normalized myoelectric potential intensity values obtained when the driver steers the vehicle of the specifications S4 and S5 are larger than those when he/she drives the vehicles of other specifications. This is true for both a case where the steering wheel is turned to the right (subsection I_2) and a case where it is turned to the left (subsection I_3). From this fact, it is judged that a large stress is placed on the driver who drives the vehicles of the specifications S4 and S5.

[0096] Samples of sensory values of the drivers as subjects are presented as comparison examples.

[0097] Figs. 13A and 14A are graphs showing sensory values of maneuvering stability (steering stability) obtained when a driver drives vehicles having the respective vehicle characteristics in the subsections I_1 to I_4. From the graphs, both the drivers D1 and D2 answered that the maneuvering stability (steering stability) was the lowest with the vehicle of the specification S4. The result coincides with the results shown in Figs. 11A and 11B and 12A and 12B that the drivers suffer from large stress when they drive the vehicle of the specification S4.

[0098] Figs. 13B and 14B are graphs showing sensory values of vehicle response sharpness obtained when the driver drives vehicles having the respective specifications. From the graphs, both the drivers D1 and D2 answered that the response sharpness was the lowest with the vehicle of the specification S5. The result coincides with the results shown in Figs. 11A and 11B and 12A and 12B that the drivers suffer from large stress when they drive the vehicle of the specification S5.

[0099] From the test results described above, it is understood that a level of stress of the driver during steering of a vehicle is properly evaluated by using the myoelectric potential intensity obtained by normalizing the myoelectric potential intensity of the masseter muscle at vehicle steering by an external force physical quantity intensity.

[0100] In the example described above, a stress placed on the driver when he/she drives the vehicle was described. However, the objective work for which a level of the stress is evaluated is not limited to driving of a vehicle, but it may be any work involving activities of muscles other than the masseter muscle.

[0101] While the stress-at-work evaluating device and the stress-at-work evaluating method have been described in detail, it should be understood that the present invention is not limited to the above examples, but various improvements and modifications may be made.

Claims

1. A stress-at-work evaluating device(10) for evaluating a stress of a subject at a work based on measurement of activities of a muscle, which are independent of activities of the right and left masseter muscles for opening and closing a jaw of the subject, said stress-at-work evaluating device comprising:

    sensors (12) for sensing myoelectric potentials of the right and left masseter muscles, said potentials being generated through the activities of the masseter muscles at the work;
    an amplifier(16) for amplifying the myoelectric potentials of said right and left masseter muscles sensed by said sensor;
    a myoelectric-potential data processing part(22) for processing time-series data of said amplified myoelectric potentials of said right and left masseter muscles, to thereby calculate a simultaneous contraction intensity of said right and left masseter muscles from a simultaneous contraction waveform of said right and left masseter muscles;
    an external-force level judging part(24) for judging a level of an external force acting on the head of said subject at the work; and
    an evaluating part(28) for calculating a normalized simultaneous contraction intensity obtained by normalizing said calculated simultaneous contraction intensity by the level of the external force, and evaluating a level of stress of said subject at the work by using said normalized simultaneous contraction intensity.

2. The stress-at-work evaluating device(10) according to claim 1, wherein said external-force level judging part (24) is adapted to judge the level of the external force acting on the head of said subject by using intensity of a myoelectric potential of a muscle acting for holding a posture of the head.

3. The stress-at-work evaluating device(10) according to claim 1 or 2, wherein the work causes a predetermined object to behave by processing said object to allow the resultant behavior to cause the external force acting on the head of said subject, and said

external-force level judging part(24) is adapted to judge the level of the external force acting on the head by using a measured physical quantity representing said behavior of said object caused by said work.

4. The stress-at-work evaluating device(10) according to claim 1, wherein the work causes a predetermined object to behave by processing said object to allow the resultant behavior to cause the external force acting on the head of said subject, and said external-force level judging part (24) is adapted to judge the level of the external force acting on the head by using a measured physical quantity obtained by measuring said behavior of said object caused by said work.

5. The stress-at-work evaluating device(10) according to anyone of claims 1 to 4, wherein said work is a steering operation done by said subject.

6. The stress-at-work evaluating device(10) according to anyone of claims 1 to 5, wherein said evaluating part (18) is adapted to evaluate a level of stress of said subject at the work by comparing the normalized simultaneous contraction intensity with predetermined values.

7. The stress-at-work evaluating device (10) according to any one of claims 1 to 6, wherein the myoelectric-potential data processing part (22) is adapted to obtain the simultaneous contraction waveform of said right and left masseter muscles by selecting a smaller one of said amplified myoelectric potentials of said right and left masseter muscles, or by calculating a geometric average of said amplified myoelectric potentials.

8. A stress-at-work evaluating method for evaluating a stress of a subject at a work based on measurement of activities of a muscle, which are independent of activities of right and left masseter muscles for opening and closing a jaw of the subject, said stress-at-work evaluating method comprising:

a myoelectric potential measurement step of sensing and amplifying a myoelectric potential of at least one of right and left masseter muscles, said potential being generated through the activities of the masseter muscle at the work;
a processing step of processing time-series data of said measured myoelectric potential of said masseter muscle and calculating intensity information on said myoelectric potential of said masseter muscle;
a judging step of judging a level of an external force acting on a head of the subject at said work; and
an evaluating step of evaluating a level of stress of said subject at work by using a normalized intensity on said myoelectric potential obtained by normalizing said intensity information on said myoelectric potential of said masseter muscle by the level of the external force judged by said judging step.

9. The stress-at-work evaluating method according to claim 8, wherein said judging step judges the level of the external force acting on the head of said subject by using intensity of a myoelectric potential of a muscle acting for holding a posture of the head.

10. The stress-at-work evaluating method according to claim 8 or 9, wherein the work causes a predetermined object to behave by operating said object, to thereby allow the resultant behavior to cause the external force acting on the head of said subject, and said judging step judges the level of the external force acting on the head by using a measured physical quantity representing said behavior of said object caused by the work.

11. The stress-at-work evaluating method according to claim 8, wherein the work causes a predetermined object to behave by operating said object, to thereby allow the resultant behavior to cause the external force acting on the head of said subject, and said judging step judges the level of the external force acting on the head by using a measured physical quantity obtained by measuring said behavior of said object caused by said work.

12. The stress-at-work evaluating method according to anyone of claims 8 to 11, wherein the work is a steering operation done by said subject.

13. The stress-at-work evaluating method according to anyone of claims 8 to 12, wherein said evaluating step evaluates the level of stress of said subject at the work by comparing the normalized intensity of the myoelectric potential of the masseter muscle with predetermined values.

14. The stress-at-work evaluating method according to anyone of claims 8 to 12, wherein
said myoelectric potential measurement step senses and amplifies myoelectric potentials of the right and left masseter muscles, said potentials being generated through the activities of the masseter muscles at work;
said processing step processes time-series data of said amplified myoelectric potentials of said right and left masseter muscles thus measured and calculates as the intensity information a simultaneous contraction intensity of said right and left masseter muscles from a simultaneous contraction waveform of said masseter muscles; and

said evaluating step calculates a normalized simultaneous contraction intensity by normalizing said calculated simultaneous contraction intensity by the level of the external force, and evaluates a level of stress of said subject at the work by using said normalized simultaneous contraction intensity.

15. The stress-at-work evaluating method according to claim 14, wherein said evaluating step evaluates a level of stress of said subject at the work by comparing the normalized simultaneous contraction intensity with predetermined values.

16. The stress-at-work evaluating method according to claim 14 or 15, wherein the simultaneous contraction waveform of said right and left masseter muscles is obtained by selecting a smaller one of said myoelectric potentials of said right and left masseter muscles, or by calculating a geometric average of said myoelectric potentials.

