HEALTH CARE APPARATUS

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ABSTRACT

The present invention provides a health care apparatus capable of performing a comfortable head care with a care unit forced on person's head in a suitable manner. The health care apparatus of the invention comprises a first support, a care unit having a contact capable of making contacts with person's head supported by the first support, an arm moving the care unit in a first direction which extends orthogonal to a surface of the person's head and/or a second direction which extends along the surface of the person's head, and a load detector having at least two load sensors arranged in different positions in the second direction for sensing loads applied thereto, the load detector being designed to detect the loads on the contact in the first direction.
Fig. 6

LOAD DETECTOR
51a

LOAD SENSOR
51b

FIRST CALCULATION UNIT
51c

SECOND CALCULATION UNIT
51d

THIRD CALCULATION UNIT
51e

CONTROLLER
14

FIRST DRIVE
13d

SECOND DRIVE
13f

JUDGING SECTION
16

MEMORY
24
Fig. 7A
Fig. 7B

[Diagram with various labeled parts: 32, 12L, 51b, 51a, 54, 52, 13a, 34, 36, 33, 55, Fn2, 21, 60, 52a, FL1, FL2, 34, 13a, 17, 21, 12L, L, C, S, E, (+), (-)].
Fig. 8B
Fig. 9

START

1. LOADS FL1, FL2 MEASURED (LOAD SENSORS) S01

2. LOAD Fs CALCULATED
   \[ Fs = (FL1 - FL2) \frac{L}{H} \] (THIRD CALCULATION UNIT) S02

3. \( Fs > F_{\text{max}} \) (JUDGING SECTION) S03
   - Yes S04
     - ARM MOVING? (JUDGING SECTION) No S05
       - LOAD Fy CALCULATED
         \[ F_y = FL1 + FL2 \] (SECOND CALCULATION UNIT) S05
       - RAISING DETECTED (JUDGING SECTION, CONTROLLER) S08
         - FORCE OF ARM CONTROLLED (CONTROLLER) S08
       - MOVEMENT OF ARM CONTROLLED (CONTROLLER) S09
     - STOP MOVEMENT OF ARM (JUDGING SECTION, CONTROLLER) S06
   - No S07

4. NO S07

END
Fig. 10

FIRST CALCULATION UNIT

WEIGHT CANCELLING SECTION
Fig. 11

START

LOAD FL1, FL2 MEASURED ~ S11

LOAD Fy CALCULATED
Fy = FL1 + FL2 ~ S12

ROTATIONAL POSITION OF ARM DETECTED (θ) ~ S13

CORRECTION VALUE Fya(θ) READ OUT ~ S14

LOAD Fyr CALCULATED
Fyr = Fy + Fya(θ) ~ S15

FORCE OF ARM CONTROLLED (CONTROLLER) ~ S16

MOVEMENT OF ARM CONTROLLED (CONTROLLER) ~ S17

END
HEAD CARE APPARATUS

TECHNICAL FIELD

[0001] The present invention relates to a head care apparatus for use in a medical or cosmetic field, which is capable of caring person’s heads automatically.

BACKGROUND OF THE INVENTION

[0002] The head care, which includes washing and massaging person’s head including hair and scalp, needs human intervention and then has been expected to be automated. For this purpose, there has been proposed an automated head washing apparatus capable of washing human’s heads automatically (see Patent Literature 1, for example).

[0003] FIG. 13 is a diagram schematically showing a major part of the conventional automated head washing apparatus. As shown in the drawing, the automated head washing apparatus comprises a washing unit 1 having nozzles 1a and 2a positioned at regular intervals on an inner peripheral portion of the unit 1.

[0004] The nozzles 1a and 2a, which are arranged to oppose the person’s head, are fluidly communicated through a liquid supply passage (not shown) mounted inside the washing unit 1 to a switching unit 3 so that a liquid from the switching unit 3 is sprayed against the person’s head.

[0005] The washing unit 1 is moved in a direction indicated by arrow 3C by a driving section 4 and is rotated about a support axis by another driving section 6.


SUMMARY OF THE INVENTION

[0007] The above automated head washing apparatus is to wash the person's head only by spraying liquid from the nozzles 1a and 2a, without making frictional contacts with the person’s head. Disadvantageously, if the care unit were to be forced onto the person’s head during washing, the care unit would be tangled in the person’s hair.

[0008] A purpose of the invention is to provide a head care apparatus which is capable of washing person’s heads in a comfortable manner by forcing the care unit onto the person’s head without causing tangling of hair with the care unit.

EMBODIMENTS OF THE INVENTION

[0009] For this purpose, the head care apparatus of the invention comprises

[0010] a first support;

[0011] a care unit having a contact designed to make contact with a person’s head supported by the first support;

[0012] an arm for moving the care unit in a first direction which extends orthogonal to a surface of the person’s head and/or a second direction which extends along the surface of the person’s head and orthogonal to the first direction; and

[0013] a load detector having at least two load sensors arranged in different positions in the second direction for sensing loads applied thereto, the load detector being designed to detect the loads on the contact in the first direction by using the loads sensed by the load sensors.

