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(54) **ALERTNESS DEVICE, SEAT, AND METHOD FOR DETERMINING ALERTNESS**

WACHSAMKEITSVORRICHTUNG, SITZ UND VERFAHREN ZUR BESTIMMUNG VON WACHSAMKEIT

DISPOSITIF DE VIGILANCE, SIÈGE, ET PROCÉDÉ POUR DÉTERMINER LA VIGILANCE

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Description

TECHNICAL FIELD

[0001] The present invention relates to an alertness device, a seat including the alertness device, and an alertness determination method. In particular, the present invention relates to an alertness device having the function of determining alertness, and a seat including the alertness device, and an alertness determination method.

BACKGROUND ART

[0002] In recent years, a change in a driver's physical condition needs to be detected for stable vehicle operation. Various techniques of detecting and calculating various parameters indicating a driver's state to determine the change in the physical condition, particularly alertness, have been proposed.

[0003] For example, Patent Document 1 discloses the following technique. A cardiac cycle sequence is obtained from a heart rate signal, and fast Fourier transformation is performed for the cardiac cycle sequence. The resultant power spectrum is repeatedly integrated to obtain a heart-rate fluctuation low-frequency component power. Driver's alertness is determined based on the heart-rate fluctuation low-frequency component power.

[0004] Moreover, Patent Document 2 discloses the following technique. A threshold is first calculated in such a manner that in an awake period, an average of R-R intervals (RRIs) for a predetermined heart rate or a predetermined period of time is obtained, and then a value of integral of an RRI exceeding the average is multiplied by a predetermined factor. Of the RRIs obtained as described above, the RRI(s) exceeding the average is integrated. When such an integrated value exceeds the threshold, it is determined that alertness is lowered.

[0005] US 2009/209829 discloses the utilization of measuring the heart rate via sensors provided on the driving wheel for determining a state of alertness. In addition, from Takashi et al.: "Development of a feedback stimulation for drowsy driver using heartbeat rhythms", Engineering in Medicine and Biology Society, EMBC, 2011 Annual International Conference of the IEEE, IEEE, 30 August 2011, pages 4153-4158, a signal processing is known for determining the alertness. An AC determination is disclosed in Bauer A. et al.: "Declaration capacity of heart rate as a predictor of mortality after myocardial infarction: cohort study", The Lancet, The Lancet Publishing Group, GB, 20 May 2006, pages 1674-1681.

CITATION LIST

PATENT DOCUMENT

[0006]

PATENT DOCUMENT 1: Japanese Patent No. 4697185
PATENT DOCUMENT 2: Japanese Patent No. 3271448

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

[0007] According to the technique of Patent Document 1, fast Fourier transformation and integration of the power spectrum need to be repeated to calculate the heart-rate fluctuation low-frequency component power as the indicator for determining the presence/absence of drowsiness. Such analysis processing requires time. For this reason, alertness determination is delayed, leading to a delay in notification to a seated passenger.

[0008] With lack of data continuity, an accurate result cannot be obtained. This leads to a lower robustness such as inexecutable detection due to a missing value and noise contamination and rapid lowering of an accuracy.

[0009] According to the technique of Patent Document 2, only the value of integral of the RRI is used as the indicator for determining the alertness. Such alertness determination depends on an RRI within an integral range. For this reason, a detection accuracy is low. In some cases, the sympathetic nerve is instantaneously activated against drowsiness when the drowsiness is initially caused, for example. In this case, the RRI value might be instantaneously lowered in association with activation of the sympathetic nerve. According to the technique of Patent Document 2 using, as a criteria for determination, the value obtained by integration of such an instantaneously-lowered RRI, it is difficult to accurately determine the alertness.

[0010] For this reason, an alertness device configured such that a load is low in the processing for alertness determination and that the accuracy in alertness determination is high, a seat including the alertness device, and an alertness determination method have been demanded.

[0011] The present invention has been made in view of the above-described problem, and is intended to provide an alertness device configured such that a load is low in the processing for alertness determination and that the accuracy in alertness determination is high, a seat including the alertness device, and an alertness determination method.
[0012] Further, the present invention is also intended to favorably maintain person's alertness based on accurate alertness determination.

SOLUTION TO PROBLEM

[0013] To solve the aforementioned problems, an alertness device is provided, which has the features defined in claim 1. Further preferred embodiments are defined in dependent claims 2 to 6. A seat is provided that has the features defined in claim 7; said seat comprises the inventive alertness device. A method is also provided for determining alertness with an alertness device, said method has the features defined in claim 8.
[0014] As described above, the determination unit determines the alert state or the unalert state of the person based on the RRIs and the PRSA signals. Thus, a processing load can be more reduced as compared to the case of determining alertness by analysis of a heart rate frequency, and the person's alertness can be more accurately determined as compared to the case of determining alertness based only on RRIs.
[0015] The waveform generation unit preferably generates a PRSA signal waveform based on the PRSA signals. When an ACn is defined by the following formula 1:

[Formula 1]

$$ACn = X(0) + X(1) - X(-1) - X(-2),$$

where in the generated PRSA signal waveform, a PRSA signal at a certain anchor is defined by X (0), a PRSA signal for a heart rate at the next succeeding anchor of the certain anchor is defined by X(1), a PRSA signal for the heart rate at the next preceding anchor of the certain anchor is defined by X(-1), and a PRSA signal for the heart rate at the next preceding anchor of the anchor at which the X(-1) is obtained is defined by X(-2), the calculation unit preferably calculates, for a predetermined time period, the RRI average and an ACn average, and the determination unit preferably determines, based on the values calculated by the calculation unit, that the person is in the unalert state when a certain RRI average is less than the next preceding RRI average and when a certain ACn average is less than the α-fold of the next preceding ACn average.
[0016] As described above, the calculation unit calculates the RRI average and the ACn average for the predetermined time period, and based on the values calculated by the calculation unit, the determination unit determines that the person is in the unalert state when a certain RRI average is less than the next preceding RRI average and when a certain ACn average is less than the α-fold of the next preceding ACn average. Thus, the person's alertness can be more accurately determined as compared to the case of determining person's alertness based only on RRIs.
[0017] An α is preferably 1.0 to 2.0.
[0018] Since the α is 1.0 to 2.0 as described above, the person's alertness can be more accurately determined.
[0019] The calculation unit may calculate the RRI average and the ACn average for every 20- to 300-second interval, and the determination unit may determine the alertness of the person based on the RRI average and the ACn average calculated by the calculation unit.
[0020] As described above, the calculation unit calculates the RRI average and the ACn average for every 20- to 300-second interval, and the determination unit determines the alertness of the person based on the RRI average and the ACn average. Thus, the person's alertness can be more accurately determined.
[0021] The α is preferably 1.4.
[0022] Since the α is 1.4 as described above, the person's alertness can be more accurately determined.
[0023] The calculation unit may calculate the RRI average and the ACn average for every 60-second interval.
[0024] Since the calculation unit calculates, as described above, the RRI average and the ACn average for every 60-second interval, the person's alertness can be more accurately determined.
[0025] The alertness device of the first aspect of the present invention preferably further includes a notification device configured for notification to the person or one or more persons therearound, and a driver configured to drive the notification device to notify the person or the one or more persons therearound of the determination unit having determined that the person is in the unalert state.
[0026] When the determination unit determines that the person is in the unalert state, the driver drives the notification device to notify the person or the one or more persons therearound of the determination result. This brings the person to the alert state, or allows the person or the one or more persons therearound to take action to maintain the person's alertness.
[0027] The above-described problem is solved by a seat of a second aspect of the present invention. The seat of the

second aspect of the present invention includes a seat cushion on which a passenger is seated, a seat back as a back rest of the seated passenger, and the above-described alertness device. The heart rate sensor is disposed in the seat back.

[0028] Since the seat includes the alertness device as described above, the alertness of the seated passenger can be more accurately determined as compared to the case of determining the alertness of a seated passenger based only on RRIs.

[0029] The above-described problem is solved by the method for determining alertness according to a third aspect of the present invention. The method of the third aspect of the present invention includes obtaining an electrocardiographic signal, generating, from an electrocardiographic waveform of the electrocardiographic signal, an RRI waveform showing transition for a predetermined time period with RRIs, each RRI being an R-R interval between R-waves, replicating the same number of RRI waveforms as that of anchors, each anchor being a point where a certain RRI is shorter than the next preceding RRI in the generated RRI waveform, moving the time axes of the replicated RRI waveforms such that the anchors of the replicated RRI waveforms are in phase with each other, calculating a PRSA signal defined as an RRI average for each time axis, and determining, based on the RRIs and the PRSA signals, whether a person is in an alert state or an unalert state,

[0030] As described above, it is determined, based on the RRIs and the PRSA signals, whether the person is in the alert state or the unalert state. Thus, a processing load can be more reduced as compared to the case of determining alertness by analysis of a heart rate frequency, and the person's alertness can be more accurately determined as compared to the case of determining alertness based only on RRIs.

[0031] A PRSA signal waveform may be generated based on the PRSA signals. When an ACn is defined by the following formula 1:

[Formula 1]

$$ACn = X(0) + X(1) - X(-1) - X(-2),$$

where in the generated PRSA signal waveform, a PRSA signal at a certain anchor is defined by X(0), a PRSA signal at the next succeeding anchor of the certain anchor is defined by X(1), a PRSA signal at the next preceding anchor of the certain anchor is defined by X(-1), and a PRSA signal at the next preceding anchor of the anchor at which the X(-1) is obtained is defined by X(-2), the RRI average and an ACn average may be calculated for a predetermined time period, and based on the calculated values, the person may be determined as being in the unalert state when a certain RRI average is less than the next preceding RRI average and when a certain ACn average is less than the α-fold of the next preceding ACn average.

[0032] As described above, the RRI average and the ACn average for the predetermined time period are calculated, and based on the calculated values, the person is determined as being in the unalert state when a certain RRI average is less than the next preceding RRI average and when a certain ACn average is less than the α-fold of the next preceding ACn average. Thus, the person's alertness can be more accurately determined as compared to the case of determining person's alertness based only on RRIs.

EFFECTS OF INVENTION

[0033] According to the present invention, an alertness device configured so that a processing load can be more reduced as compared to the case of determining alertness by analysis of a heart rate frequency and that person's alertness can be accurately determined, a seat including the alertness device, and an alertness determination method can be provided.

[0034] Moreover, according to the present invention, the person's alertness can be favorably maintained.

BRIEF DESCRIPTION OF DRAWINGS

[0035]

FIG. 1 is a view of an entire configuration of an alertness device of an embodiment of the present invention.
FIG. 2 is a flow chart of an example of alertness determination processing.
FIG. 3 is a graph of a pattern of an electrocardiographic waveform.
FIG. 4 is a graph of a chronological change in an RRI, and shows, as an anchor, each point where in comparison between RRIs at adjacent time points, a latter one of the RRIs is shorter than a former one of the RRIs.
FIG. 5 is a graph in which the same number of waveforms as that of the anchors of FIG. 4 are replicated, and the

time axes at the anchor points of the replicated waveforms are aligned to each other.

FIG. 6 is a graph of PRSA signals obtained in such a manner that the waveforms of the FIG. 5 are averaged for each index.

Fig. 7A is a graph of an RRI and an RRIm as an average of RRIs for every 60 seconds, and Fig. 7B is a graph of an AC, an ACm as an average of ACs for every 60 seconds, and the value obtained by multiplying an ACm (t) as an average of ACs for 60 seconds by α.