Patentansprüche

1. Arbeitsbelastungs-Bewertungsvorrichtung (10) zum Bewerten einer Belastung eines Subjekts bei einer Arbeit auf der Grundlage von Messung von Aktivitäten eines Muskels, die unabhängig von Aktivitäten des rechten und linken Kaumuskels zum Öffnen und Schließen eines Kiefers des Subjekts sind, wobei die Arbeitsbelastungs-Bewertungsvorrichtung aufweist:

Sensoren (12) zum Erfassen myoelektrischer Potenziale des rechten und linken Kaumuskels, wobei die Potenziale durch die Aktivitäten der Kaumuskeln bei der Arbeit erzeugt werden;
einen Verstärker (16) zum Verstärken der durch den Sensor erfassten myoelektrischen Potenziale des rechten und linken Kaumuskels;
ein Verarbeitungsteil (22) für myoelektrische Potenzialdaten zum Verarbeiten von Zeitreihendaten der verstärkten myoelektrischen Potenziale des rechten und linken Kaumuskels, um dadurch eine gleichzeitige Kontraktionsintensität des rechten und linken Kaumuskels anhand einer gleichzeitigen Kontraktionswellenform des rechten und linken Kaumuskels zu berechnen;
ein Beurteilungsteil (24) für Außenkraftpegel zum Beurteilen eines Pegels einer auf den Kopf des Subjekts bei der Arbeit wirkenden Außenkraft; und
ein Bewertungsteil (28) zum Berechnen einer normierten gleichzeitigen Kontraktionsintensität, die durch Normieren der berechneten gleichzeitigen Kontraktionsintensität durch den Pegel der Außenkraft erhalten wird, und Bewerten eines Belastungspegels des Subjekts bei der Arbeit mit Hilfe der normierten gleichzeitigen Kontraktionsintensität.

2. Arbeitsbelastungs-Bewertungsvorrichtung (10) nach Anspruch 1, wobei das Beurteilungsteil (24) für Außenkraftpegel geeignet ist, den Pegel der auf den Kopf des Subjekts wirkenden Außenkraft mit Hilfe der Intensität eines myoelektrischen Potenzials eines Muskels zu beurteilen, der zum Beibehalten einer Haltung des Kopfes wirkt.

3. Arbeitsbelastungs-Bewertungsvorrichtung (10) nach Anspruch 1 oder 2, wobei die Arbeit bewirkt, dass ein vorbestimmtes Objekt ein Verhalten zeigt, indem das Objekt so bearbeitet wird, dass das resultierende Verhalten die auf den Kopf des Subjekts wirkende Außenkraft verursachen kann, und das Beurteilungsteil (24) für Außenkraftpegel geeignet ist, den Pegel der auf den Kopf wirkenden Außenkraft mit Hilfe einer gemessenen physikalischen Größe zu beurteilen, die das durch die Arbeit bewirkte Verhalten des Objekts darstellt.

4. Arbeitsbelastungs-Bewertungsvorrichtung (10) nach Anspruch 1, wobei die Arbeit bewirkt, dass ein vorbestimmtes Objekt ein Verhalten zeigt, indem das Objekt so bearbeitet wird, dass das resultierende Verhalten die auf den Kopf des Subjekts wirkende Außenkraft verursachen kann, und das Beurteilungsteil (24) für Außenkraftpegel geeignet ist, den Pegel der auf den Kopf wirkenden Außenkraft mit Hilfe einer gemessenen physikalischen Größe zu beurteilen, die durch Messen des durch die Arbeit bewirkten Verhaltens des Objekts erhalten wird.

5. Arbeitsbelastungs-Bewertungsvorrichtung (10) nach einem der Ansprüche 1 bis 4, wobei die Arbeit eine durch das Subjekt vorgenommene Lenkbetätigung ist.

6. Arbeitsbelastungs-Bewertungsvorrichtung (10) nach einem der Ansprüche 1 bis 5, wobei das Bewertungsteil (18) geeignet ist, einen Belastungspegel des Subjekts bei der Arbeit durch Vergleichen der normierten gleichzeitigen Kontraktionsintensität mit vorbestimmten Werten zu bewerten.

7. Arbeitsbelastungs-Bewertungsvorrichtung (10) nach einem der Ansprüche 1 bis 6, wobei das Verarbeitungsteil (22) für myoelektrische Potenzialdaten geeignet ist, die gleichzeitige Kontraktionswellenform des rechten und linken Kaumuskels zu erhalten, indem es ein kleineres der verstärkten myoelektrischen Potenziale des rechten und linken Kaumuskels auswählt oder indem es ein geometrisches Mittel der verstärkten myoelektrischen Potenziale berechnet.

8. Arbeitsbelastungs-Bewertungsverfahren zum Bewerten einer Belastung eines Subjekts bei einer Arbeit auf der Grundlage von Messung von Aktivitäten eines Muskels, die unabhängig von Aktivitäten des rechten und linken Kaumuskels zum Öffnen und Schließen eines Kiefers des Subjekts sind, wobei das Arbeitsbelastungs-Bewertungsverfahren aufweist:

einen Messschritt für myoelektrische Potenziale des Erfassens und Verstärkens eines myoelektrischen Potenzials des rechten und/oder linken Kaumuskels, wobei das Potenzial durch die Aktivitäten des Kaumuskels bei der Arbeit erzeugt wird;
einen Verarbeitungsschritt des Verarbeitens von Zeitreihendaten des gemessenen myoelektrischen Potenzials des Kaumuskels und Berechnens von Intensitätsinformationen über das myoelektrische Potenzial des Kaumuskels;
einen Beurteilungsschritt des Beurteilens eines Pegels einer auf einen Kopf des Subjekts bei der Arbeit wirkenden Außenkraft; und
einen Bewertungsschritt des Bewertens eines Belastungspegels des Subjekts bei der Arbeit mit Hilfe einer normierten Intensität des myoelektrischen Potenzials, die durch Normieren der Intensitätsinformationen über das myoelektrische Potenzial des Kaumuskels durch den Pegel der Außenkraft erhalten wird, der durch den Beurteilungsschritt beurteilt wird.

9. Arbeitsbelastungs-Bewertungsverfahren nach Anspruch 8, wobei der Beurteilungsschritt den Pegel der auf den Kopf des Subjekts wirkenden Außenkraft mit Hilfe der Intensität eines myoelektrischen Potenzials eines Muskels beurteilt, der zum Beibehalten einer Haltung des Kopfes wirkt.

10. Arbeitsbelastungs-Bewertungsverfahren nach Anspruch 8 oder 9, wobei die Arbeit bewirkt, dass ein vorbestimmtes Objekt ein Verhalten zeigt, indem das Objekt betätigt wird, wodurch das resultierende Verhalten die auf den Kopf des Subjekts wirkende Außenkraft verursachen kann, und der Beurteilungsschritt den Pegel der auf den Kopf wirkenden Außenkraft mit Hilfe einer gemessenen physikalischen Größe beurteilt, die das durch die Arbeit bewirkte Verhalten des Objekts darstellt.

11. Arbeitsbelastungs-Bewertungsverfahren nach Anspruch 8, wobei die Arbeit bewirkt, dass ein vorbestimmtes Objekt ein Verhalten zeigt, indem das Objekt betätigt wird, wodurch das resultierende Verhalten die auf den Kopf des Subjekts wirkende Außenkraft verursachen kann, und der Beurteilungsschritt den Pegel der auf den Kopf wirkenden Außenkraft mit Hilfe einer gemessenen physikalischen Größe beurteilt, die durch Messen des durch die Arbeit bewirkten Verhaltens des Objekts erhalten wird.

12. Arbeitsbelastungs-Bewertungsverfahren nach einem der Ansprüche 8 bis 11, wobei die Arbeit eine durch das Subjekt vorgenommene Lenkbetätigung ist.

13. Arbeitsbelastungs-Bewertungsverfahren nach einem der Ansprüche 8 bis 12, wobei der Bewertungsschritt den Belastungspegel des Subjekts bei der Arbeit durch Vergleichen der normierten Intensität des myoelektrischen Potenzials des Kaumuskels mit vorbestimmten Werten bewertet.