Effects of the Invention

[0014] According to the head care apparatus of the invention, the hair tangling with the care unit is reduced during the head washing in which the care unit is forced on the head and, as a result, a comfortable head caring is obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. 1A is a perspective view showing an automated head washing apparatus according to the first embodiment of the invention;

[0016] FIG. 1B is a side elevational view showing a major part of the automated head washing apparatus according to the first embodiment of the invention;

[0017] FIG. 2 is a plan view of the left washing unit and the left arm of the automated head washing apparatus;

[0018] FIG. 3 is a diagram of the left washing unit and the left arm of the automated head washing apparatus viewed from the person’s head;

[0019] FIG. 4 is a cross sectional view taken along lines K-K in FIG. 2, showing the load detector and its peripheries;

[0020] FIG. 5 is a cross sectional view taken along lines M-M in FIG. 3, showing the load detector and its peripheries;

[0021] FIG. 6 is a block diagram of the control system relating to the load detector in the first embodiment;

[0022] FIG. 7A is a cross sectional view taken along lines N-N in FIG. 3, showing the load detector and its peripheries;

[0023] FIG. 7B is a cross sectional view, similar to FIG. 7A, showing that the contacts are tangled in hair;

[0024] FIG. 8A is a cross sectional view, similar to FIG. 7A, showing that the arm is swinging;

[0025] FIG. 8B is a cross sectional view, similar to FIG. 7A, showing that the contact is tangled in hair while the arm is swinging;

[0026] FIG. 9 is a flow chart showing a control which uses the load detector in the first embodiment;

[0027] FIG. 10 is a side elevational view showing the left washing unit and the left arm in the second embodiment of the invention;

[0028] FIG. 11 is a flow chart showing a control which uses the weight cancelling section in the second embodiment;

[0029] FIG. 12 is a diagram, similar to FIG. 5, showing an internal structure of the washing unit of the third embodiment of the invention; and

[0030] FIG. 13 is a schematic structural view showing a major part of the conventional automated head washing apparatus.
As shown in FIG. 1A, the automated head washing apparatus 11 has washing units 12L and 12R, arms 13L and 13R moving the washing units 12L and 12R, respectively, a load detector 15, a bowl 18, pipes 19L and 19R, a head support 20 for supporting person’s head 17 within the bowl 18, and a controller 14 controlling various operations of the automated head washing apparatus 11. The washing units 12L and 12R are designed so that they scrub the person’s head supported by the head support 20. The washing units 12L and 12R are specific embodiments of the head care unit. The pipes 19L and 19R each have a nozzle ejecting washing liquid and water against the person’s head 17. The bowl 18 is designed so that it can accommodate the person’s head 17a (see FIG. 1B). The head support 20 is the first support which is an embodiment of a back support supporting the back of person’s head 17a.

The person’s head 17 is accommodated within the interior of the bowl 18 with his/her face upward, so that when the person’s head 17 is suitably positioned against the bowl 18 with the back of his/her head 17a supported on the head support 20, the body axis, the left-right axis, and the anterior-posterior axis of the person are directed Y, X, and Z directions, respectively.

The pair of washing units 12L and 12R are provided on the left and right sides, respectively. The left and right washing units 12L and 12R are provided for scrubbing the left and right sides of the person’s head 17, respectively. The left and right arms 13L and 13R are provided to move the left and right washing units 12L and 12R, respectively.

The pipes 19L and 19R are provided on the left and right sides and attached to the left and right arms 13L and 13R, respectively.

Referring to FIGS. 1B, 2, and 3, discussions will be made to the structures of the arm 13L and the washing unit 12L.

FIG. 1B is a side elevational view of the left arm 13L and the left washing unit 12L. FIG. 2 is a plan view of the left washing unit and the left arm 13L. FIG. 3 is a diagram of the left washing unit 12L and the left arm 13L of the horizontally positioned apparatus and viewed from the person’s head. The left and right arms 13L and 13R and washing units 12L and 12R are symmetric in construction and then no discussions will be made to the right arm 13R and washing unit 12R in the following descriptions.

As shown in FIGS. 2 and 3, the washing unit 12L has a cover or housing 32 for accommodating the load detector 15 which will be described below and a plurality of contacts 21 which are designed to make contacts with the person’s head 17 supported on the head support 20. The contacts are the specific embodiment of a contact portion.

The contacts 21 are provided on the outside of the housing 32. As shown in FIG. 3, the contacts 21 are positioned in two rows. Each of contacts 21 in one row is connected with one of the contacts in the other row through a connector 22. The connector 22 is rotatably mounted to the housing 32 so that the paired contacts 21 on each connector 22 move about the rotational axis of the connector 22.

As shown in FIG. 2, the arm 13L has a link mechanism 13a supporting the washing unit 12L, and a link supporting the link mechanism 13a.

The link mechanism 13a is a five-bar link mechanism with four links. The link mechanism 13a supports the washing unit 12L through a support axis 36. The link mechanism 13a is in turn supported by a support 15 through two rotational axes 13b and 13g. The rotational axes 13b and 13g are arranged in parallel to the support axis 36. The rotational axis 13a is fixed to a link of the link mechanism 13a and rotatably supported on the support 13c. The other rotational axis 13b is connected to a first drive 13d and the first drive 13d is designed so that it rotates the rotational axis 13b in a direction indicated by arrow A (see FIG. 2). The first drive 13d is mounted in an interior of the support 13c.

The support 13c is connected to a second drive 13f through a connecting shaft 13e. The connecting shaft 13e is positioned orthogonal to the support axis 36 and the rotational axes 13b and 13g. Specifically, the connecting shaft 13e is positioned so that it extends through substantially the center of the person’s head 17 and parallel to the X-axis. The second drive 13f is provided so that the connecting shaft 13e rotates about its axis in the direction indicated by arrow B (see FIGS. 1B and 2). The support 13c is designed to rotate with the connecting shaft 13e when the connecting shaft 13e is rotated by the second drive 13f. The second drive 13f is mounted in the interior of the housing of the bowl 18 (see FIG. 1).

As shown in FIG. 2, when the arm 13L is rotated by the first drive 13d in a direction indicated by arrow A, the washing unit 12L moves in a first direction with respect to the person’s head 17. The first direction is an example of a forcing direction which is indicated by arrow C in FIG. 2 and substantially normal to the surface of the person’s head 17 with which the contacts 21 will contact. The first direction includes not only one direction toward the person’s head 17 but also the other direction away from there.