FIG. 8 is a graph of a change in subject's RRIm and ACm in continuous curve traveling.

FIG. 9 is a graph of a change in subject's RRIm and ACm in highway traveling.

FIG. 10 is a flow chart of an example of alertness maintenance processing.

DESCRIPTION OF EMBODIMENTS

[0036] An alertness device, a seat including the alertness device, and an alertness determination method according to an embodiment of the present invention will be specifically described below with reference to attached drawings.

[0037] First, an alertness device 10 of the present embodiment will be described with reference to FIG. 1. FIG. 1 is a view of an entire configuration of the alertness device 10 of the embodiment of the present invention.

[0038] The alertness device 10 of the present embodiment is configured to determine the alertness of a seated passenger based on a potential difference signal for a heart rate. As illustrated in FIG. 1, the alertness device 10 of the present embodiment mainly includes a vehicle seat S having, in a seat back 2, two sheet-shaped heart rate sensors 20 and a vibration motor M, and a control device 70 connected to the heart rate sensors 20 via a signal processing circuit 30 to control the vibration motor M.

[0039] The vehicle seat S includes a seat cushion 1 on which the passenger is seated, and the seat back 2 serving as a back rest of the seated passenger. In the vehicle seat S, the heart rate sensors 20 and the vibration motor M are provided close to a seated passenger side in the seat back 2.

[0040] Each heart rate sensor 20 is a capacitive sensor, and is capacitive-coupled to the seated passenger to detect the body potential of the seated passenger. Each heart rate sensor 20 is formed of a conductive metal conductor, conductive fibers, or a conductive fabric tape.

[0041] The signal processing circuit 30 is connected to the heart rate sensors 20 and the control device 70. The signal processing circuit 30 has the function of amplifying the body potential detected by the heart rate sensors 20, outputting a potential difference signal, removing noise of the potential difference signal other than an electrocardiographic frequency, and converting the potential difference signal into a digital signal.

[0042] The control device 70 includes a storage unit 72 including a not-shown RAM, a waveform generation unit 73a functioning by execution of a program stored in the not-shown ROM by a not-shown CPU and configured to generate voltage waveform data, a calculation unit 73b configured to perform data calculation for alertness determination, a determination unit 73c configured to determine alertness, and a driver 73d configured to drive the vibration motor M.

[0043] The storage unit 72 is configured to temporarily store parameters contained in a signal under arithmetic control and input and output signals and to store the potential difference signal converted into the digital signal and other signals in the present embodiment.

[0044] The waveform generation unit 73a is configured to generate the voltage waveform data from the potential difference signal obtained from the heart rate sensors 20.

[0045] The calculation unit 73b is configured to perform later-described calculation based on the voltage waveform data generated by the waveform generation unit 73a.

[0046] The determination unit 73c is configured to use, as an indicator, the data calculated by the calculation unit 73b to determine the alertness.

[0047] The driver 73d is configured to drive the vibration motor M according to the determination of the seated passenger's alertness being lowered to provide vibratory stimulation to the seated passenger.

<Alertness Determination Processing>

[0048] Next, a calculation method in the alertness determination processing by the alertness device 10 configured as described above will be specifically described with reference to FIGS. 2 to 7. Note that the alertness maintenance processing by the alertness device 10 will be described later.

[0049] FIG. 2 is a flow chart of an example of the alertness determination processing, and FIG. 3 is a graph of a pattern of an electrocardiographic waveform.

[0050] Further, FIG. 4 is a graph of a chronological change in an RRI. FIG. 4 shows, as an anchor, each point where in comparison between RRIs at adjacent time points, a latter one of the RRIs is shorter than a former one of the RRIs. FIG. 5 illustrates the state in which the same number of waveforms as that of the anchors of FIG. 4 are replicated and the time axes at the anchor points of the replicated waveforms are aligned to each other. FIG. 6 is a graph of PRSA signals obtained in such a manner that the waveforms of the FIG. 5 are averaged for each index.

[0051] Further, Fig. 7A is a graph of an RRI and an RRIm as an average of RRIs for every 60 seconds, and Fig. 7B is a graph of an AC, an ACm as an average of ACs for every 60 seconds, and the value obtained by multiplying an ACm (t) as the average of ACs for 60 seconds by α.

[0052] The alertness determination processing of the present embodiment is the processing executed using, as an indicator for alertness determination, a later-described acceleration capacity (AC) which tends to be lower in association with sympathetic nerve activation occurring at an initial stage in an alertness decrease to intentionally shake off drowsiness.

[0053] The details of each processing step will be described with reference to the flow of the alertness determination processing of the present embodiment. First, each heart rate sensor 20 responds to start of an engine of a vehicle or pressing of a not-shown start switch to detect a potential signal corresponding to the body potential of the seated passenger.

[0054] The potential signals detected by the heart rate sensors 20 are, as potential difference data, stored in the storage unit 72 of the control device 70 via the signal processing circuit 30. That is, the control device 70 obtains the potential difference data on the heart rate of the seated passenger (step S11).

[0055] Next, based on the potential difference data obtained by the heart rate sensors 20, the waveform generation unit 73a generates electrocardiographic waveform data taking a potential difference and a time as axes as illustrated in FIG. 3 (step S12).

[0056] Next, the calculation unit 73b calculates, from the generated electrocardiographic waveform data, an RRI as a time interval between adjacent R-waves each instantaneously showing a waveform with a great potential difference. As illustrated in Fig. 7A, the calculation unit 73b calculates an average RRIm of RRIs for every 60-second interval.

[0057] Next, the determination unit 73c compares between an RRIm (t) calculated for a certain interval and an RRIm (t + 1) calculated for the subsequent interval, and then, determines whether or not the RRIm (t + 1) is less than the next preceding RRIm (t) (step S13).

[0058] When it is determined that the RRIm (t +1) is less than the RRIm (t) ("Yes" at step S13), the calculation unit 73b calculates phase-rectified signal averaging (PRSA) signals (step S14). When the RRIm (t + 1) is equal to or greater than the RRIm (t) ("No" at step S13), the determination unit 73c determines that the seated passenger is in an alert state (step S18).

[0059] The PRSA signal is the signal obtained in such a manner that partial time-series averaging is performed for selected RRIs for a predetermined time period based on predetermined RRI change points.

[0060] The method for calculating the PRSA signals will be specifically described with reference to FIGS. 4 to 6. FIGS. 4 to 6 are graphs where an RRI is taken as the vertical axis and an index indicating a chronological order is taken as the horizontal axis.

[0061] As illustrated in FIG. 4, in a graph including 10 points of RRIs (i.e., a graph of RRIs based on the data on 11 heart beats), each point where a certain RRI is shorter than the next preceding RRI is taken as an anchor $\gamma 1$, $\gamma 2$, $\gamma 3$.

[0062] Note that in order to reduce the influence of false data detection, an RRI(s) decreased from the next preceding RRI by the value exceeding 5% is excluded from the candidates for anchor.

[0063] Next, as illustrated in FIG. 5, the same number of graphs each connecting the RRIs as that of the anchors $\gamma 1$, $\gamma 2$, $\gamma 3$, i.e., three graphs in the present embodiment, are replicated. Then, the graphs each connecting the RRIs are moved parallel to the horizontal axis direction, and are aligned to each other such that the indices for the anchors $\gamma 1$, $\gamma 2$, $\gamma 3$ in the horizontal axis are in phase with each other. Then, an RRI average is calculated for each index in the horizontal axis, and the RRI averages for the indices are connected together to obtain the PRSA signals illustrated in FIG. 5 and enlarged in FIG. 6. With the PRSA signals obtained by setting of the anchors $\gamma 1$, $\gamma 2$, $\gamma 3$ and averaging for each index, the change pattern exhibiting the common characteristics between before and after an instantaneous heart rate decrease.

[0064] In the description made below, the anchors $\gamma 1$, $\gamma 2$, $\gamma 3$ aligned to be in phase with each other are simply referred to as "anchors γ." Note that for the sake of easy understanding, it has been described above that the PRSA signals are calculated from three graphs each connecting the RRIs. However, the PRSA signals illustrated in FIG. 5 are an example of the signals obtained in such a manner that more graphs each connecting RRIs are replicated and synthesized together.

[0065] Next, the calculation unit 73b calculates an AC based on the calculated PRSA signals (step S15).

[0066] The AC is for quantification of sympathetic nerve activity by analysis of a decrease in an averaged RRI based on PRSA signals. The AC is the value defined by the following formula 2, where a PRSA signal at a certain anchor γ is defined as "X(0)," a PRSA signal at the next succeeding anchor γ of the certain anchor γ is defined as "X(1)," a PRSA signal at the next preceding anchor γ of the certain anchor γ is defined as "X(-1)," and a PRSA signal at the point right before the X(-1) is defined as "X(-2)."

[Formula 2]

$$AC = \frac{X(0)+X(1)-X(-1)-X(-2)}{4}$$

[0067] The above-described four points of the PRSA signals are used for AC calculation, and the calculated AC is sufficient to show the decreasing trend between adjacent RRIs. However, the present invention is not limited to four points, and more points may be used to calculate the AC.

[0068] Next, an AC average is calculated for every 60-second interval, and is compared between adjacent intervals. Specifically, when AC averages for adjacent intervals are represented by ACm (t) and ACm (t + 1) as illustrated in Fig. 7B, the α-fold of the former ACm (t) is compared with the latter ACm (t + 1) (step S16). The factor α is 1.0 to 2.0, and more preferably 1.4.

[0069] When the comparison shows that the ACm (t + 1) is less than the α-fold of the ACm (t) ("Yes" at step S16), it is determined that the seated passenger is in an unalert state (step S17). On the other hand, when the ACm (t + 1) is equal to or greater than the α-fold of the ACm (t) ("No" at step S16), it is determined that the seated passenger is in the alert state (step S18).

[0070] Finally, the control device 70 determines whether or not there is a processing termination instruction made by, e.g., pressing of a not-shown stop switch by the seated passenger (step S19). When there is no instruction ("No" at step S19), the process returns to the step S11 of obtaining the potential difference data. When there is the processing termination instruction ("Yes" at step S19), the process is terminated.

[0071] In the alertness determination processing, the seated passenger is, as a comprehensive evaluation, not determined as being in the unalert state when both of the following conditions are not particularly satisfied: the condition where the RRIm (t + 1) is less than the RRIm (t) at step S13; and the condition where the ACm (t + 1) is less than the α-fold of the ACm (t) at step S16.

[0072] Note that the interval for which the RRIm as the RRI average is calculated at step S13 and the interval for which the ACm as the AC average is calculated at step S16 are each 60 seconds. However, the present invention is not limited to the 60-second interval. Each of these intervals may be a 20- to 300-second interval. A longer interval results in a longer delay in alertness determination. However, the number of data pieces extracted for averaging each parameter increases, and therefore, the reliability of alertness determination increases.

<Specific Example of Alertness Determination>

[0073] Next, the flow of the above-described alertness determination processing while the vehicle including the alertness device 10 is being operated will be specifically described with reference to measurement data shown in FIGS. 8 and 9.

[0074] FIG. 8 is a graph of a change in subject's RRIm and ACm in continuous curve traveling, and FIG. 9 is a graph of a change in subject's RRIm and ACm in highway traveling.

[0075] In these figures, the RRIm shown at each point of the graph is an RRI average obtained for one minute after such a point. Similarly, the ACm shown at each point of the graph is an AC average obtained for one minute after such a point. Particularly in alertness determination of the present measurement process, a constant α for comparison between ACms of adjacent intervals is set at 1.4, and is shown at each graph for alertness evaluation.