14. Arbeitsbelastungs-Bewertungsverfahren nach einem der Ansprüche 8 bis 12, wobei der Messschritt für myoelektrische Potenziale myoelektrische Potenziale des rechten und linken Kaumuskels erfasst und verstärkt, wobei die Potenziale durch die Aktivitäten der Kaumuskel bei der Arbeit erzeugt werden; der Verarbeitungsschritt Zeitreihendaten der so gemessenen verstärkten myoelektrischen Potenziale des rechten und linken Kaumuskels verarbeitet und als Intensitätsinformationen eine gleichzeitige Kontraktionsintensität des rechten und linken Kaumuskels anhand einer gleichzeitigen Kontraktionswellenform der Kaumuskel berechnet; und
der Bewertungsschritt eine normierte gleichzeitige Kontraktionsintensität berechnet, indem er die berechnete gleichzeitige Kontraktionsintensität durch den Pegel der Außenkraft normiert, und einen Belastungspegel des Subjekts bei der Arbeit mit Hilfe der normierten gleichzeitigen Kontraktionsintensität bewertet.

15. Arbeitsbelastungs-Bewertungsverfahren nach Anspruch 14, wobei der Bewertungsschritt einen Belastungspegel des Subjekts bei der Arbeit durch Vergleichen der normierten gleichzeitigen Kontraktionsintensität mit vorbestimmten Werten bewertet.

16. Arbeitsbelastungs-Bewertungsverfahren nach Anspruch 14 oder 15, wobei die gleichzeitige Kontraktionswellenform des rechten und linken Kaumuskels erhalten wird, indem ein kleineres der myoelektrischen Potenziale des rechten und linken Kaumuskels ausgewählt oder indem ein geometrisches Mittel der myoelektrischen Potenziale berechnet wird.

Revendications

1. Dispositif d'évaluation du stress au travail (10) permettant d'évaluer le stress d'un sujet au travail en mesurant l'activité d'un muscle, indépendante de l'activité du muscle masséter gauche et du muscle masséter droit pour ouvrir et refermer la mâchoire du sujet, ledit dispositif d'évaluation du stress au travail comprenant :

des capteurs (12) permettant de détecter des potentiels myoélectriques des muscles masséters gauche et droit, lesdits potentiels étant générés par l'activité des muscles masséters au travail ;
un amplificateur (16) permettant d'amplifier les potentiels myoélectriques des muscles masséters gauche et droit détectés par le capteur ;
une unité de traitement (22) de potentiel myoélectrique permettant de traiter des données chronologiques des potentiels myoélectriques amplifiés des muscles masséters gauche et droit, pour calculer une intensité de contraction simultanée desdits muscles masséters gauche et droit à partir d'une forme d'onde de contraction simultanée desdits muscles masséters gauche et droit ;
une unité d'estimation (24) d'un niveau de force externe permettant d'estimer un niveau d'une force externe exercée sur la tête du sujet au travail ; et
une unité d'évaluation (28) permettant de calculer une intensité de contraction simultanée normalisée, obtenue par normalisation de l'intensité de contraction simultanée calculée par le niveau de la force externe, et d'évaluer un niveau de stress du sujet au travail en recourant à ladite intensité de contraction simultanée normalisée.

2. Dispositif d'évaluation du stress au travail (10) selon la revendication 1, où l'unité d'estimation (24) d'un niveau de force externe est prévue pour estimer le niveau de la force externe exercée sur la tête du sujet en recourant à l'intensité du potentiel myoélectrique d'un muscle agissant pour maintenir une position de la tête.

3. Dispositif d'évaluation du stress au travail (10) selon la revendication 1 ou la revendication 2, où le travail provoque un comportement d'un objet prédéterminé par traitement dudit objet de manière à permettre au comportement résultant de déclencher l'application de la force externe sur la tête du sujet, et où l'unité d'estimation (24) du niveau de force externe est prévue pour estimer le niveau de la force externe exercée sur la tête en recourant à une quantité physique mesurée représentant le comportement de l'objet provoqué par le travail.

4. Dispositif d'évaluation du stress au travail (10) selon la revendication 1, où le travail provoque un comportement d'un objet prédéterminé par traitement dudit objet de manière à permettre au comportement résultant de déclencher l'application de la force externe sur la tête du sujet, et où l'unité d'estimation (24) du niveau de force externe est prévue pour estimer le niveau de la force externe exercée sur la tête en recourant à une quantité physique mesurée obtenue par mesure du comportement de l'objet provoqué par le travail.

5. Dispositif d'évaluation du stress au travail (10) selon l'une des revendications 1 à 4, où le travail est une manoeuvre de conduite exécutée par le sujet.

6. Dispositif d'évaluation du stress au travail (10) selon l'une des revendications 1 à 5, où l'unité d'évaluation (18) est prévue pour évaluer le niveau de stress du sujet au travail par comparaison de l'intensité de contraction simultanée normalisée avec des valeurs prédéterminées.

7. Dispositif d'évaluation du stress au travail (10) selon l'une des revendications 1 à 6, où l'unité de traitement (22) de potentiel myoélectrique est prévue pour obtenir la forme d'onde de contraction simultanée desdits muscles masséters gauche et droit par sélection d'un potentiel inférieur parmi les potentiels myoélectriques amplifiés des muscles masséters gauche et droit, ou par calcul d'une moyenne géométrique desdits potentiels myoélectriques amplifiés.

8. Procédé d'évaluation du stress au travail permettant d'évaluer le stress d'un sujet au travail en mesurant l'activité d'un muscle, indépendante de l'activité du muscle masséter gauche et du muscle masséter droit pour ouvrir et refermer la mâchoire du sujet, ledit procédé d'évaluation du stress au travail comprenant :

une étape de mesure de potentiel myoélectrique par détection et amplification d'un potentiel myoélectrique d'au moins un des muscles masséters gauche et droit, ledit potentiel étant généré par l'activité du muscle masséter au travail ;
une étape de traitement de données chronologiques du potentiel myoélectrique mesuré pour le muscle masséter et de calcul d'une information d'intensité relative au potentiel myoélectrique du muscle masséter ;
une étape d'estimation d'un niveau d'une force externe exercée sur la tête du sujet au travail ; et
une étape d'évaluation d'un niveau de stress du sujet au travail, recourant à une intensité normalisée du potentiel myoélectrique obtenue par normalisation de l'information d'intensité relative au potentiel myoélectrique du muscle masséter par le niveau de la force externe estimé à l'étape d'évaluation.

9. Procédé d'évaluation du stress au travail selon la

revendication 8, où l'étape d'estimation estime le niveau de la force externe exercée sur la tête du sujet en recourant à l'intensité du potentiel myoélectrique d'un muscle agissant pour maintenir une position de la tête.

10. Procédé d'évaluation du stress au travail selon la revendication 8 ou la revendication 9, où le travail provoque un comportement d'un objet prédéterminé par traitement dudit objet de manière à permettre au comportement résultant de déclencher l'application de la force externe sur la tête du sujet, et où l'étape d'estimation estime le niveau de la force externe exercée sur la tête en recourant à une quantité physique mesurée représentant le comportement de l'objet provoqué par le travail.

11. Procédé d'évaluation du stress au travail selon la revendication 8, où le travail provoque un comportement d'un objet prédéterminé par traitement dudit objet de manière à permettre au comportement résultant de déclencher l'application de la force externe sur la tête du sujet, et où l'étape d'estimation estime le niveau de la force externe exercée sur la tête en recourant à une quantité physique mesurée obtenue par mesure du comportement de l'objet provoqué par le travail.

12. Procédé d'évaluation du stress au travail selon l'une des revendications 8 à 11, où le travail est une manoeuvre de conduite exécutée par le sujet.