As shown in FIG. 1B, the washing unit 12L rotates in a second direction along the person’s head 17 when the arm 13L rotates about the axis extending substantially the center of the person’s head 17 by the driving of the second drive 13f. The second direction is an example of a movement direction which is a rotational direction about the connecting axis 13e indicated by arrow E in FIG. 1B in the embodiment. The second direction coincides substantially with a tangential line through the contact portion between each contact 21 and the person’s head 17. The rotational movements of the arm 13L and 13R movement the washing units 12L and 12R in the second direction are referred to as “swing movement”.

The automated head washing apparatus 11 according to the first embodiment is operated so that, when washing the person’s head 17 on the head support 20, the arms 13L and 13R are swung in the second direction as described above with the washing units 12L and 12R forced on the person’s head in the first direction. The person’s head 17 is washed and scrubbed by the combination with the ejection of shampoo liquid and water from the nozzles of the pipes 19L and 19R. The scrubbing may be performed more effectively in combination with the swinging movements of the contacts 21.

The automated head washing apparatus 11 according to the first embodiment has a load detector 15 detecting a load applied to the contact 21 in the first direction in order that a substantially uniform force is applied to the person’s head from the contacts during washing and scrubbing.

The automated head washing apparatus 1 according to the first embodiment is featured in having the load detector 15 so that the tangling of hair 60 with the contacts 21 can be detected by the load detector 15 and then reduced to provide a comfortable head care.

Referring to FIGS. 4, 5, and 7A, a structure of the load detector 15 will be described. FIG. 4 is a cross sectional view taken along lines K-K in FIG. 2, showing the load
detector 15 and its peripheries. FIG. 5 is a cross sectional view taken along lines M-M in FIG. 3, showing the load detector and its peripheries. FIG. 7A is a cross sectional view taken along lines N-N in FIG. 3, showing the load detector and its peripheries.

[0051] As shown in FIGS. 4, 5, and 7A, the load detector 15 is accommodated in the interior of the housing 32 of the washing unit 12L and has two load sensors 51a and 51b and a first calculation unit 51c as a load calculation unit.

[0052] The first calculation unit 51c, which is an electronic component incorporating electronic circuits, is mounted adjacent the load sensors 51a and 51b within the housing 32 and is designed to calculate a load applied to the contacts in the first direction using outputs from the load sensors 51a and 51b.

[0053] The load sensors 51a, 51b are arranged at respective positions spaced a distance in the second direction extending along the surface of the person's head 17. The distance between the centers of the load sensors 51a and 51b is twice as long as the distance L between the centers of the load sensors 51a and 51b and the center of the support shaft 36.

[0054] Load cells with the same structure and size may be used for the load sensors 51a and 51b. As shown in FIG. 5, the load sensor 51a has a pair of leaf spring spaced parallel to each other and a plurality of strain gauges 54a attached to the leaf spring 54.

[0055] Each of the leaf springs 54 and 55 is extended in a direction orthogonal to the first and second directions. The leaf springs 54 and 55 are stacked one on top the other through spacers 52 and 53. The stacking direction is parallel to the first direction and orthogonal to the second direction.

[0056] As shown in FIGS. 4 and 5, the spacers 52 and 53 are positioned spacing a distance in the lengthwise direction of the leaf springs 54 and 55. One end of the leaf springs 54 and 55 are fixed to one spacer 52 and other ends of the leaf springs 54 and 55 are fixed to the other spacer 53.

[0057] As shown in FIG. 5, two strain gauge 54a are mounted on each major surface of the leaf spring 54 and spaced a distance therebetween in the lengthwise direction of the leaf spring 54. The strain gauges 54a may be mounted only on one major surface of the leaf spring.

[0058] With the arrangement, the load sensors 51a and 51b detect a load only in the stacking direction of the leaf springs 54 and 55.

[0059] As shown in FIGS. 4 and 5, one side of the load sensors 51a and 51b with respect to the lengthwise direction of the leaf springs 54 and 55 is fixed to a base 37 of the casing unit 12L. On the other side of the load sensors 51a and 51b, the support shaft 36 of the arm 13L is extended through the spacer 52. The base 37 bearing the load sensors 51a and 51b is integrally mounted or fixed on the inner surface of the housing 32. The first calculation unit 51c is mounted on the base 37. One of the spaces 52 may serve as a support supporting the support shaft. The spacer 52 has a through-hole 52a extending in the second direction in which the support shaft 36 is extended. The spacer 52 supports the support shaft 36 through a bearing 52b mounted in the through-hole 52a so that the support shaft 36 is capable of rotating about its axis but incapable of moving in the axial direction.

[0060] As shown in FIGS. 4 and 7A, the support shaft 36 is extended through the pair of apertures 34 defined in the housing 32 to communicate between the interior and exterior thereof. A gap is defined between the support shaft 36 and the peripheral surfaces of the apertures 34 so that the support shaft 36 is not fixed to the housing 32. This allows that the load from the person's head 17 to the contacts 21 of the washing unit 12L is transmitted from the housing 32 through the base 37 and the load detectors 51a and 51b to the support shaft 36. This means that the load on the contacts 21 is applied to and thereby detected by the load sensors 51a and 51b.

[0061] Typically, a displacement of the load sensors 51a and 51b are designed to be several tens of micrometers for the detection of the load from the contacts 21 of the washing unit 12L to the person's head 17. Considering errors such as assembly error, the gap between the support shaft 36 and the aperture 34 for accommodating the displacement is determined to be about one millimeter.

[0062] The washing unit 12L, when it is forced to the person's head, rotates about the support shaft 36 to align on the surface of the person's head. This allows that the leaf springs 54 and 55 become substantially parallel to the surface of the person's head, adjacent the contacts 21, so that the stacking direction of the leaf springs 54 and 55 is substantially parallel to the normal direction running through a surface portion of the person's head 17 at or adjacent the contact portions of the contacts 21 with the person's head 17. This allows that the load sensors 51a and 51b detect the load applied to the person's head from the contacts 21 in the first direction, i.e., in the normal direction from the surface of the person's head 17.