(Data in Continuous Curve Traveling)

[0076] First, the RRIm in continuous curve traveling will be described. In FIG. 8, the RRIms at the points of two minutes and seven minutes are each surrounded by a dashed circle. As shown in FIG. 8, the RRIm at the point of two minutes, i.e., the point showing the interval right after the interval for the point of one minute, is less than the RRIm at the point of one minute. Moreover, the RRIm at the point of seven minute, i.e., the point showing the interval right after the interval for the point of six minutes, is less than the RRIm at the point of six minutes. That is, the RRIm condition determined as the unalert state is satisfied at the points surrounded by the dashed circles.

[0077] Further, the ACm in continuous curve traveling will be described. The ACm at the point of eight minutes is surrounded by a dashed circle. As shown in FIG. 8, the ACm at the point of eight minutes, i.e., the point showing the interval right after the interval for the point of seven minutes, is less than the α-fold of the ACm at the point of seven minutes. That is, the ACm condition determined as the unalert state is satisfied at the point surrounded by the dashed circle.

[0078] However, if both of the RRIm and ACm conditions determined as the unalert state are not satisfied at the same interval as described above, the seated passenger is not determined as being in the unalert state as the comprehensive evaluation. As a result, the data of FIG. 8 shows that in continuous curve traveling, the subject is not determined as being in the unalert state across the entire intervals. In other words, it is determined that the alert state is maintained.

(Data in Highway Traveling)

[0079] Next, the RRIm in highway traveling will be described. In FIG. 9, the RRIms at the points of two minutes, three minutes, six minutes, and eight minutes from the beginning of measurement are each surrounded by a dashed circle. As shown in FIG. 9, each of the RRIms at the points of two minutes, three minutes, six minutes, and eight minutes, i.e., each point showing the interval right after the interval for the next preceding point, is less than the RRIm at the next preceding point. The RRIm condition determined as the unalert state is satisfied at these points surrounded by the dashed circles.

[0080] Further, the ACm in highway traveling will be described. The ACms at the points of one minute, two minutes, four minutes, and eight minutes from the beginning of measurement are each surrounded by a dashed circle. Each of the ACms at the points of one minute, two minutes, four minutes, and eight minutes, i.e., each point showing the interval right after the interval for the next preceding point, is less than the α-fold of the ACm at the next preceding point. The ACm condition determined as the unalert state is satisfied at these points surrounded by the dashed circles.

[0081] Both of the RRIm and ACm conditions determined as the unalert state are satisfied at the points of two minutes and eight minutes. Thus, in highway traveling, the subject is, as the comprehensive evaluation, determined as being in the unalert state at the points of two minutes and eight minutes.

<Alertness Maintenance Processing>

[0082] Next, the alertness maintenance processing for driving the vibration motor M according to the determination result as the unalert state in the above-described alertness determination processing will be described.

[0083] First, each heart rate sensor 20 responds to start of the engine of the vehicle or pressing of the not-shown start switch to detect a potential signal corresponding to the body potential of the seated passenger.

[0084] The potential signals detected by the heart rate sensors 20 are, as potential difference data, stored in the storage unit 72 of the control device 70 via the signal processing circuit 30. That is, the control device 70 obtains the potential difference data on the heart rate of the seated passenger (step S21).

[0085] Next, based on the potential difference data obtained by the heart rate sensors 20, the waveform generation unit 73a generates electrocardiographic waveform data taking a potential difference and a time as axes as illustrated in FIG. 3 (step S22).

[0086] Next, the calculation unit 73b calculates, from the generated electrocardiographic waveform data, an RRI as a time interval between adjacent R-waves each instantaneously showing a waveform with a great potential difference. As illustrated in Fig. 7A, the calculation unit 73b calculates an average RRIm of RRIs for every 60-second interval.

[0087] Next, the determination unit 73c compares between a certain calculated RRIm (t) and an RRIm (t + 1) calculated as an average for the next 60-second interval, and then, determines whether or not the RRIm (t + 1) is less than the next preceding RRIm (t) (step S23).

[0088] When the determination unit 73c determines that the RRIm (t +1) is equal to or greater than the RRIm (t) ("No" at step S23), the process returns to step S21 of obtaining the potential difference data. When the determination unit 73c determines that the RRIm (t + 1) is less than the RRIm (t) ("Yes" at step S23), the calculation unit 73b calculates PRSA signals (step S24).

[0089] Further, the calculation unit 73b calculates an AC based on the calculated PRSA signals (step S25).

[0090] Next, an AC average is calculated for every 60-second interval, and is compared between adjacent intervals. Specifically, when AC averages for adjacent intervals are represented by ACm (t) and ACm (t + 1) as illustrated in Fig. 7B, the α-fold of the former ACm (t) is compared with the latter ACm (t + 1) (step S26). The factor α is 1.0 to 2.0, and more preferably 1.4.

[0091] When the comparison shows that the ACm (t + 1) is equal to or greater than the α-fold of the ACm (t) ("No" at step S26), the process returns to the step S21 of obtaining the potential difference data. On the other hand, when the ACm (t + 1) is less than the α-fold of the ACm (t) ("Yes" at step S26), the driver 73d drives the vibration motor M (step S27).

[0092] The driver 73d continuously drives the vibration motor M for a predetermined period of time (step S28), and then, stops the vibration motor M (step S29).

[0093] Finally, the control device 70 determines whether or not there is a processing termination instruction made by, e.g., pressing of the not-shown stop switch by the seated passenger (step S30). When there is no instruction ("No" at step S30), the process returns to the step S21 of obtaining the potential difference data. When there is the processing termination instruction ("Yes" at step S30), the process is terminated.

[0094] When the RRIm and ACm conditions indicating lowering of the alertness of the seated passenger are satisfied, the vibration motor M can be driven to provide stimulation to the seated passenger in the alertness maintenance processing. Thus, the alertness of the seated passenger can be effectively maintained.

[0095] Note that the interval for which the RRIm as the RRI average is calculated at step S23 and the interval for which the ACm as the AC average is calculated at step S26 are each 60 seconds. However, the present invention is not limited to the 60-second interval. Each of these intervals may be a 20- to 300-second interval. A longer interval results in a longer delay in alertness determination. However, the number of data pieces extracted for averaging each parameter increases, and therefore, the reliability of alertness determination increases.

[0096] In the above-described embodiment, the ACm as the comparison target in alertness determination is compared between adjacent intervals in alertness determination, the ACm being the average obtained by division by a constant of four, i.e., the number of indices X(1), X(-1), X(0), X(-2) of the PRSA signals. In the case where the AC is compared between adjacent intervals, the common constant, i.e., a constant of four, is presented between adjacent intervals. For this reason, a constant of four as the denominator of the formula for defining the AC is not necessarily required. Thus, the AC average is not compared between adjacent intervals, but an average of ACn defined by the following formula may be compared.

[Formula]

$$ACn = X(0) + X(1) - X(-1) - X(-2)$$

[0097] In the present embodiment, the alertness device, the seat, and the alertness determination method according to the present invention have been mainly described.

[0098] Note that the above-described embodiment has been merely set forth as an example for the sake of easy understanding of the present invention, and does not limit the present invention. Change and modification can be made to the present invention without departing from the gist of the present invention. Needless to say, the present invention includes all equivalents.

[0099] For example, in the above-described embodiment, it has been described that when the alertness device determines the seated passenger as being in the unalert state, the vibration motor M provides stimulation to the seated passenger. However, the present invention is not limited to the notification method using stimulation, and the unalert state may be notified by other methods. For example, when the alertness device determines the seated passenger as being in the unalert state, alarm sound may be emitted from a speaker, or light may be emitted from a light emitter. Further, an image may be displayed on a display placed inside the vehicle.

[0100] In the above-described embodiment, the vehicle seat which can be mounted on the automobile has been described as a specific example. However, the present invention is not limited to such a vehicle seat. The present invention can be used as a seat for a vehicle such as an airplane or a ship. In addition, the present invention may be employed for seats at movie theaters and stage theaters and seats for relaxation, for example.

REFERENCE SIGNS LIST

[0101]

S: vehicle seat
- 1: seat cushion
- 2: seat back

10: alertness device
- 20: heart rate sensor
- 30: signal processing circuit
- 70: control device
- 72: storage unit
- 73a: waveform generation unit
- 73b: calculation unit
- 73c: determination unit
- 73d: driver

M: vibration motor

Claims

1. An alertness device (10) comprising:

a heart rate sensor (20) configured to measure an electrocardiographic signal of a person;
a waveform generation unit (73a) for generating an electrocardiographic waveform based on the signals meas-

ured with the heart rate sensor (20) and for generating based on the electrocardiographic waveform an RRI waveform being a curve of R-R intervals (RRI) between R-waves depending on the time;
a calculation unit (73b)
for replicating the same number of RRI waveforms as that of anchors, each anchor being a point where a certain R-R interval (RRI) between R-waves is shorter than a next preceding R-R interval (RRI) between R-waves in the RRI waveform,
for horizontally moving the time axes of the replicated RRI waveforms such that the anchors of the replicated RRI waveforms are in phase with each other on the horizontal axis, and
for calculating a phase-rectified signal averaging signal (PRSA signal), which is an average of the R-R interval (RRI) between R-waves of the replicated RRI waveforms for each index on the horizontal axis; and
a determination unit (73c) configured to determine an alertness of the person, whether the person is in an alert state or an unalert state based on the R-R intervals (RRI) between R-waves and the phase-rectified signal averaging signals (PRSA signals);
wherein the waveform generation unit (73a) generates a PRSA signal waveform based on the phase-rectified signal averaging signals (PRSA signals);
the calculation unit (73b) calculates in a predetermined time period in the RRI waveform an average value of the R-R intervals (RRI) between R-waves and an average of an ACn,
wherein the ACn is defined by the following formula (1):

[Formula 1]

$$ACn = X(0) + X(1) - X(-1) - X(-2),$$

where in the generated PRSA signal waveform, a PRSA signal at a certain index is defined by X(0), a PRSA signal for a heart rate at a next succeeding index of the certain index is defined by X(1), a PRSA signal for the heart rate at a next preceding index of the certain index is defined by X(-1), and a PRSA signal for the heart rate at a next preceding index of the index at which the X(-1) is obtained is defined by X(-2); and
the determination unit (73c) determines that the person is in the unalert state if it is the case that the average value of the R-R intervals (RRI) between R-waves in a subsequent predetermined time period less than an average value of the R-R intervals (RRI) between R-waves in a predetermined time period directly previous to the subsequent predetermined time period, and if it is the case that the ACn average of the subsequent predetermined time period is less than a value which is obtained by multiplying the ACn average of the predetermined time period directly previous to the subsequent predetermined time period by an α value.

2. The alertness device (10) of claim 1, wherein the α value is 1.0 to 2.0.

3. The alertness device (10) of claim 1 or 2,
wherein the calculation unit (73b) is adapted to calculate the average value of the R-R intervals (RRI) between R-waves and the average of the ACn, for every 20- to 300-second interval, and
wherein the determination unit (73c) is adapted to determine the alertness of the person based on average value of the R-R intervals (RRI) between R-waves and the average of the ACn calculated by the calculation unit (73b).

4. The alertness device (10) of claim 1, wherein the α value is 1.4.

5. The alertness device (10) of claim 3, wherein the calculation unit (73b) is adapted to calculate the average value of the R-R intervals (RRI) between R-waves and the average of the ACn, for every 60-second interval.