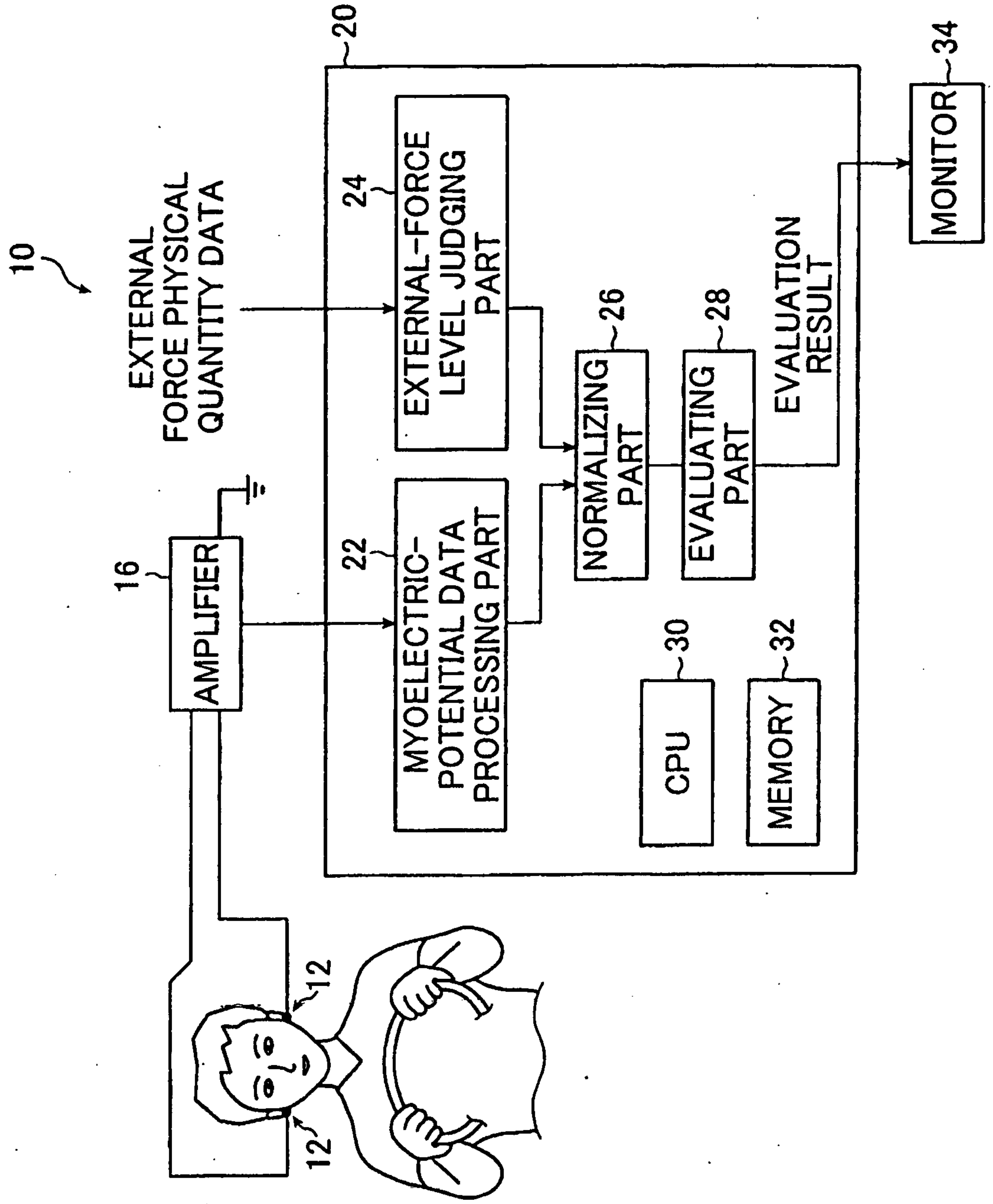
13. Procédé d'évaluation du stress au travail selon l'une des revendications 8 à 12, où l'étape d'évaluation évalue le niveau de stress du sujet au travail par comparaison de l'intensité normalisée du potentiel myoélectrique du muscle masséter avec des valeurs prédéterminées.

14. Procédé d'évaluation du stress au travail selon l'une des revendications 8 à 12, où l'étape de mesure du potentiel myoélectrique détecte et amplifie les potentiels myoélectriques des muscles masséters gauche et droit, lesdits potentiels étant générés par l'activité des muscles masséters au travail ;
l'étape de traitement traite des données chronologiques des potentiels myoélectriques amplifiés des muscles masséters gauche et droit ainsi mesurés et calcule comme information d'intensité une intensité de contraction simultanée des muscles masséters gauche et droit à partir d'une forme d'onde de contraction simultanée desdits muscles masséters ; et
où l'étape d'évaluation calcule une intensité de contraction simultanée normalisée par normalisation de l'intensité de contraction simultanée calculée par le niveau de la force externe, et évalue un niveau de stress du sujet au travail en recourant à ladite intensité de contraction simultanée.

15. Procédé d'évaluation du stress au travail selon la revendication 14, où l'étape d'évaluation évalue le niveau de stress du sujet au travail par comparaison de l'intensité de contraction simultanée normalisée avec des valeurs prédéterminées.

16. Procédé d'évaluation du stress au travail selon la revendication 14 ou la revendication 15, où la forme d'onde de contraction simultanée des muscles masséters gauche et droit est obtenue par sélection d'un potentiel inférieur parmi les potentiels myoélectriques des muscles masséters gauche et droit, ou par calcul d'une moyenne géométrique desdits potentiels myoélectriques.

FIG. 1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EXTERNAL
FORCE PHYSICAL
QUANTITY DATA
16
AMPLIFIER
20
22
MYOELECTRIC-
POTENTIAL DATA
PROCESSING PART
24
EXTERNAL-FORCE
LEVEL JUDGING
PART
26
NORMALIZING
PART
28
EVALUATING
PART
EVALUATION
RESULT
30
CPU
32
MEMORY
34
MONITOR
12
12