[0063] As described above, the load sensors 51a and 51b are covered by the housing 32. The gap between the periphery of the aperture 34 and the support shaft 36 is closed by an elastic material 33, preventing water from entering into the interior of the housing 32 and thereby preventing the load sensors 51a and 51b from being in contact with the water. The elastic material 33 may be an elastic ring member made of rubber, for example. Preferably, the elasticity is determined so that a substantial part of the load from the contacts 21 is absorbed in the elastic member 33 without being transmitted to the support shaft 36. This allows that, even if the gap between the support shaft 36 and the periphery of the aperture 34 is closed by the elastic member 33, the load applied to the washing unit 12L is reliably transmitted to the load sensors 51a and 51b, ensuring the load sensors 51a and 51b to detect the load in a precise manner.

[0064] Referring to FIGS. 6, 7A, 7B, 8A, and 8B, discussions will be made to the control system using the outputs from the load detector 15.

[0065] FIG. 6 is a block diagram showing a control system using the outputs from the load detector 15. FIGS. 7A, 7B, 8A, and 8B are cross sectional views taken along lines N-N in FIG. 3, showing the load detector 15 and its peripheries. Specifically, FIG. 7A shows the arm 13L in its stationary position, FIG. 7B the arm 13L in its stationary position in which the contacts 21 are tanged in hair 60, FIG. 8A the arm 13L in its swinging position, and FIG. 8B the arm in its swinging position in which the contacts 21 are tanged in hair 60.

[0066] Although the load detector 15 is provided for each of the washing units 12L and 12R, it may be provided only one of the washing units.

[0067] As shown in FIG. 6, the output signals from the load sensors 51a and 51b are transmitted into the first calculation unit 51c. The first calculation unit 51c further includes a second calculation unit 51d calculating a load applied to the contacts 21 in the first direction and a third calculation unit 51e calculating a load applied to the contacts 21 in the second direction. The second calculation unit 51d is an example of a
load calculation section in the forcing direction for calculating the load in the first direction (forcing direction) using the sum of the outputs from the load sensors $S_1a$ and $S_1b$. The third calculation unit $S_1e$ is an example of a load calculation section in the moving direction for calculating the load in the second direction (moving direction) using the difference between the outputs from the load sensors $S_1a$ and $S_1b$.

[0068] The output from the first calculation unit $S_1c$ is transmitted to the controller $14$. The controller $14$ has a judging section $16$ judging whether the load in the second direction calculated in the third calculation unit $S_1e$ is larger than a predetermined value, and a memory section $24$ memorizing various information.

[0069] The control signal from the controller $14$ is transmitted to the first and second drive units $13d$ and $13f$. This allows that the controller $14$ to control the first and second drive units $13d$ and $13f$, and as a result, the arms $13L$ and $13R$ according to the output from the load detector $15$.

[0070] Referring to FIGS. 7A, 7B, 8A, and 8B, a method for calculating the load at the second and third calculation units $S_1a$ and $S_1e$ will be described below.

[0071] First, various sizes of the portions and various loads indicated in FIGS. 7A, 7B, 8A, and 8B will be described below.

[0072] As described above, with respect to the second direction, the distance between the centers of the load sensors $S_1a$ and $S_1b$ is indicated as "L", and the distance between the centers of the load sensors $S_1a$ and $S_1b$ and the center of the support shaft $36$ is indicated as "L". Also with respect to the second direction, the distance between the centers of the paired contacts $21$ is indicated as "2S" and the distance between the centers of each contact and the support shaft $36$ is indicated as "S". With respect to the first direction, the distance between the contact portions of the contacts with the person's head $17$ and the support shaft $36$ is indicated as "IT", "FL1" and "FL2" are the outputs from the load sensors $S_1a$ and $S_1b$, respectively. "Fn1" and "Fn2" are the loads on respective contacts. In FIGS. 8A and 8B, "Fs1" and "Fs2" are the loads on respective contacts $21$ in the second direction.

[0073] Referring to FIGS. 7A and 7B showing the washing unit $12L$ in the initial or home position, discussions will be made to a method made at the second calculation unit $S_1d$ for calculating the load on the contacts $21$ in the first direction.

[0074] When the contacts $21$ are brought into contacts with the person's head $17$, the second calculation unit $S_1d$ calculates the load on the contacts $21$ in the first direction using the outputs $FL1$ and $FL2$ from the load sensors $S_1a$ and $S_1b$. Specifically, the second calculation unit $S_1d$ calculates the load $Fy$ on the contacts in the first direction by adding the outputs $FL1$ and $FL2$ from the load sensors $S_1a$ and $S_1b$, as indicated in the following equation (1).

$$Fy = FL1 + FL2$$

[0075] According to the load detector $15$ in the first embodiment, the load on the contacts $21$ in the first direction varies little irrespective of whether the contact or contacts $21$ are tangled in the person's hair $60$, which ensures that the load $Fy$ in the first direction on the contact or contacts $21$ can be determined by using the equation (1) even when the they are tangled in hair $60$.

[0076] The controller $14$ controls the arms $13L$ and $13R$ so that the load on the contacts $21$ in the first direction is larger than a predetermined value which is memorized in the memory $24$, which ensures that the automated head washing apparatus $11$ scrubs and washes the person's head while applying substantially the same force on the person's head $17$.

[0077] Next, referring to FIGS. 8A and 8B, discussions will be made to method for calculating the loads on the contacts $21$ in the first and second directions during the movement of the washing unit $12L$ in the second direction, made at the second and third calculation units $S_1d$ and $S_1e$, respectively.

[0078] As shown in FIG. 8A, while the washing unit $12$ is moving in the second direction by the swinging operation of the arm $13L$, not only the loads $Fn1$ and $Fn2$ in the first direction but also the loads $Fs1$ and $Fs2$ in the second direction are applied on the contacts $21$ due to the frictional contacts between the contacts $21$ and the person's head $17$.