6. The alertness device (10) of any one of claims 1 to 5, further comprising:

a notification device configured for notification to the person or one or more persons therearound; and
a driver configured to drive the notification device to notify the person or the one or more persons therearound of the determination unit having determined that the person is in the unalert state.

7. A seat (S) comprising:

a seat cushion (1) on which a passenger is seated;
a seat back (2) as a back rest of the seated passenger; and

the alertness device of any one of the foregoing claims,
wherein the heart rate sensor (20) is disposed in the seat back (2).

8. A method for determining alertness with an alertness device (10), the method comprising the steps of:

measuring an electrocardiographic signal;
generating an electrocardiographic waveform based on the measured electrocardiographic signal; generating based on the electrocardiographic waveform an RRI waveform being a curve of R-R intervals (RRI) between R-waves depending on the time;
replicating the same number of RRI waveforms as that of anchors, each anchor being a point where a certain R-R interval (RRI) between R-waves is shorter than a next preceding R-R interval (RRI) between R-waves in the RRI waveform;
horizontally moving the time axes of the replicated RRI waveforms such that the anchors of the replicated RRI waveforms are in phase with each other on the horizontal axis;
calculating a phase-rectified signal averaging signal (PRSA signal), which is an average of the R-R interval (RRI) between R-waves of the replicated RRI waveforms for each index on the horizontal axis;
and determining an alertness of the person, whether the person is in an alert state or an unalert state based on the R-R intervals (RRI) between R-waves and the phase-rectified signal averaging signals (PRSA signals),
wherein the method further comprises the steps of
generating a PRSA signal waveform based on the phase-rectified signal averaging signals (PRSA signals);
calculating in a predetermined time period in the RRI waveform an average value of the R-R intervals (RRI) between R-waves and an average of an ACn,
wherein the ACn is defined by the following formula (1):

[Formula 1]

$$ACn = X(0) + X(1) - X(-1) - X(-2),$$

where in the generated PRSA signal waveform, a PRSA signal at a certain index is defined by X(0), a PRSA signal for a heart rate at a next succeeding index of the certain index is defined by X(1), a PRSA signal for the heart rate at a next preceding index of the certain index is defined by X(-1), and a PRSA signal for the heart rate at a next preceding index of the index at which the X(-1) is obtained is defined by X(-2); and
determining that the person is in the unalert state if it is the case that the average value of the R-R intervals (RRI) between R-waves in a subsequent predetermined time period less than an average value of the R-R intervals (RRI) between R-waves in a predetermined time period directly previous to the subsequent predetermined time period, and if it is the case that the ACn average of the subsequent predetermined time period is less than a value which is obtained by multiplying the ACn average of the predetermined time period directly previous to the subsequent predetermined time period by an α value.

Patentansprüche

1. Aufmerksamkeitsvorrichtung (10), umfassend:

einen Herzfrequenzsensor (20), der konfiguriert ist zum Messen eines elektrokardiographischen Signals einer Person,
eine Wellenformerzeugungseinheit (73a) zum Erzeugen einer elektrokardiographischen Wellenform basierend auf den mit dem Herzfrequenzsensor (20) gemessenen Signalen und zum Erzeugen, basierend auf der elektrokardiographischen Wellenform, einer RRI-Wellenform, die eine Kurve von R-R-Intervallen (RRIs) zwischen R-Wellen in Abhängigkeit von der Zeit ist,
eine Berechnungseinheit (73b):

zum Replizieren einer der Anzahl von Ankern entsprechenden Anzahl von RRI-Wellenformen, wobei jeder Anker ein Punkt ist, an dem ein bestimmtes R-R-Intervall (RRI) zwischen R-Wellen kürzer als ein unmittelbar vorausgehendes R-R-Intervall (RRI) zwischen R-Wellen in der RRI-Wellenform ist,
zum horizontalen Bewegen der Zeitachsen der replizierten RRI-Wellenformen derart, dass die Anker der replizierten RRI-Wellenformen in Phase miteinander auf der horizontalen Achse sind, und

zum Berechnen eines ein phasengleichgerichtetes Signal mittelnden Signals (PRSAA-Signals), das ein Durchschnitt des R-R-Intervalls (RRI) zwischen R-Wellen der replizierten RRI-Wellenformen für jeden Index auf der horizontalen Achse ist, und

eine Bestimmungseinheit (73c), die konfiguriert ist zum Bestimmen der Aufmerksamkeit der Person, d.h. ob sich die Person in einem aufmerksamen Zustand oder einem unaufmerksamen Zustand befindet, basierend auf den R-R-Intervallen (RRIs) zwischen R-Wellen und den ein phasengleichgerichtetes Signal mittelnden Signalen (PRSA-Signalen),
wobei die Wellenformerzeugungseinheit (73a) eine PRSA-Signal-Wellenform basierend auf den ein phasengleichgerichtetes Signal mittelnden Signalen (PRSA-Signalen) erzeugt,
wobei die Berechnungseinheit (73b) in einer vorbestimmten Zeitperiode in der RRI-Wellenform einen durchschnittlichen Wert der R-R-Intervalle (RRIs) zwischen R-Wellen und einen Durchschnitt von ACn berechnet, wobei ACn durch die folgende Formel (1) definiert wird:

[Formel 1]

$$ACn = X(0) + X(1) - X(-1) - X(-2)$$

wobei in der erzeugten PRSA-Signalwellenform ein PRSA-Signal mit einem bestimmten Index durch X(0) definiert wird, ein PRSA-Signal für eine Herzfrequenz mit einem auf den bestimmten Index unmittelbar folgenden Index durch X(1) definiert wird, ein PRSA-Signal für die Herzfrequenz mit dem zu dem bestimmten Index unmittelbar vorausgehenden Index durch X(-1) definiert wird und ein PRSA-Signal für die Herzfrequenz mit dem zu dem Index, bei dem X(-1) erhalten wird, unmittelbar vorausgehenden Index durch X(-2) definiert wird, und die Bestimmungseinheit (73c) bestimmt, dass sich die Person in einem unaufmerksamen Zustand befindet, wenn der durchschnittliche Wert der R-R-Intervalle (RRIs) zwischen R-Wellen in einer folgenden vorbestimmten Zeitperiode kleiner als ein durchschnittlicher Wert der R-R-Intervalle (RRIs) zwischen R-Wellen in einer vorbestimmten Zeitperiode direkt vor der folgenden vorbestimmten Zeitperiode ist und wenn der ACn-Durchschnitt der folgenden vorbestimmten Zeitperiode kleiner als ein Wert ist, der erhalten wird, indem der ACn-Durchschnitt der vorbestimmten Zeitperiode, die der folgenden vorbestimmten Zeitperiode direkt vorausgeht, mit einem α-Wert multipliziert wird.

2. Aufmerksamkeitsvorrichtung (10) nach Anspruch 1, wobei der α-Wert 1,0 bis 2,0 ist.

3. Aufmerksamkeitsvorrichtung (10) nach Anspruch 1 oder 2, wobei:

die Berechnungseinheit (73b) ausgebildet ist zum Berechnen des durchschnittlichen Werts der R-R-Intervalle (RRIs) zwischen R-Wellen und des Durchschnitts von ACn für jedes 20- bis 300-Sekunden-Intervall, und
die Bestimmungseinheit (73c) ausgebildet ist zum Bestimmen der Aufmerksamkeit der Person basierend auf dem durchschnittlichen Wert der R-R-Intervalle (RRIs) zwischen R-Wellen und dem Durchschnitt von ACn, die jeweils durch die Berechnungseinheit (73b) berechnet wurden.

4. Aufmerksamkeitsvorrichtung (10) nach Anspruch 1, wobei der α-Wert gleich 1,4 ist.

5. Aufmerksamkeitsvorrichtung (10) nach Anspruch 3, wobei die Berechnungseinheit (73b) ausgebildet ist zum Berechnen des durchschnittlichen Werts der R-R-Intervalle (RRIs) zwischen R-Wellen und des Durchschnitts von ACn für jedes 60-Sekunden-Intervall.

6. Aufmerksamkeitsvorrichtung (10) nach einem der Ansprüche 1 bis 5, die weiterhin umfasst:

eine Benachrichtigungseinrichtung, die konfiguriert ist für eine Benachrichtigung an die Person oder an eine oder mehrere Person in der Umgebung, und
einen Treiber, der konfiguriert ist zum Treiben der Benachrichtigungseinrichtung für das Benachrichtigen der Person oder der einen oder der mehreren Personen in der Umgebung, wenn die Bestimmungseinheit bestimmt hat, dass sich die Person in einem unaufmerksamen Zustand befindet.

7. Sitz (S), der umfasst:

ein Sitzpolster (1), auf dem ein Insasse sitzt,
eine Sitzlehne (2) als eine Rückenlehne für den sitzenden Insassen, und
die Aufmerksamkeitsvorrichtung gemäß einem der vorstehenden Ansprüche,
wobei der Herzfrequenzsensor (20) in der Sitzlehne (2) angeordnet ist.

8. Verfahren zum Bestimmen der Aufmerksamkeit mittels einer Aufmerksamkeitsvorrichtung (10), wobei das Verfahren die folgenden Schritte umfasst:

Messen eines elektrokradiographischen Signals,
Erzeugen einer elektrokardiographischen Wellenform basierend auf dem gemessenen elektrokardiographischen Signal,
Erzeugen, basierend auf der elektrokardiographischen Wellenform, einer RRI-Wellenform, die eine Kurve von R-R-Intervallen (RRIs) zwischen R-Wellen in Abhängigkeit von der Zeit ist,
Replizieren einer der Anzahl von Ankern entsprechenden Anzahl von RRI-Wellenformen, wobei jeder Anker ein Punkt ist, an dem ein bestimmtes R-R-Intervall (RRI) zwischen R-Wellen kürzer als ein unmittelbar vorausgehendes R-R-Intervall (RRI) zwischen R-Wellen in der RRI-Wellenform ist,
horizontales Bewegen der Zeitachsen der replizierten RRI-Wellenformen derart, dass die Anker der replizierten RRI-Wellenformen in Phase miteinander auf der horizontalen Achse sind, und
Berechnen eines ein phasengleichgerichtetes Signal mittelnden Signals (PRSAA-Signals), das ein Durchschnitt des R-R-Intervalls (RRI) zwischen R-Wellen der replizierten RRI-Wellenformen für jeden Index auf der horizontalen Achse ist, und
Bestimmen der Aufmerksamkeit der Person, d.h. ob sich die Person in einem aufmerksamen Zustand oder einem unaufmerksamen Zustand befindet, basierend auf den R-R-Intervallen (RRIs) zwischen R-Wellen und den ein phasengleichgerichtetes Signal mittelnden Signalen (PRSA-Signalen),
wobei das Verfahren weiterhin die folgenden Schritte umfasst:

Erzeugen einer PRSA-Signal-Wellenform basierend auf den ein phasengleichgerichtetes Signal mittelnden Signalen (PRSA-Signalen),
Berechnen, in einer vorbestimmten Zeitperiode in der RRI-Wellenform, eines durchschnittlichen Werts der R-R-Intervalle (RRI) zwischen R-Wellen und eines Durchschnitts von ACn,
wobei ACn durch die folgende Formel (1) definiert wird:

[Formel 1]

$$ACn = X(0) + X(1) - X(-1) - X(-2)$$

wobei in der erzeugten PRSA-Signalwellenform ein PRSA-Signal mit einem bestimmten Index durch X(0) definiert wird, ein PRSA-Signal für eine Herzfrequenz mit einem auf den bestimmten Index unmittelbar folgenden Index durch X(1) definiert wird, ein PRSA-Signal für die Herzfrequenz mit dem zu dem bestimmten Index unmittelbar vorausgehenden Index durch X(-1) definiert wird und ein PRSA-Signal für die Herzfrequenz mit dem zu dem Index, bei dem X(-1) erhalten wird, unmittelbar vorausgehenden Index durch X(-2) definiert wird, und
Bestimmen, dass sich die Person in einem unaufmerksamen Zustand befindet, wenn der durchschnittliche Wert der R-R-Intervalle (RRIs) zwischen R-Wellen in einer folgenden vorbestimmten Zeitperiode kleiner als ein durchschnittlicher Wert der R-R-Intervalle (RRIs) zwischen R-Wellen in einer vorbestimmten Zeitperiode direkt vor der folgenden vorbestimmten Zeitperiode ist und wenn der ACn-Durchschnitt der folgenden vorbestimmten Zeitperiode kleiner als ein Wert ist, der erhalten wird, indem der ACn-Durchschnitt der vorbestimmten Zeitperiode, die der folgenden vorbestimmten Zeitperiode direkt vorausgeht, mit einem α-Wert multipliziert wird.