FIG. 2

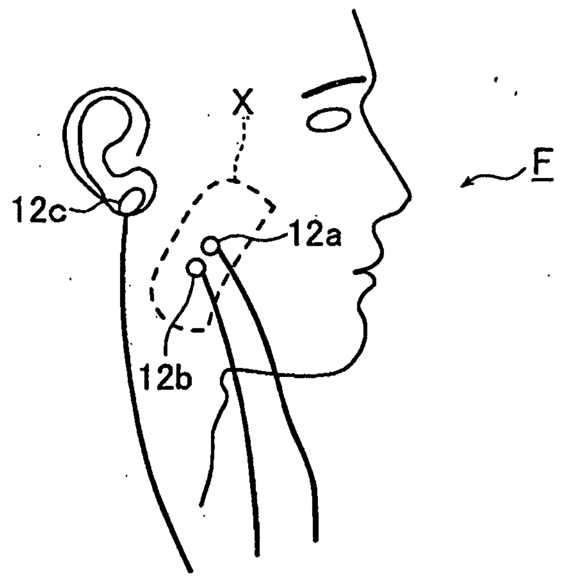


FIG.3A

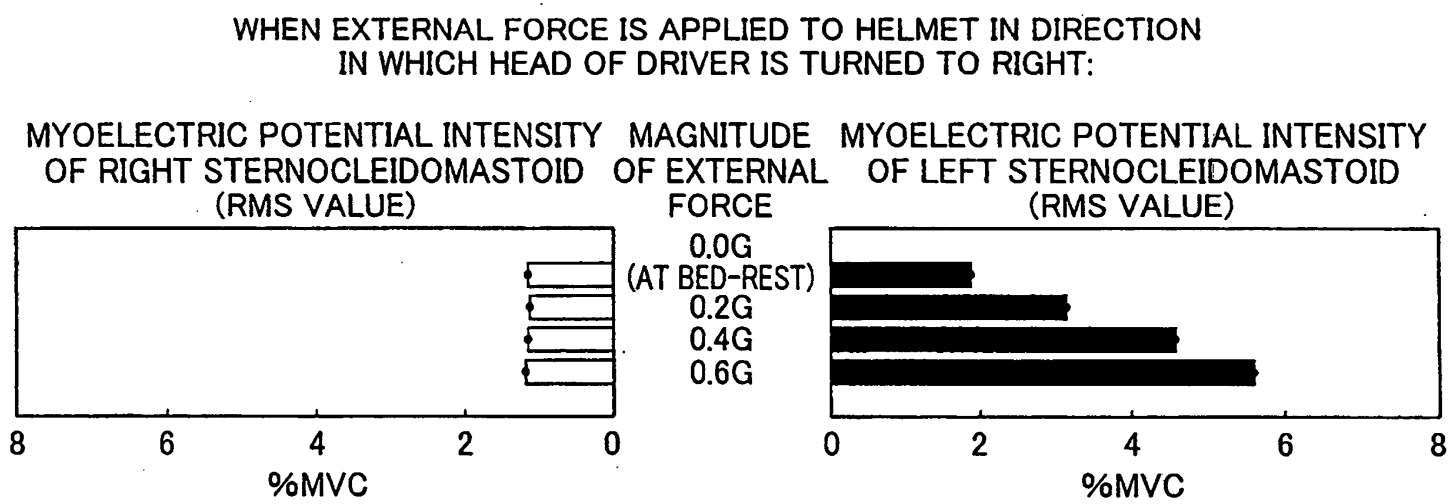

WHEN EXTERNAL FORCE IS APPLIED TO HELMET IN DIRECTION IN WHICH HEAD OF DRIVER IS TURNED TO RIGHT:
MYOELECTRIC POTENTIAL INTENSITY OF RIGHT STERNOCLEIDOMASTOID (RMS VALUE)
MAGNITUDE OF EXTERNAL FORCE
MYOELECTRIC POTENTIAL INTENSITY OF LEFT STERNOCLEIDOMASTOID (RMS VALUE)
0.0G (AT BED-REST)
0.2G
0.4G
0.6G
8
6
4
2
0
%MVC
0
2
4
6
8
%MVC

FIG.3B

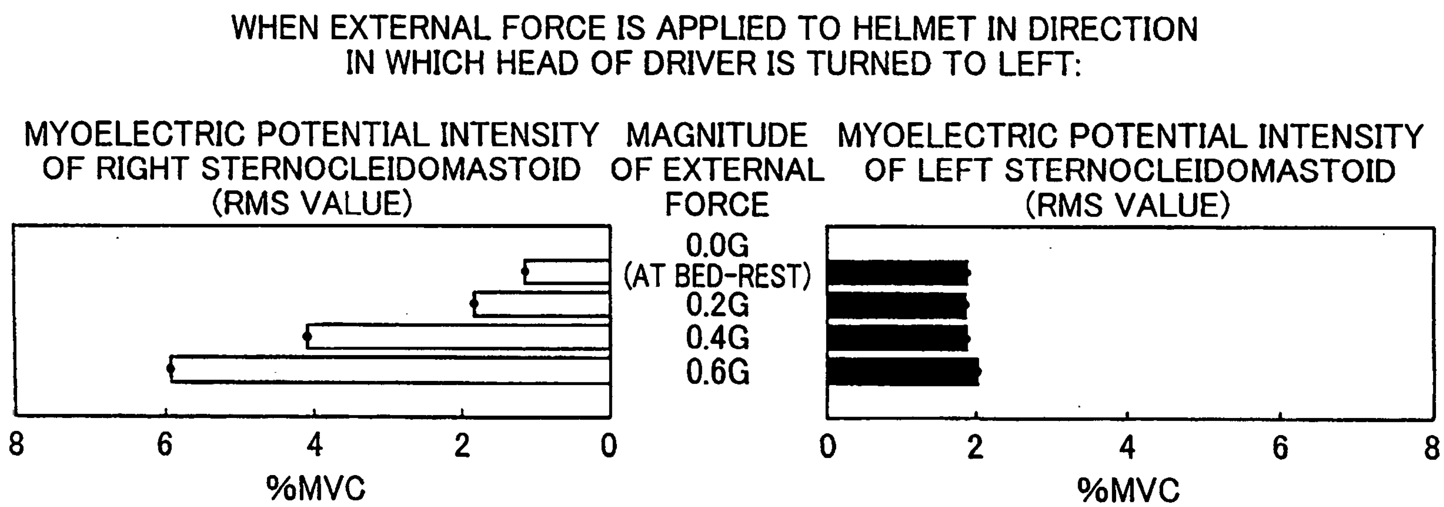

WHEN EXTERNAL FORCE IS APPLIED TO HELMET IN DIRECTION IN WHICH HEAD OF DRIVER IS TURNED TO LEFT:
MYOELECTRIC POTENTIAL INTENSITY OF RIGHT STERNOCLEIDOMASTOID (RMS VALUE)
MAGNITUDE OF EXTERNAL FORCE
MYOELECTRIC POTENTIAL INTENSITY OF LEFT STERNOCLEIDOMASTOID (RMS VALUE)
0.0G (AT BED-REST)
0.2G
0.4G
0.6G
8
6
4
2
0
%MVC
0
2
4
6
8
%MVC