[0079] The loads $Fs1$ and $Fs2$ on the contacts $21$ in the second direction cause a movement of force on the support shaft $36$. The load sensors $S_1a$ and $S_1b$ are positioned on opposite sides of the support shaft $36$ while leaving distance $L$ from the middle of the shaft in the second direction. This results in that, when a moment $Me$ is generated on the support shaft $36$, a positive load is applied on one load sensor $S_1a$ and a negative load is applied to the other load sensor $S_1b$. This means that, during the swinging movements of the arm $13L$, the outputs from the load sensors $S_1a$ and $S_1b$ include not only components of $Fn1$ and $Fn2$ on the contacts $21$ in the first direction but also the positive and negative components caused by the moment $Me$, respectively.

[0080] The absolute value of the positive component on the load sensor $S_1a$ is substantially the same as that of the negative component on the load sensor $S_1b$. Then, as indicated in the equation (1), adding the outputs $FL1$ and $FL2$ from the load sensors $S_1a$ and $S_1b$ cancels the components on the load sensors $S_1a$ and $S_1b$ due to the moment $Me$ and thereby fully eliminates any affect caused by the moment. This ensures that the load detector $15$ in the first embodiment calculates the load $Fy$ on the contacts in the first direction in a substantially precise manner by using the equation (1) even when the arms $13L$ and $13R$ are swinging.

[0081] Next, discussions will be made to a method for calculating the load in the second direction during the swinging movements of the arm $13L$, which is made at the third calculation unit $S_1e$.

[0082] The third calculation unit $S_1e$ calculates the load $Fy$ on the contacts $21$ in the second direction by using the difference between the outputs $FL1$ and $FL2$ from the load sensors $S_1a$ and $S_1b$, respectively, which will be described as follows.

[0083] The moment $Me$ is caused due to the loads in the first and second directions on the paired contacts $21$. This means that the moment can be determined by using the loads on the contacts $21$ in the first and second directions according to the following equation (2).

$$Me = (Fn1 + Fn2) + (Fs1 + Fs2) / 2$$

[0084] Because the loads $Fn1$ and $Fn2$ on the paired contacts in the first direction are substantially the same, it can be assumed that $Fn1$ is equal to $Fn2$. Then the equation (2) can be rewritten as the following equation (3).

$$Me = (Fn1 + Fn2) / 2$$

[0085] The total load $Fs$ on the paired contacts $21$ in the second direction is equal to the sum of the loads $Fs1$ and $Fs2$ in the second direction, i.e., $Fs = Fs1 + Fs2$. Then, the equation (3) can be rewritten as the following equation (4).

$$Me = Fs / 2$$
Also, the moment $M_e$ can be calculated from the following equation (5) by using leads FL1 and FL2 detected by the load sensors $51a$ and $51b$. Because the load sensors $51a$ and $51b$ are disposed on opposite sides of the support shaft 36, the moment $M_e$ can be calculated from the following equation (5) by using the outputs FL1 and FL2 from the load sensors $51a$ and $51b$.

$$M_e = (F_{11} - F_{12})L$$  \hspace{1cm} (5)

The following equation (6) is obtained from the equations (4) and (5).

$$F_s = \frac{F_{11} - F_{12}}{L/H}$$  \hspace{1cm} (6)

According to the equation (6), the third calculation unit $51e$ calculates the load on contacts 21 in the second direction using the difference between the outputs FL1 and FL2 from the load sensors $51a$ and $51b$, caused by the moment $M_e$.

Also, the automated head washing apparatus 11 according to the first embodiment can detect a trouble due to the difference in the head line in the second direction which is calculated by the third calculation unit $51e$. The trouble may be a hair tangle in the contacts 21, for example. Detailed discussions will be made to the detection of the trouble.

If there is no trouble as shown in FIG. 8A, the load $F_s$ in the second direction during the swinging of the arm 13L, which is calculated by the third calculation unit $51e$, is substantially equal to the frictional force between the contacts 21 and the person's head 17.

If any trouble occurs such as tangling of hair 60 in the contact 21 of the swinging arm 13L, the contacts 21 is subject to an excessive force which is greater the regular frictional force and acts as a braking force to the contacts moving in the second direction. The regular frictional force is a frictional force generated between contacts 21 and the person's head 17 in the absence of any resistance other than sliding resistance and in the absence of drastically changing of any resistance during the movement of the contacts. When the load $F_s1$ and $F_s2$ on the contacts 21 in the second direction becomes greater than the regular frictional force due to the trouble, the moment $M_e$ on the support shaft 36 increases than the normal, which in turn increases the outputs FL1 and FL2 from the load sensors $51a$ and $51b$ and also the resultant load $F_s$ calculated by the third calculation unit $51e$.

The person whose hair is being washed sometimes feels to raise his or her head 17 fom the head support 20 while the washing unit 12L is not swinging. In this instance, the difference between the outputs FL1 and FL2 from the load sensors $51a$ and $51b$ increases more than its normal, which in turn increases the load $F_s$ calculated by the third calculation unit $51e$ more than its normal.

Accordingly, the judging section 16 of the controller 14 judges whether the load $F_s$ in the second direction calculated by the third calculation unit $51e$ is greater than a predetermined value to determine the occurrence of any trouble. The troubles which may be detected by the judging section 16 include tangling of hair 60 in the contact 21, raising of person's head 17 away from the head support 20, and bouncing of contacts 21 due to surface undulations of the person's head.

For the determination at the judging section 16, the memory 24 memorizes a load $F_{s\text{max}}$ which is greater than the frictional force regularly occurred. The load $F_{s\text{max}}$ is defined to be equal to or more than three times the vertical force against the person's head.

The judging section 16 judges that any trouble has occurred when the load $F_s$ in the second direction calculated by the third calculation unit $51e$ is greater than the $F_{s\text{max}}$ memorized in the memory 24. If the judging section 16 determines that any trouble has occurred, the automated head washing apparatus 11 is controlled by the controller 14 to perform a first emergency action. The first emergency action includes, for example, stopping the pivotal movements of arms 13L and 13R and the swinging movements of the contacts 21, moving the washing units 12L and 12R away from the person's head 17, and so on. This results in that the automated head washing apparatus 11 according to the first embodiment reduces a feeling of discomfort and ensures the safety of the subject person.