Revendications

1. Dispositif de vigilance (10) comprenant :

un capteur de fréquence cardiaque (20) configuré pour mesurer un signal d’électrocardiographie d’une personne ;

une unité de génération de forme d'onde (73a) pour générer une forme d'onde d'électrocardiographie sur la base des signaux mesurés avec le capteur de fréquence cardiaque (20) et pour générer sur la base de la forme d'onde d'électrocardiographie une forme d'onde RRI étant une courbe des intervalles R-R (RRI) entre les ondes R en fonction du temps ;
une unité de calcul (73b)
pour répliquer le même nombre de formes d'onde RRI que celles des ancres, chaque ancre étant un point où un certain intervalle R-R (RRI) entre les ondes R est plus court qu'un prochain intervalle R-R précédent (RRI) entre les ondes R dans la forme d'onde RRI,
pour déplacer horizontalement les axes de temps des formes d'onde RRI répliquées de sorte que les ancres des formes d'onde RRI répliquées se trouvent en phase l'une avec l'autre sur l'axe horizontal, et
pour calculer un signal de pondération de signal à phase rectifiée (signal PRSA), qui est une moyenne de l'intervalle R-R (RRI) entre les ondes R des formes d'onde RRI répliquées pour chaque indice sur l'axe horizontal ; et
une unité de détermination (73c) configurée pour déterminer une vigilance de la personne, que la personne se trouve en un état d'alerte ou un état hors alerte sur la base des intervalles R-R (RRI) entre les ondes R et les signaux de pondération de signal à phase rectifiée (signaux PRSA) ;
où l'unité de génération de forme d'onde (73a) génère une forme d'onde de signal PRSA sur la base des signaux de pondération de signal à phase rectifiée (signaux PRSA) ;
l'unité de calcul (73b) calcule une période de temps prédéterminée dans la forme d'onde RRI d'une valeur moyenne des intervalles R-R (RRI) entre les ondes R et une moyenne d'ACn,
ACn étant défini par la formule suivante (1) :

[Formule 1]

$$ACn = X(0) + X(1) - X(-1) - X(-2),$$

où dans la forme d'onde de signal PRSA générée, un signal PRSA à un certain indice est défini par X(0), un signal PRSA pour une fréquence cardiaque à un indice ultérieur suivant du certain indice est défini par X(1), un signal PRSA pour la fréquence cardiaque à un prochain indice précédent du certain indice est défini par X(-1), et un signal PRSA pour la fréquence cardiaque à un prochain indice précédent de l'indice auquel le X(-1) est obtenu est défini par X(-2) ; et
l'unité de détermination (73c) détermine que la personne se trouve sous l'état hors alerte si le cas est que la valeur moyenne des intervalles R-R (RRI) entre les ondes R sur une période de temps prédéterminée ultérieure inférieure à une valeur moyenne des intervalles R-R (RRI) entre les ondes R sur une période de temps prédéterminée directement antérieure à la période de temps prédéterminée ultérieure, et si le cas est que la moyenne d'ACn de la période de temps prédéterminée ultérieure est inférieure à une valeur qui est obtenue en multipliant la moyenne d'ACn de la période de temps prédéterminée directement antérieure à la période de temps prédéterminée ultérieure d'une valeur a.

2. Dispositif de vigilance (10) selon la revendication 1, la valeur α étant 1,0 à 2,0.

3. Dispositif de vigilance (10) selon la revendication 1 ou 2,
l'unité de calcul (73b) étant adaptée pour calculer la valeur moyenne des intervalles R-R (RRI) entre les ondes R et la moyenne d'ACn, pour chaque intervalle de 20 à 300 secondes, et
dans lequel l'unité de détermination (73c) est adaptée pour déterminer la vigilance de la personne sur la base de la valeur moyenne des intervalles R-R (RRI) entre les ondes R et la moyenne d'ACn calculée par l'unité de calcul (73b).

4. Dispositif de vigilance (10) selon la revendication 1, la valeur α étant 1,4.

5. Dispositif de vigilance (10) selon la revendication 3, l'unité de calcul (73b) étant adaptée pour calculer la valeur moyenne des intervalles R-R (RRI) entre les ondes R et la moyenne d'ACn, pour chaque intervalle de 60 secondes.

6. Dispositif de vigilance (10) selon l'une quelconque des revendications 1 à 5, comprenant en outre :

un dispositif de notification configuré pour la notification à la personne ou à une ou plusieurs personnes autour ; et
un dispositif d'entraînement configuré pour entraîner le dispositif de notification à effectuer une notification à la personne ou auxdites personnes autour de l'unité de détermination ayant déterminé que la personne se trouve sous l'état hors alerte.

7. Assise (S) comprenant :

un coussin d'assise (1) sur lequel un passager est assis ;
un dossier d'assise (2) comme repos pour le dos du passager assis ; et
le dispositif de vigilance selon l'une quelconque des revendications précédentes,
le capteur de fréquence cardiaque (20) étant disposé dans le dossier d'assise (2).

8. Procédé de détermination de la vigilance d'un dispositif de vigilance (10), le procédé comprenant les étapes de :

mesure d'un signal d'électrocardiographie ;
génération d'une forme d'onde d'électrocardiographie sur la base du signal d'électrocardiographie mesuré ;
génération sur la base de la forme d'onde d'électrocardiographie d'une forme d'onde RRI qui est une courbe des intervalles R-R (RRI) entre les ondes R en fonction du temps ;
réplication du même nombre de formes d'onde RRI que celles des ancres, chaque ancre étant un point où un certain intervalle R-R (RRI) entre les ondes R est plus court qu'un prochain intervalle R-R précédent (RRI) entre les ondes R dans la forme d'onde RRI ;
déplacement horizontalement des axes de temps des formes d'onde RRI répliquées de sorte que les ancres des formes d'onde RRI répliquées se trouvent en phase l'une avec l'autre sur l'axe horizontal ;
calcul d'un signal de pondération de signal à phase rectifiée (signal PRSA), qui est une moyenne de l'intervalle R-R (RRI) entre les ondes R des formes d'onde RRI répliquées pour chaque indice sur l'axe horizontal ;
et de détermination d'une vigilance de la personne, que la personne se trouve en un état d'alerte ou un état hors alerte sur la base des intervalles R-R (RRI) entre les ondes R et les signaux de pondération de signal à phase rectifiée (signaux PRSA),
le procédé comprenant en outre les étapes de génération d'une forme d'onde de signal PRSA sur la base des signaux de pondération de signal à phase rectifiée (signaux PRSA) ;
calcul sur une période de temps prédéterminée dans la forme d'onde RRI d'une valeur moyenne des intervalles R-R (RRI) entre les ondes R et une moyenne d'ACn,
ACn étant défini par la formule suivante (1) :

[Formule 1]

$$ACn = X(0) + X(1) - X(-1) - X(-2),$$

où dans la forme d'onde de signal PRSA générée, un signal PRSA à un certain indice est défini par X(0), un signal PRSA pour une fréquence cardiaque à un indice ultérieur suivant du certain indice est défini par X(1), un signal PRSA pour la fréquence cardiaque à un prochain indice précédent du certain indice est défini par X(-1), et un signal PRSA pour la fréquence cardiaque à un prochain indice précédent de l'indice auquel le X(-1) est obtenu est défini par X(-2) ; et
la détermination que la personne se trouve sous l'état hors alerte si le cas est que la valeur moyenne des intervalles R-R (RRI) entre les ondes R sur une période de temps prédéterminée ultérieure inférieure à une valeur moyenne des intervalles R-R (RRI) entre les ondes R sur une période de temps prédéterminée directement antérieure à la période de temps prédéterminée ultérieure, et si le cas est que la moyenne d'ACn de la période de temps prédéterminée ultérieure est inférieure à une valeur qui est obtenue en multipliant la moyenne d'ACn de la période de temps prédéterminée directement antérieure à la période de temps prédéterminée ultérieure d'une valeur α.