FIG. 4

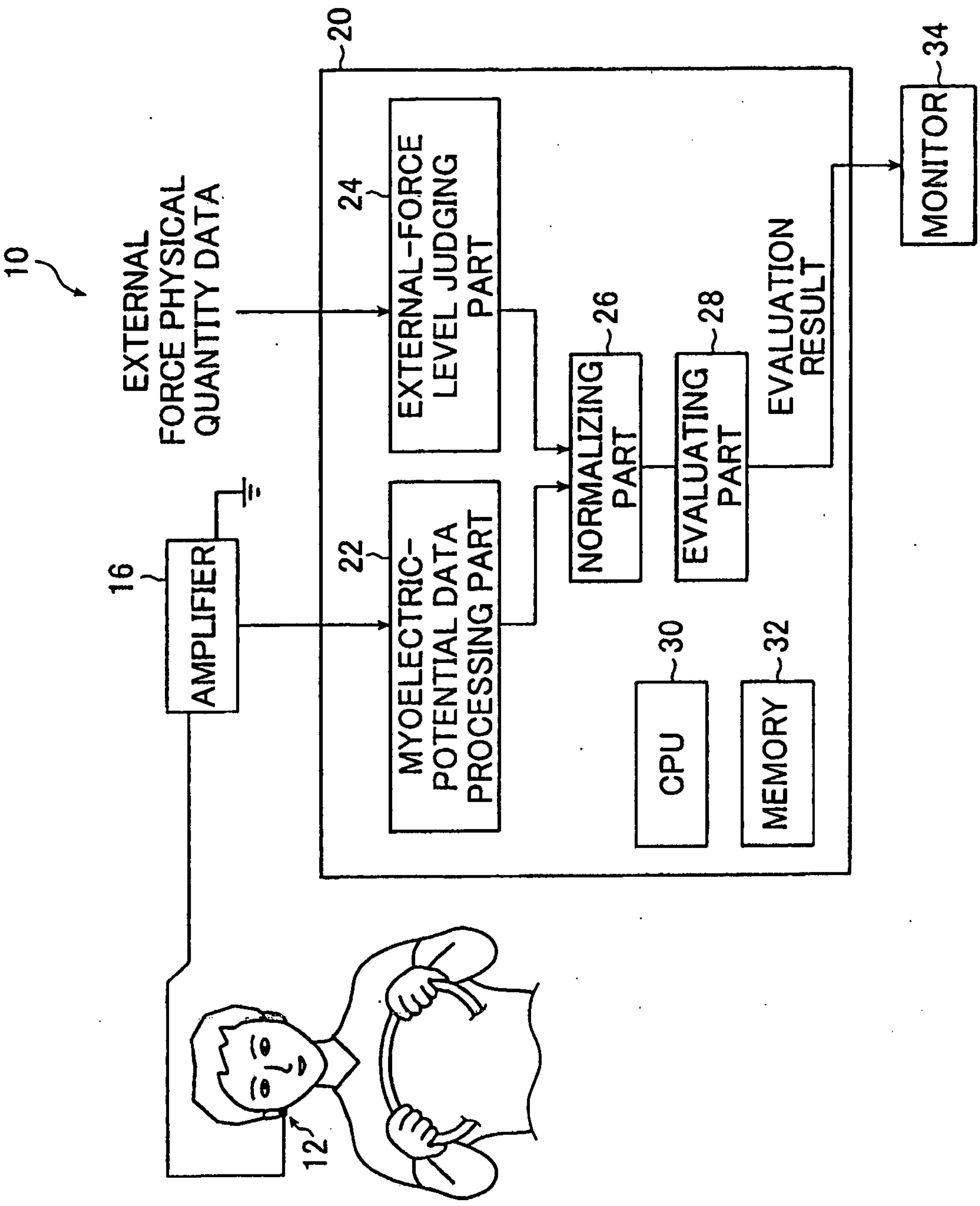

10
EXTERNAL FORCE PHYSICAL QUANTITY DATA
16
AMPLIFIER
20
22
MYOELECTRIC-POTENTIAL DATA PROCESSING PART
24
EXTERNAL-FORCE LEVEL JUDGING PART
26
NORMALIZING PART
28
EVALUATING PART
EVALUATION RESULT
30
CPU
32
MEMORY
34
MONITOR
12

FIG.5

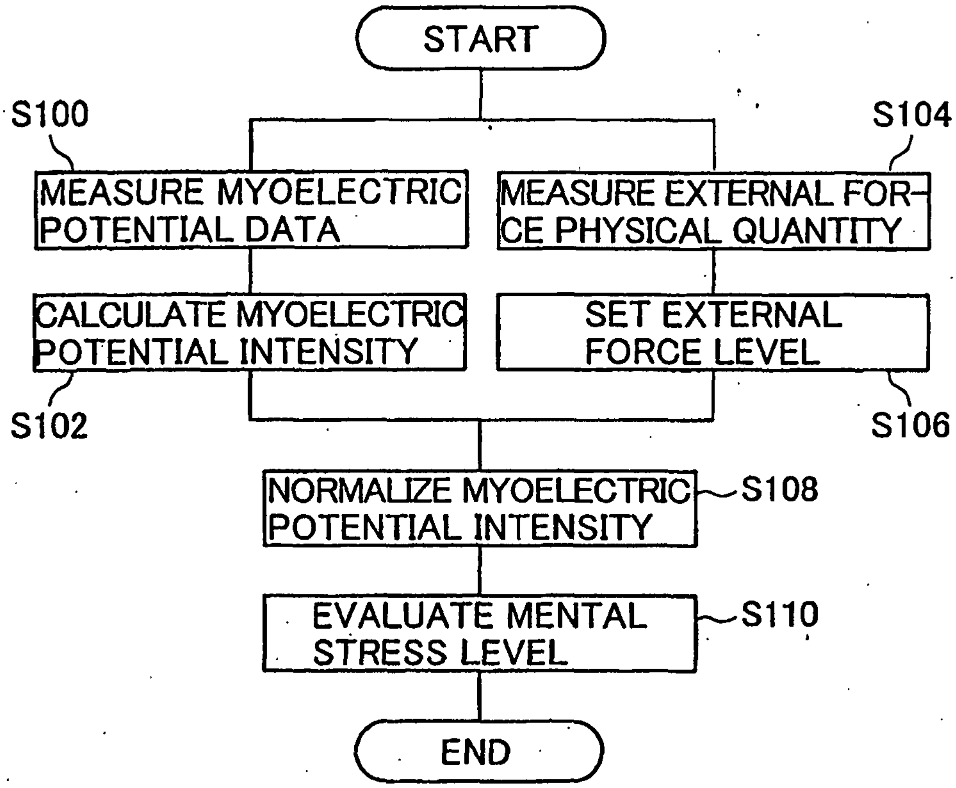

START
S100
MEASURE MYOELECTRIC POTENTIAL DATA
S104
MEASURE EXTERNAL FORCE PHYSICAL QUANTITY
CALCULATE MYOELECTRIC POTENTIAL INTENSITY
S102
SET EXTERNAL FORCE LEVEL
S106
NORMALIZE MYOELECTRIC POTENTIAL INTENSITY
S108
EVALUATE MENTAL STRESS LEVEL
S110
END

FIG.6

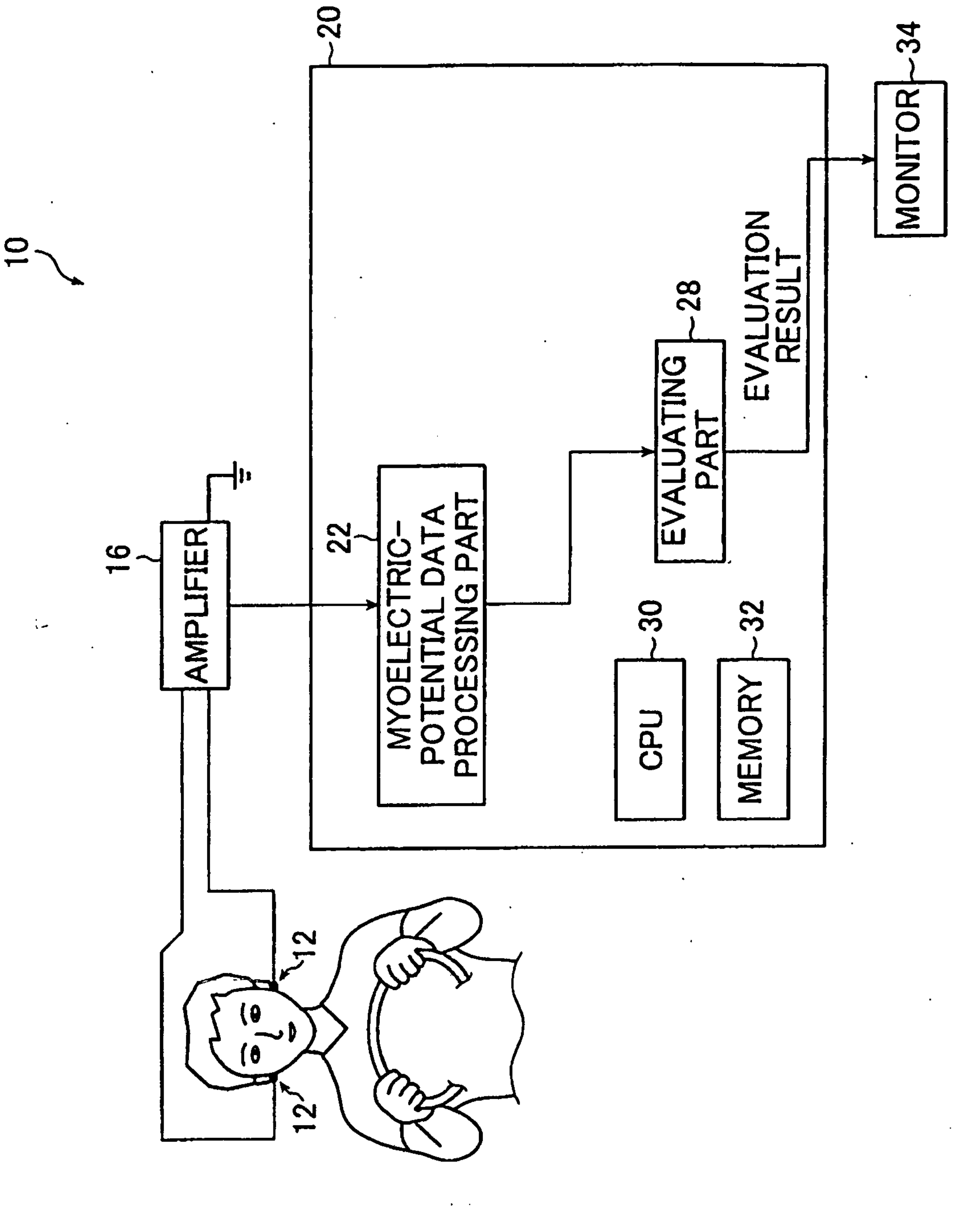

10
16
AMPLIFIER
20
22
MYOELECTRIC-
POTENTIAL DATA
PROCESSING PART
EVALUATING
PART
28
EVALUATION
RESULT
MONITOR
34
CPU
30
MEMORY
32
12
12