The load on the person's head from the contacts 21 may vary depending upon the configuration of the head. This results in that the difference between the outputs FL1 and FL2 from the load sensors $51a$ and $51b$ increases as a function of angle between the washing units 12L and 12R and the surface of the person's head 17. Therefore, a curvature of the person's head 17 is determined precisely by using the difference between the outputs FL1 and FL2 from the load sensors $51a$ and $51b$ which is obtained from a configuration scanning of the person's head 17 in which the washing units 12L and 12R are moved in the second direction with the contacts 21 forced on the person's head 17.

Referring to the program flow shown in FIG. 9, discussions will be made to a control in the first embodiment relating to the load detector 15.

First, the outputs FL1 and FL2 from the load sensors $51a$ and $51b$ are obtained (step S01). Then, the third calculation unit $51e$ calculates the load $F_s$ in the second direction on the contacts 21 are calculated from the outputs FL1 and FL2 obtained at step S01, according to the equation (6) (step S02).

At step S03, the judging section 16 judges whether the load $F_s$ in the second direction calculated at step S02 is greater than the $F_{s\text{max}}$ in the memory 24. If the load $F_s$ is greater than the $F_{s\text{max}}$, the judging section 16 judges that any trouble has occurred and then program proceeds to a subsequent judging step S04.

At step S04, the judging section 16 judges whether the arm 13L is moving, i.e., whether the washing unit 12L is moving in the second direction by the swinging of the arm 13L.

If the washing unit 12L is not moving in the second direction (if No at step S04), the judging section 16 determines whether the person's head is raised, i.e., whether the head 17 is moved up away from the head support 20 due to the subject person's action to raise his or her head. At step S05, the controller 14 performs a second emergency action which is an example of the first emergency action, in which a warning is issued through display or voice message or the washing units 12L and 12R are moved away from the person's head 17, for example. The second emergency action at step S05 ensures the safety of the subject person who has raised his or her head.

When the washing unit 12L is moving in the second direction (if Yes at step S04), the judging section 16 judges that the contact 21 is tangled in hair 60 and then the controller 14 performs a third emergency action (step S06) which is an example of the first emergency action, in which the movement of the arm 13L is stopped. By the third emergency action at step S06, the hair 60 of the subject person is prevented from

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being drawn by the washing unit 12L, eliminating the feeling of discomfort from the subject person.

[0103] If it is determined at step S03 that the Fs in the second direction is less than Fmax (if No at step S03), the judging section 16 judges that the automated head washing apparatus 11 is in the normal operation and then the program proceeds to steps S07-S09.

[0104] At step S07, the second calculation unit 51d calculates the load Fy in the first direction on the contacts 21 from the outputs FL1 and FL2 obtained at step S01, according to the equation (1).

[0105] At next step S08, the controller 14 controls the movement of the arm 13L in the first direction by using the load Fy at step S07 so that the load on the contacts 21 in the first direction coincides with the load memorized in the memory 24. By the feedback control at step S08, the person’s head 17 is comfortably washed under substantially the same contact force.

[0106] At next step S09, the controller 14 controls the swinging movements of the arm 13L so that the washing units 12L maintains its movement in the first direction or continues moving or its stopped state.

[0107] The control shown in FIG. 9 is an example, and the operational order of the automated head washing apparatus 11 and the emergency controls at steps S05 and S06, for example, are not limited to those described in the above-described embodiments. Although, according to the control in FIG. 9, two troubles due to the raising of head and the tangle of hair 60 are detected in which the same threshold Fmax is used as the threshold for load F’s in the second direction for both of those detections (step S03 in FIG. 9), different thresholds may be used for respective detections.

[0108] As described above, the automated head washing apparatus 11 according to the first embodiment can detect the load in the first direction irrespective of the load in the second direction by using two load sensors 51a and 51b in the load detector 15. Also, the automated head washing apparatus 11 according to the first embodiment can detect the load not only in the first direction but also in the second direction by using the load sensor capable of detecting load only in one direction. This results in a structural simplicity, a size reduction, and a cost reduction of the apparatus.

[0109] In another embodiment, the third calculation unit 51e may be eliminated if it is not necessary to detect the load in the second direction. In this instance, the load in the first direction is detected by using the first equation (1).

Second Embodiment

[0110] FIG. 10 is a side elevational view showing the washing unit 12L and the arm 13L according to the second embodiment of the invention.

[0111] Referring to the drawings, only features in the second embodiment which are different from those in the first embodiment will be described below.

[0112] According to this embodiment of the automated head washing apparatus 11, the swinging movements of the arms 13L and 13R cause the washing units 12L and 12R to move in the second direction between a first position P1 in which the washing units 12L and 12R are adjacent the forehead of the subject person, above a second horizontal position P2, and a third position P3 in which the washing units 12L and 12R are adjacent the back of the person’s head, below the horizontal position P2. The washing units 12L and 12R are supported by the arms 13L and 13R through the load detectors 15, respectively. This results in that the load of the washing units 12L and 12R can affect the load detection by the load detectors 15 depending upon positions of the washing units 12L and 12R in the second direction. For example, when taking positions P1 or P3, the load Fy in the first direction detected by the load detector 15 includes a part of weight of the washing unit, i.e., a component of weight of the washing unit in the first direction. With respect to the fixed vertical direction indicated by arrow C, the first and second directions can vary depending upon the positions of the washing units. This means that a component in the first direction of the weight of the washing unit 12L, 12R varies depending upon a rotational angle of the arm 13L, 13R.