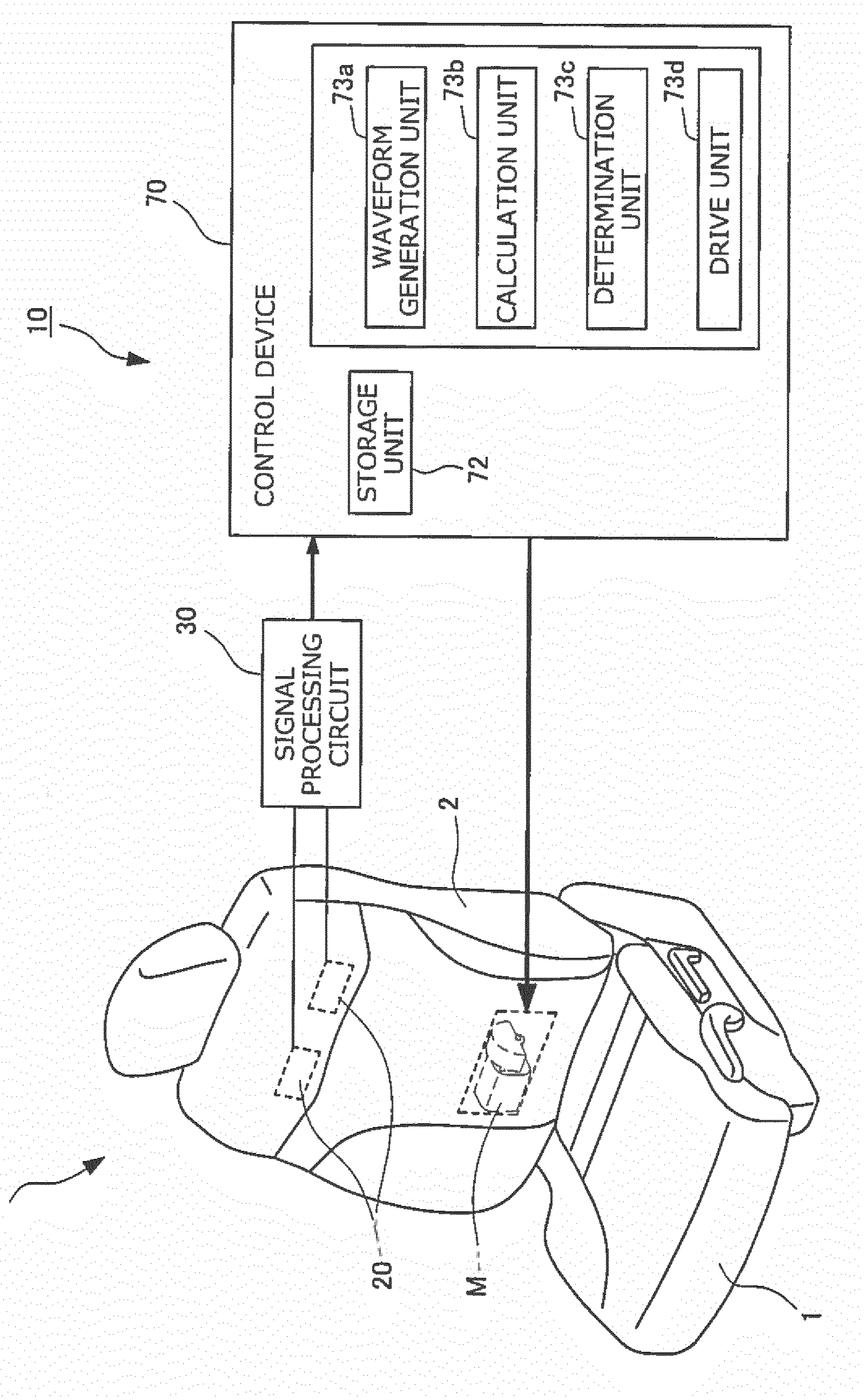

10
70
CONTROL DEVICE
STORAGE UNIT
72
WAVEFORM GENERATION UNIT
73a
CALCULATION UNIT
73b
DETERMINATION UNIT
73c
DRIVE UNIT
73d
30
SIGNAL PROCESSING CIRCUIT
S
2
20
M
1

FIG. 1

FIG. 2

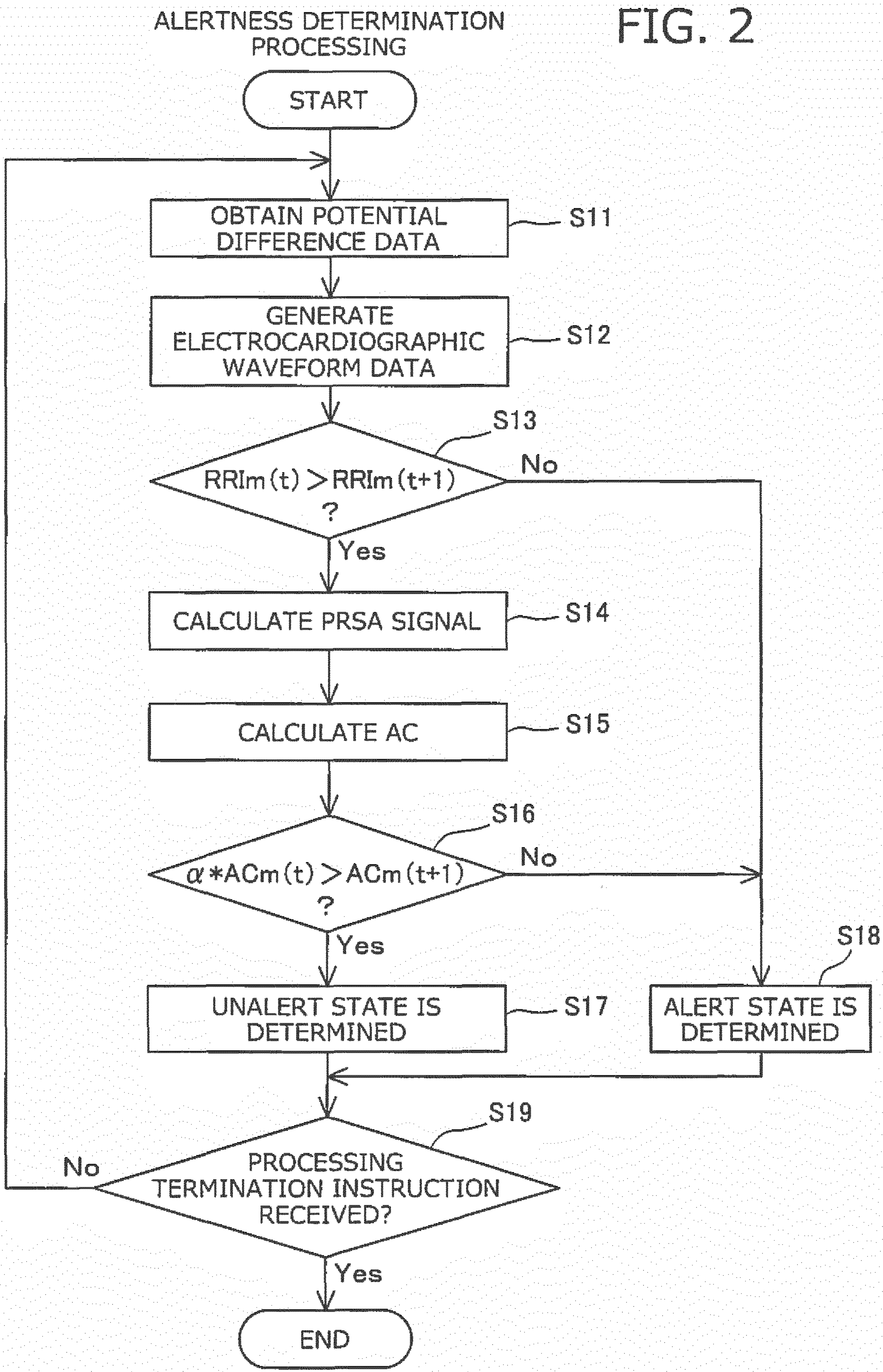
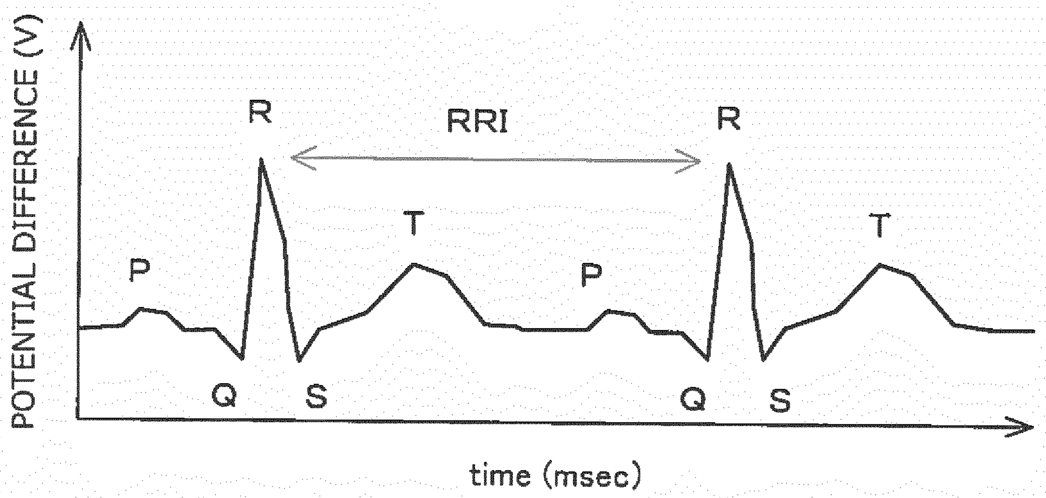
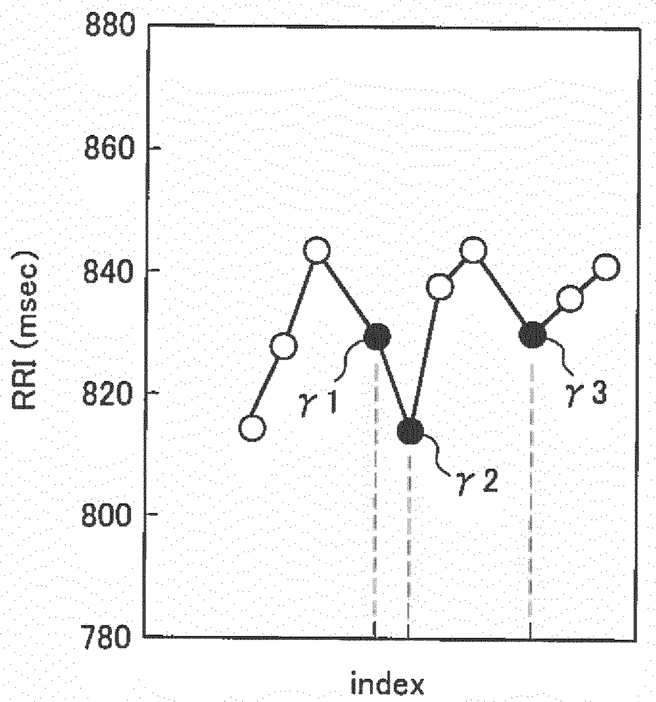

ALERTNESS DETERMINATION PROCESSING
START
OBTAIN POTENTIAL DIFFERENCE DATA
S11
GENERATE ELECTROCARDIOGRAPHIC WAVEFORM DATA
S12
S13
RRIm(t) > RRIm(t+1) ?
No
Yes
CALCULATE PRSA SIGNAL
S14
CALCULATE AC
S15
S16
α*ACm(t) > ACm(t+1) ?
No
Yes
S18
UNALERT STATE IS DETERMINED
S17
ALERT STATE IS DETERMINED
S19
PROCESSING TERMINATION INSTRUCTION RECEIVED?
No
Yes
END

FIG. 3



POTENTIAL DIFFERENCE (V)
R
RRI
R
P
T
P
T
Q
S
Q
S
time (msec)