FIG.7

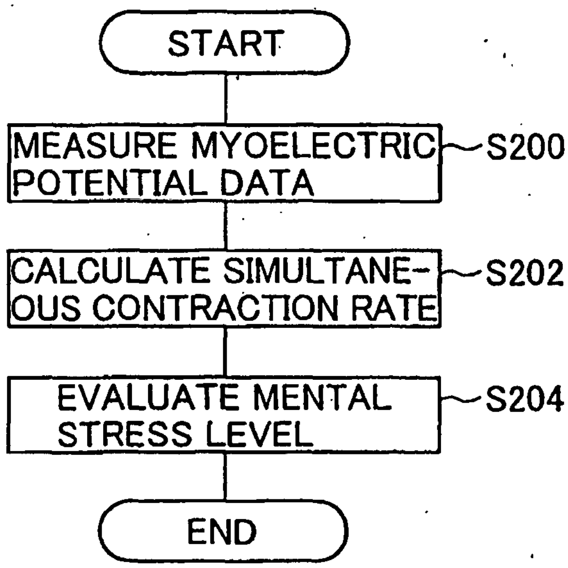

START
MEASURE MYOELECTRIC POTENTIAL DATA
S200
CALCULATE SIMULTANE-OUS CONTRACTION RATE
S202
EVALUATE MENTAL STRESS LEVEL
S204
END

FIG.8

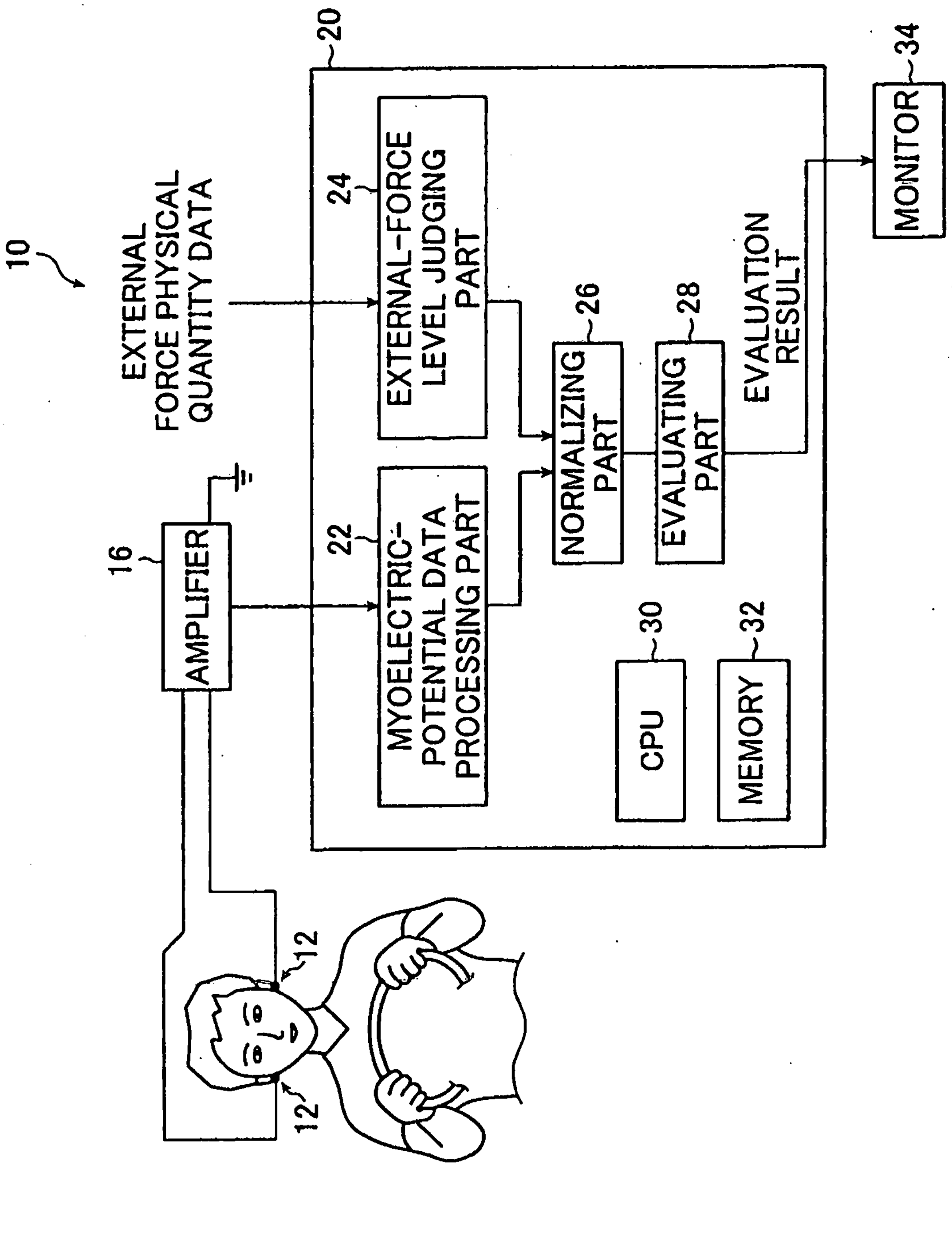

10
EXTERNAL FORCE PHYSICAL QUANTITY DATA
20
24
EXTERNAL-FORCE LEVEL JUDGING PART
16
AMPLIFIER
22
MYOELECTRIC-POTENTIAL DATA PROCESSING PART
26
NORMALIZING PART
28
EVALUATING PART
EVALUATION RESULT
34
MONITOR
30
CPU
32
MEMORY
12
12

FIG.9

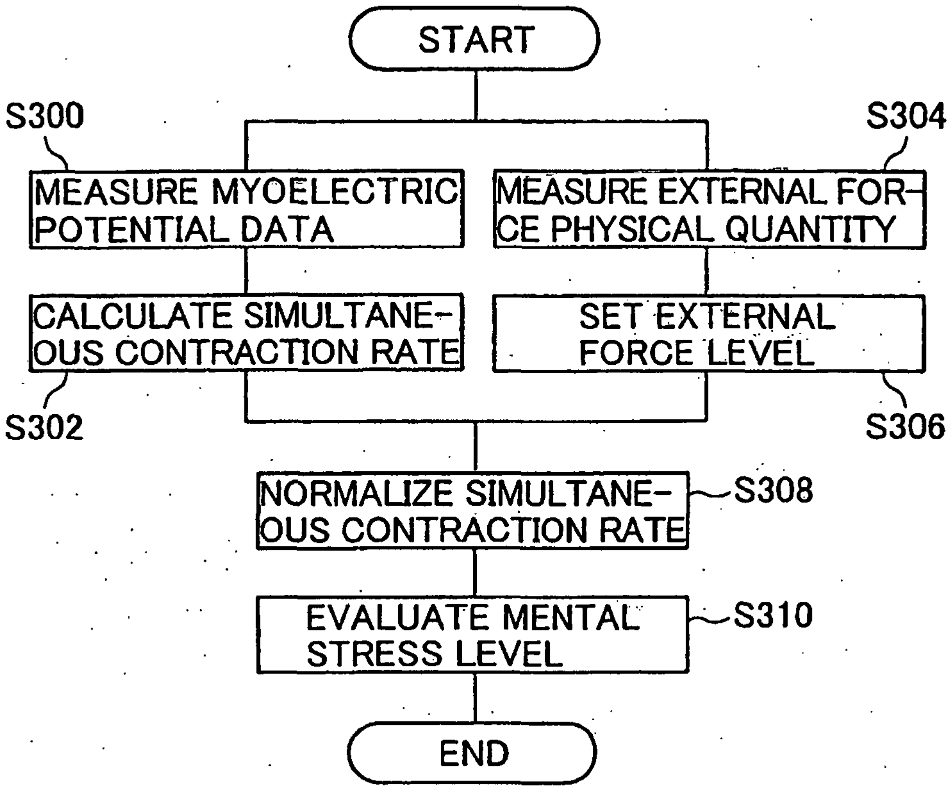
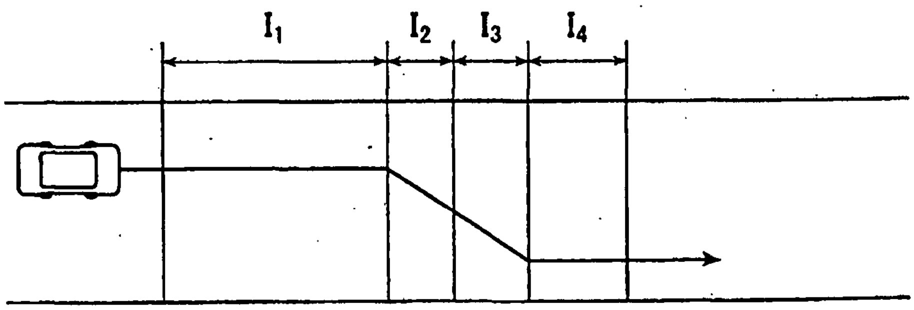