[0113] In order to eliminate such adverse effect from the weight of the washing unit 12L, 12R, the automated head washing apparatus 11 according to the second embodiment has a weight cancelling section 61 to cancel the component of weight in the first direction of the washing unit 12L, 12R, which is included in the load Fy in the first direction detected by the load detector 15. The weight cancelling section 61 is connected to the first calculation unit 51c.

[0114] As shown in FIG. 10, the weight of the washing unit 12L in the first position P1 primarily acts in a positive direction of the first direction on the person’s head 17. In this instance, the weight cancelling section 61 subtracts the load component in the first direction caused by the weight of the washing unit 12L from the load Fy in the first direction detected from the load detector 15.

[0115] The weight of the washing unit 12L in the position P2 does not act on the person’s head in the first direction. In this instance, the weight cancelling section 61 maintains the load Fy in the first direction detected from the load detector 15, without making any subtraction or addition.

[0116] The weight of the washing unit 12L in the third position P3 primarily acts in a negative direction of the first direction on the person’s head 17. In this instance, the weight cancelling section 61 adds the load component in the first direction caused by the weight of the washing unit 12L to the load Fy in the first direction detected from the load detector 15.

[0117] As described above, an effect by the weight of the washing unit 12L, 12R varies depending upon the position of the washing unit 12L, 12R. This means that weight cancelling section 61 adds load values to or subtracts them from the outputs from the load detectors 15, depending upon the positions of the washing units 12L, 12R. For the addition and subtraction, the weight cancelling section 61 uses data which is memorized in the memory 24 (see FIG. 6) for the correction of arm weight. The data for the correction of arm weight includes rotational position or angle of arm 13L, 13R and load values used for cancelling weight of the washing unit 12L, 12R.

[0118] The data for the correction of arm weight may be obtained by reading the output from the load detectors 15 while the arms 13L, 13R are swinging without keeping the contacts 21 out of contact with the person’s head 17, before the washing operation of the automated head washing apparatus 11. The correction data may be obtained as a function of rotational position 0 of the arm 13L, 13R if the physical properties of the system such as weight and gravity center of the arm 13L, 13R are known.
Referring to a flowchart in FIG. 11, discussions will be made to an operation control relating to the weight cancelling section 61 according to the second embodiment of the invention. In this drawing, detailed descriptions of such as initial and final processing and calculation of the load Fs in the second direction are omitted.

First, the loads FL1 and FL2 are obtained by using the outputs from the load sensors S1a and S1b, respectively. Then, the first calculation unit S1c calculates the loads FY on the contacts 21 in the first direction from the loads FL1 and FL2 according to the equation (1) (step S12). The load FY is a press force.

Next, a rotational position 0 of the arm 13L is detected (step S13). The rotational position 0 may be an angle measured from a position (0°–0°) in which the washing unit 12L takes the horizontal position or may be an angle measured from a position (0°–0°) in which the washing unit 12L takes the uppermost or lowermost position. The rotational angle 0 can be calculated by using, for example, a rotation encoder (not shown) mounted in the second driving unit 13C of the arm 13L.

Then, a correction value Fya (0) is read out from the correction data of arm weight memorized in the memory 24 in the form of a correction table, as a function of the rotational angle 0 (step S14). The correction value Fya (0) can be positive or negative value.

Next, a load FYr, from which the weight effect of the washing unit 12L is eliminated or cancelled, is obtained by adding the correction value Fya (0) read out at step S14 to the load FY calculated at step S12 (step S15). The load FYr is the actual force applied thereto. If the correction value Fya (0) takes negative, the load FY is subtracted.

At step S16, the controller 14 controls the movement of the arm 13L in the first direction by using the load FYr calculated at step S15 so that the load on the contacts 21 in the first direction becomes the certain value memorized in the memory 24. By this control at step S16, the person's head 17 is ensured to be scrubbed and washed in a comfortable manner with substantially uniform force.

At step S17, the controller 14 controls the swinging movements of the arm 13L so that the washing unit 12L continues to move in the second direction or stop without moving in that direction.

As described above, according to the automated head washing apparatus 11 according to the second embodiment of the invention, the weight effect of the washing unit 12L, 12R is eliminated or cancelled, allowing the load in the first direction to be precisely calculated by the load detector 15.

The above described control shown in FIG. 11 is a mere example and the operational steps of the automated head washing apparatus 11 for this control are not limited to the second embodiment.

Meanwhile, if the support shaft 36 does not coincide with the gravity center of the washing unit 12L, 12R, the weight of the washing unit 12L, 12R can affect the load Fs in the second direction which is detected by the load detector 15. For example, the weight of the washing unit 12L in the position P2 shown in FIG. 10 can shift in the second direction to a certain extent.

Then, the weight cancelling section 61 can eliminate or cancel the weight effect of the washing unit 12L, 12R, not only for the load FY in the first direction detected by the load detector 15 but also for the load Fs in the second direction. In this instance, the weight cancelling section 61 can be corrected by eliminating or cancelling the weight effect of the washing unit 12L, 12R, by adding or subtracting a load value in the second direction of the weight of the washing unit 12L, 12R to or from the load Fs in the second direction detected by the load detector 15.

Third Embodiment

FIG. 12 is a cross sectional view of the washing unit 62L according to the third embodiment of the invention. FIG. 12 corresponds to FIG. 5 in the first embodiment.

Referring to the drawing, discussions will be made to features in the third embodiment which are different from those in the first embodiment.

The washing unit 62L is needed to have a waterproof structure to prevent the washing liquid or water from entering into the interior thereof. For this purpose, in the automated head washing apparatus according to the third embodiment of the invention, the arm 13L and the load sensor 51a are connected with each other through a projection 71 extending through the housing 72 in the first direction so that a high waterproof property is obtained irrespective of the movement of the load sensor 51a, 51b. Discussions will be made to the specific structure of the washing unit 62L.