FIG. 4



880
860
840
820
800
780
RRI (msec)
γ1
γ2
γ3
index

FIG. 5

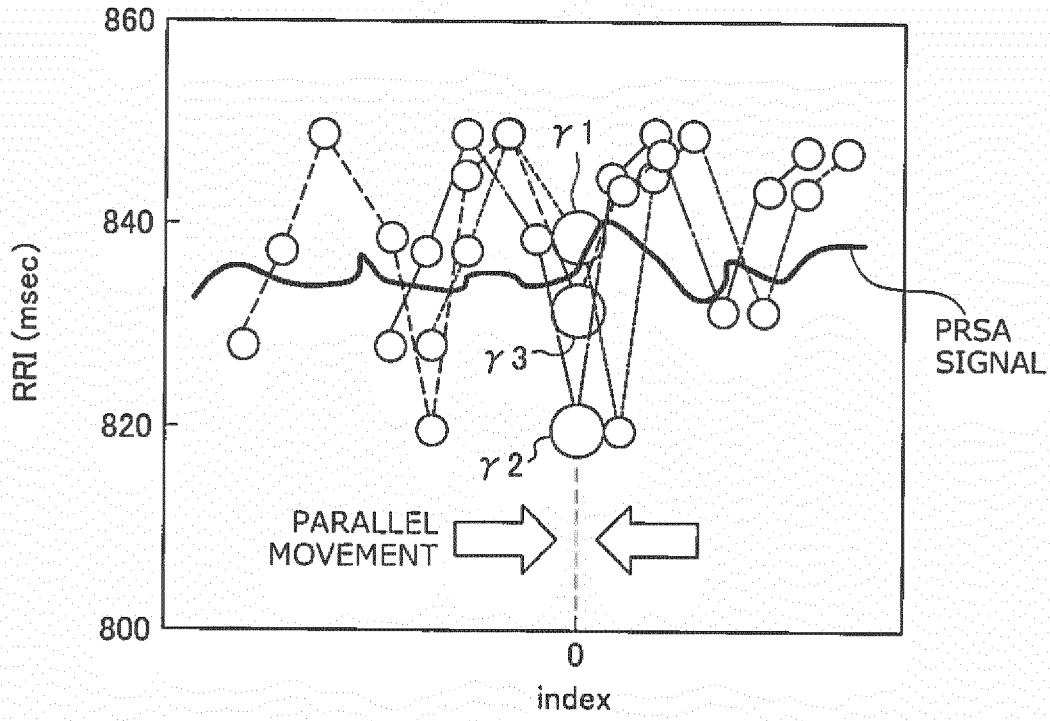

860
840
820
800
RRI (msec)
γ1
γ3
γ2
PRSA
SIGNAL
PARALLEL
MOVEMENT
0
index

FIG. 6

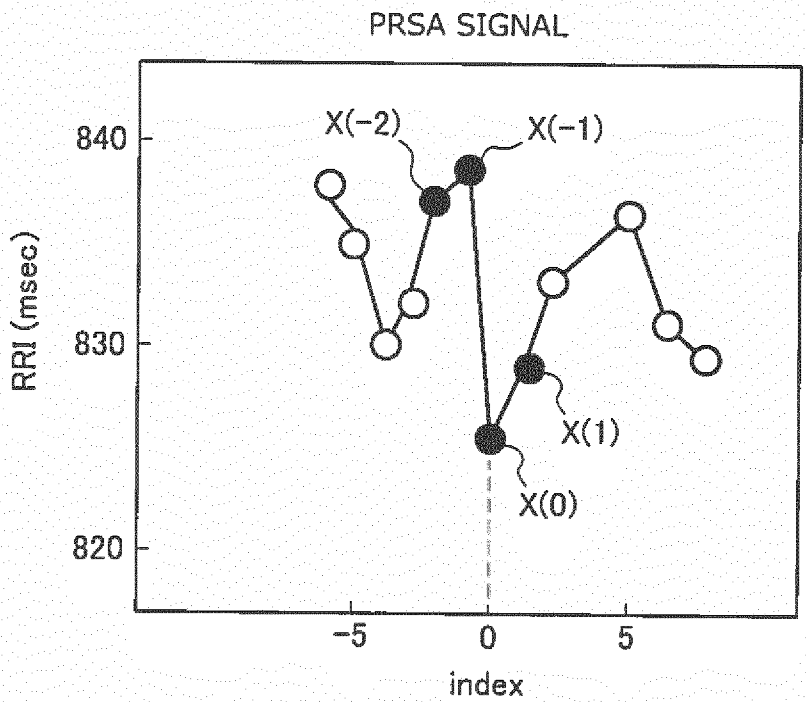
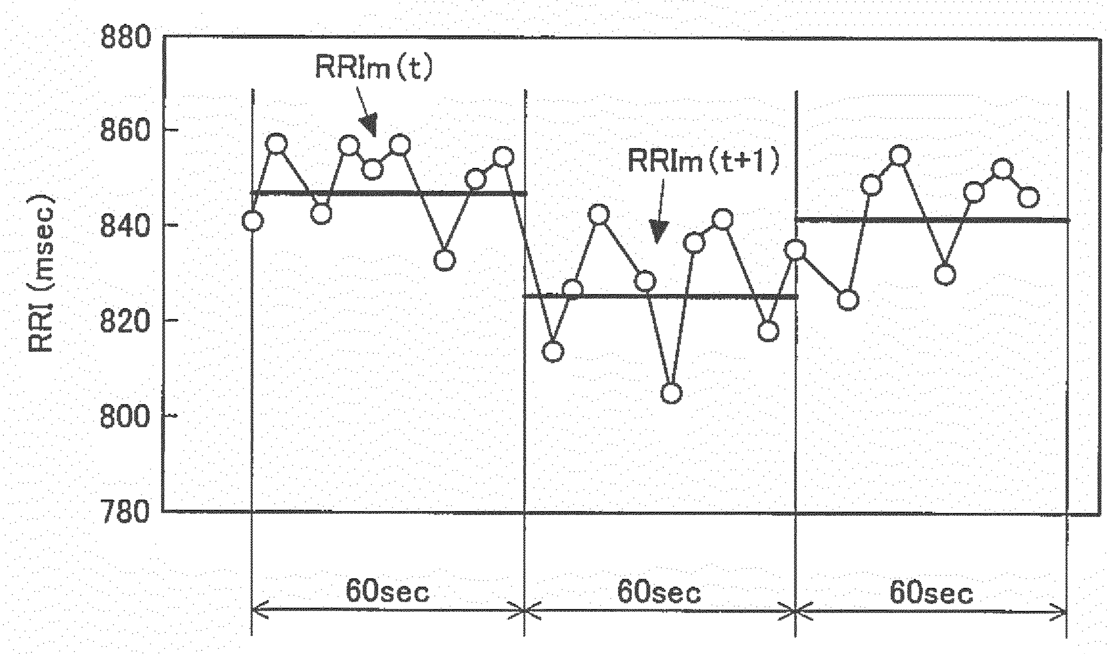

PRSA SIGNAL
840
830
820
RRI (msec)
X(−2)
X(−1)
X(1)
X(0)
−5
0
5
index

FIG. 7

(a) RRIm(t) > RRIm(t+1)



(b) α*ACm(t) > ACm(t+1)

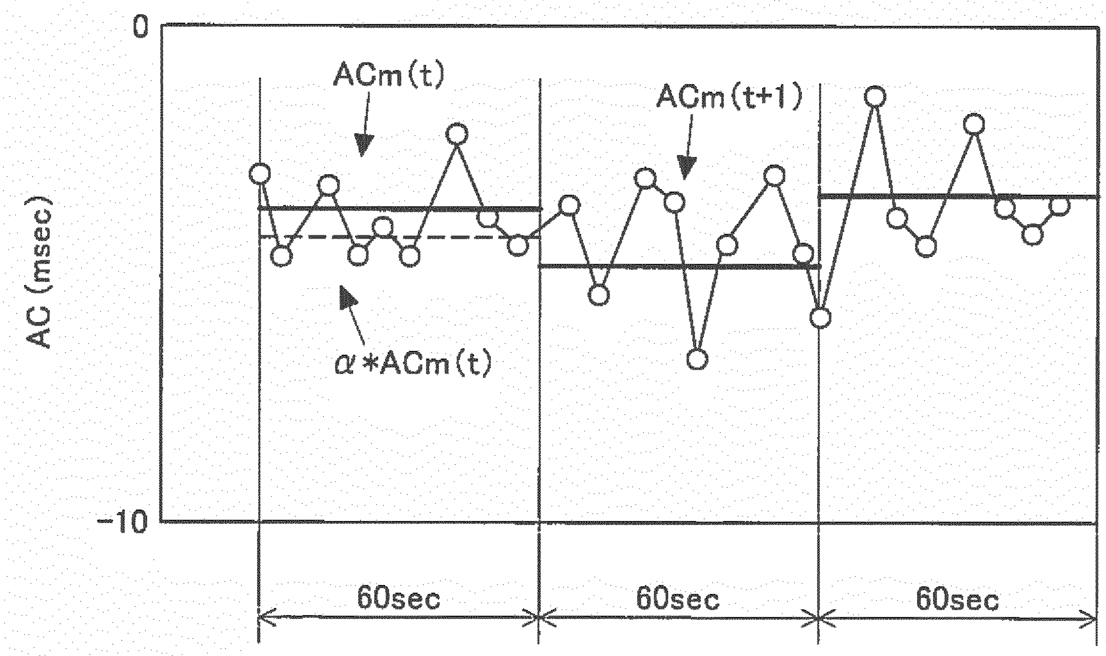


FIG. 8

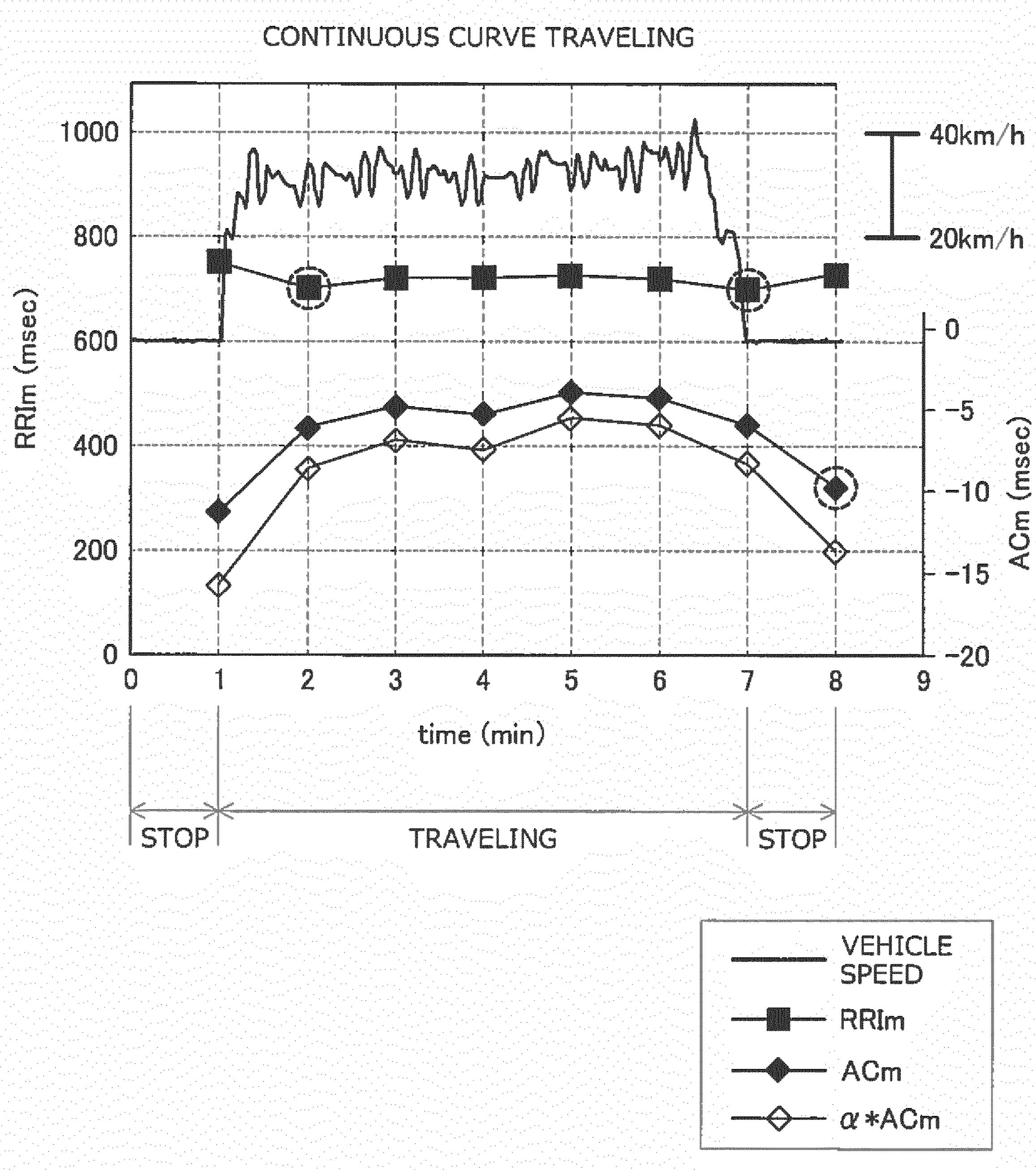

CONTINUOUS CURVE TRAVELING
RRIm (msec)
1000
800
600
400
200
0
40km/h
20km/h
0
-5
-10
-15
-20
ACm (msec)
0
1
2
3
4
5
6
7
8
9
time (min)
STOP
TRAVELING
STOP
VEHICLE SPEED
RRIm
ACm
α*ACm