START
S300
MEASURE MYOELECTRIC POTENTIAL DATA
S304
MEASURE EXTERNAL FORCE PHYSICAL QUANTITY
CALCULATE SIMULTANEOUS CONTRACTION RATE
SET EXTERNAL FORCE LEVEL
S302
S306
NORMALIZE SIMULTANEOUS CONTRACTION RATE
S308
EVALUATE MENTAL STRESS LEVEL
S310
END

FIG.10


I1
I2
I3
I4

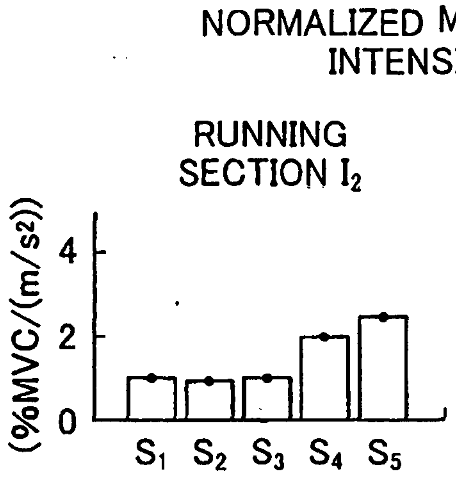


FIG.11A

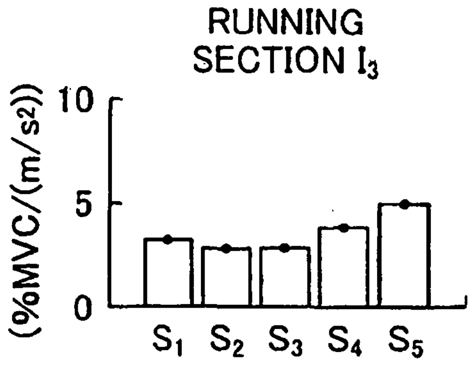


FIG.11B

FIG.12A

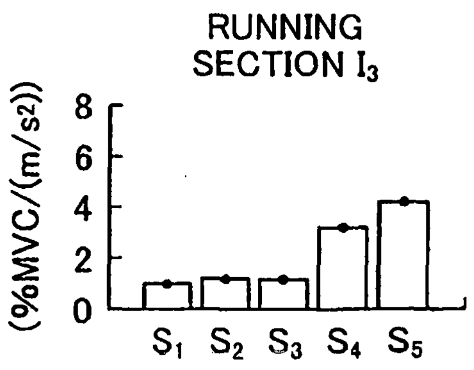


FIG.12B

SENSORY VALUE OF DRIVER D1

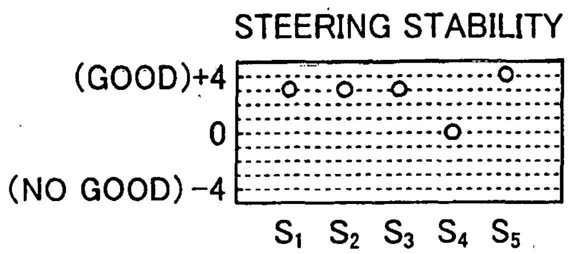


FIG.13A

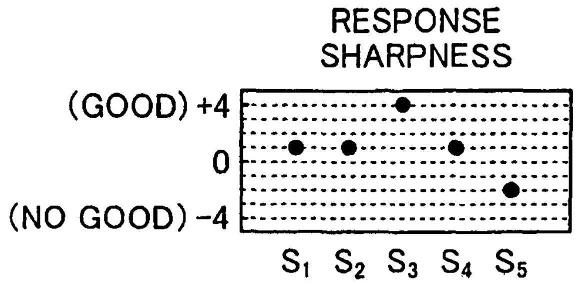


FIG.13B

SENSORY VALUE OF DRIVER D2

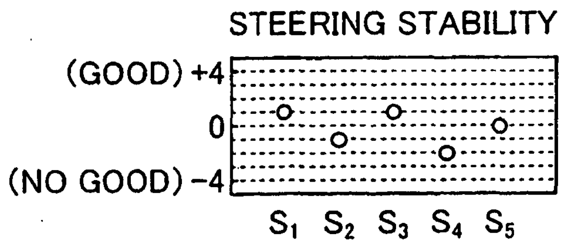


FIG.14A

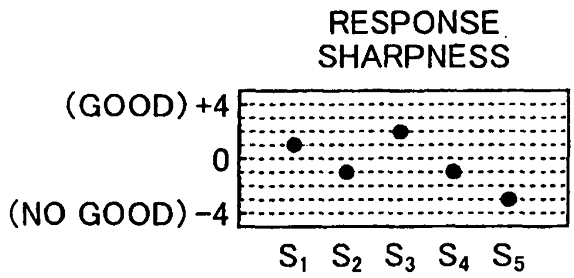


FIG.14B

REFERENCES CITED IN THE DESCRIPTION

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Non-patent literature cited in the description

- Wearable and Automotive Systems for Affect Recognition from Physiology. **J.A. HEALEY.** Ph. D. dissertation. Massachusetts Institute of Technology, May 2000 **[0010]**

专利名称(译)	工作压力评估装置和方法		
公开(公告)号	EP1516586B1	公开(公告)日	2014-03-05
申请号	EP2004022243	申请日	2004-09-17
[标]申请(专利权)人(译)	横滨橡胶株式会社		
申请(专利权)人(译)	横滨橡胶有限公司.		
当前申请(专利权)人(译)	横滨橡胶有限公司.		
[标]发明人	KURAMORI AKIRA C OTHE YOKOHAMA RUBBER CO LTD KOGUCHI NORITAKA C OTHE YOKOHAMA RUBBER CO LTD KAMIJO MASAYOSHI C OSHINSHU UNIV SADOYAMA TSUGUTAKE C OSHINSHU UNIV		
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IPC分类号	A61B5/18 A61B5/0488 A61B5/00 A61B5/16 A61B5/22		
CPC分类号	A61B5/0488 A61B5/18 A61B5/228 A61B5/4528		
代理机构(译)	法思博事务所		
优先权	2003325043 2003-09-17 JP		
其他公开文献	EP1516586A3 EP1516586A2		
外部链接	Espacenet		

摘要(译)

工作压力评价装置通过测量肌肉的活动性来评价被检者在工作中的压力，其独立于用于打开和关闭被检者的下巴的左右咬合器的活动。该装置通过使作用于工作的对象的头部的外力的水平将咬肌的肌电位归一化来评估应力。或者，可以使用通过咬肌的同时收缩波形获得的右和左咬肌的同时收缩强度来代替标准化的肌电电位。

FIG.1