The washing unit 62L has a housing 72 accommodating the load sensors 51a, 51b, a projection 71 projecting from the load sensors 51a, 51b in the first direction and extending through the housing 72 in the first direction, an a ring-like elastic member 73 sealing a gap between the inner periphery of the aperture 72a formed in the housing 72 through which the projection 71 extends and the projection 71 extending through the aperture.

Although only one projection 71 provided for the load sensor 51a is shown in the drawing, like projection is provided to the other load sensor 51b. In another embodiment, the projection 71 may be provided for the load sensor 51a only.

The elastic member 73 is made of, for example, O-ring. As above, a waterproof structure is obtained between the peripheral wall of the aperture 72a and the projection 71 by the ring-like elastic member 73.

The projection 71 is made of bar having a circular cross section. The projection 71 has a substantially constant diameter. A distal end of the projection 71 is projected from the housing 72 and has a through-hole 71a extending therethrough in the second direction. The support shaft 36 is extended through the through-hole 71a and supported by a bearing (not shown) also mounted in the through-hole. With the arrangement, the support shaft 36 is supported by the projection 71 so that it can rotate about its axis but immovable in the direction parallel to the axis. This ensures, in the third embodiment, that the projection 71 acts as a support supporting the support shaft 36.

As described above, the arm 13L and the load sensor 51 are connected to each other through the projection 71 extending in the first direction through the housing 72 and the support shaft 36 supported by the projection. Because the projection 71 has substantially the constant diameter, the gap between the projection 71 and the peripheral wall of the aperture 71a is kept substantially constant. Also, the gap between the projection 71 and the peripheral wall of the aperture 71a is closed by the ring-like elastic member 73 with
substantially the same force, a high waterproof property is provided for the washing unit 62L.

[0139] As described above, according to the third embodiment of the invention, the washing unit 62L with a high waterproof property is obtained.

[0140] Although several embodiments of the invention have been described above, they may be modified or altered in various ways in light of knowledge of the ordinary artisan in this field, without departing from the gist of the invention.

[0141] For example, although two load sensors are provided in the load detector, three or more load sensors may be arranged in the load detector so that they take different positions with respect to the second direction.

INDUSTRIAL APPLICABILITY

[0142] The head care apparatus according to the invention is applicable in various fields such as medical and cosmetic industries for taking care of person's heads.

PARTS LIST

[0143] 11: automated head washing apparatus
[0144] 12L, 12R, 62L: washing unit
[0145] 13L, 13R: arm
[0146] 13a: link mechanism
[0147] 13b: rotational axis
[0148] 13c: support
[0149] 13d: first drive
[0150] 13f: second drive
[0151] 14: controller
[0152] 15: load detector
[0153] 16: judging section
[0154] 17: head
[0155] 18: bowl
[0156] 19L, 19R: pipe
[0157] 20: head support
[0158] 21: contact
[0159] 24: memory
[0160] 32, 72: housing
[0161] 33, 73: elastic member
[0162] 34, 72a: aperture
[0163] 36: support shaft
[0164] 37: base
[0165] 51a, 51b: load sensor
[0166] 51c: first calculation unit
[0167] 51d: second calculation unit
[0168] 51e: third calculation unit
[0169] 52, 53: spacer
[0170] 54, 55: leaf spring
[0171] 54a: strain gauge
[0172] 61: weight cancelling section
[0173] 71: projection

1. A head care apparatus comprising:

   a first support;
   a care unit having a contact designed to be make contact with a person's head supported by the first support;
   an arm moving the care unit in a first direction which extends orthogonal to a surface of the person's head and/or a second direction which extends along the surface of the person's head and orthogonal to the first direction; and

   a load detector having at least two load sensors arranged in different positions in the second direction for sensing loads applied thereto, the load detector being designed to detect the loads on the contact in the first direction by using the loads sensed by the load sensors.

2. The head care apparatus in claim 1, wherein the load detector detects the load on the contacts in the first direction by using a sum of the loads sensed by the load sensors.

3. The head care apparatus in claim 1, wherein the load detector comprises a first calculation unit calculating the load on the contacts in the second direction by using a difference between the loads sensed by the load sensors.

4. The head care apparatus in claim 3, further comprising a judging section judging whether the load in the second direction is greater than a predetermined value to determine that a trouble has occurred.

5. The head care apparatus of claim 4, wherein the judging section judges whether the load in the second direction is greater than the predetermined value when the arm is moving in the second direction to determine that the contacts are tangled in hair of the person's head supported by the first support.

6. The head care apparatus of claim 4, wherein the judging section judges whether the load in the second direction is greater than the predetermined value when the arm is at a stop to determined that the person's head is out of contact with the first support.

7. The head care apparatus in claim 1, wherein each of the load sensors is a sensor to detect a load in one direction only.

8. The head care apparatus in claim 1, wherein the load sensor is a load cell.

9. The head care apparatus in claim 8, wherein each of the load sensors has a pair of leaf springs positioned in parallel to each other and at least two strain gauges attached to one of the paired leaf springs.

10. The head care apparatus in claim 1, wherein the arm has a support shaft, and wherein each of the load sensor has a support through which the support shaft of the arm extends, the support supporting the support shaft so that the support shaft is rotatable about its axis but immovable in a direction parallel to the axis.

11. The head care apparatus in claim 1, further comprising a weight cancelling section cancelling a load in the first direction caused by a weight of the care unit from the load in the first direction detected by the load detector.

12. The head care apparatus in claim 1, wherein the care unit comprises a housing accommodating the load sensors, the housing having an aperture defined therein by a peripheral wall in which the support shaft of the arm is extended, and an elastic member closing a gap between the peripheral wall and the support shaft of the arm provided in the aperture.

13. The head care apparatus in claim 1, wherein the care unit comprises a housing for accommodating the load sensors, the housing having an aperture defined therein by a peripheral wall, a projection projecting from the load sensors to extend through the housing in the first direction and connected to the arm outside the housing, and an elastic member for closing a gap between the peripheral wall of an aperture and the projection.

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