FIG. 9

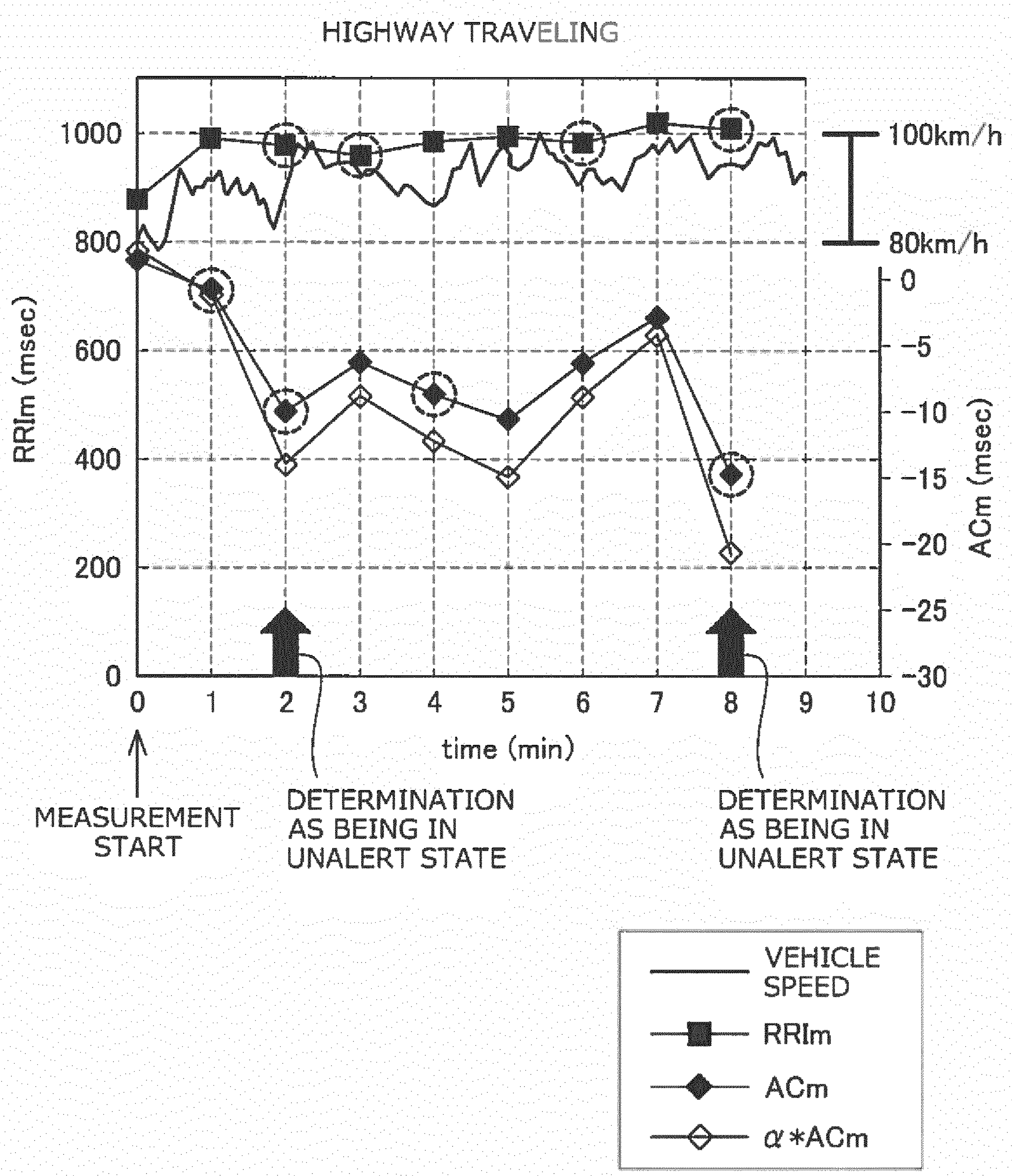
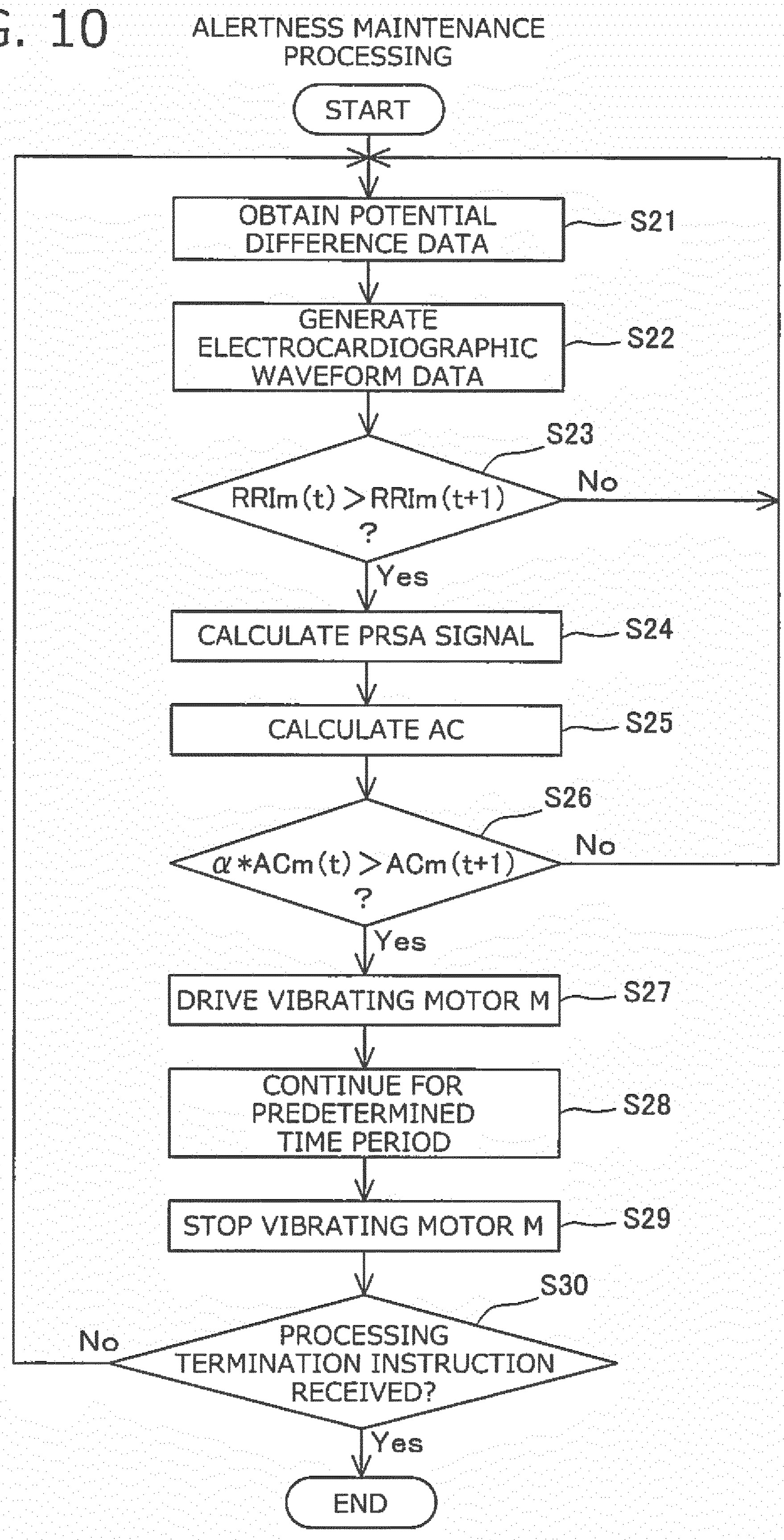

HIGHWAY TRAVELING
1000
800
600
400
200
0
RRIm (msec)
100km/h
80km/h
0
-5
-10
-15
-20
-25
-30
ACm (msec)
0 1 2 3 4 5 6 7 8 9 10
time (min)
MEASUREMENT START
DETERMINATION AS BEING IN UNALERT STATE
DETERMINATION AS BEING IN UNALERT STATE
VEHICLE SPEED
RRIm
ACm
α*ACm

FIG. 10


ALERTNESS MAINTENANCE PROCESSING
START
OBTAIN POTENTIAL DIFFERENCE DATA
S21
GENERATE ELECTROCARDIOGRAPHIC WAVEFORM DATA
S22
S23
RRIm(t) > RRIm(t+1) ?
No
Yes
CALCULATE PRSA SIGNAL
S24
CALCULATE AC
S25
S26
α*ACm(t) > ACm(t+1) ?
No
Yes
DRIVE VIBRATING MOTOR M
S27
CONTINUE FOR PREDETERMINED TIME PERIOD
S28
STOP VIBRATING MOTOR M
S29
S30
PROCESSING TERMINATION INSTRUCTION RECEIVED?
No
Yes
END

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 2009209829 A **[0005]**
- JP 4697185 B **[0006]**
- JP 3271448 B **[0006]**

Non-patent literature cited in the description

- Development of a feedback stimulation for drowsy driver using heartbeat rhythms. **TAKASHI et al.** Engineering in Medicine and Biology Society, EMBC, 2011 Annual International Conference of the IEEE. IEEE, 30 August 2011, 4153-4158 **[0005]**
- Declaration capacity of heart rate as a predictor of mortality after myocardial infarction: cohort study. **BAUER A. et al.** The Lancet. The Lancet Publishing Group, 20 May 2006, 1674-1681 **[0005]**

专利名称(译)	警报装置，座位和用于确定警觉性的方法		
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[标]申请(专利权)人(译)	东京座椅技术股份公司 公立大学法人名古屋市立大学		
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[标]发明人	SUGIYAMA SHINJI ITO TAKAYOSHI YOKOYAMA KIYOKO TAKAHASHI ISSEY		
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CPC分类号	A61B5/02405 A61B5/0245 A61B5/0456 A61B5/168 A61B5/18 A61B5/6893 A61B5/7264 A61B2503/22 B60W40/08 G16H50/20 A61B5/02455		
优先权	2013218702 2013-10-21 JP		
其他公开文献	EP3061396A1 EP3061396A4		
外部链接	Espacenet		

摘要(译)

提供了一种警报装置，其被配置为使得警报确定处理中的负载低并且警报确定的准确度高，包括警报装置的座位和警报确定方法。警觉装置包括：心率传感器，被配置为获得人的心电图信号;计算单元，被配置为计算从心率传感器获得的心电图信号;波形生成单元，被配置为从心电图波形中生成RRI波形。心电图信号和确定单元，被配置为基于心电图信号确定人的警觉性。计算单元复制与锚点相同数量的RRI波形，每个锚点是某个RRI比下一个在前RRI短的点。然后，计算单元移动复制的RRI波形的时间轴，使得复制的RRI波形的锚点彼此同相，并计算定义为每个时间轴的RRI平均值的PRSA信号。确定单元基于RRI和PRSA信号确定人的警觉性。

[Formula 1]

$$ACn = X(0) + X(1) - X(-1) - X(-2),$$