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(54) DETERMINING WHEN AN OPERATIONAL HEAD NEEDS REPLACING

(57) The subject-matter of the present disclosure relates to a computer-implemented method of determining when an operational head (106) of a personal care appliance (100) requires replacing. The computer-implemented method comprising: monitoring (700) an operational parameter sensed by a sensor (114) of the personal care appliance, the operational parameter associated with operating the operational head; determining (702) values of the operational parameter over time for each use; determining (704) that the operational head needs replacing based on changes of the values of the operational parameters of a subsequent use compared to a previous use; and sending (706) a signal indicating that the operational head needs to be replaced in response to the determining that the operational head needs to be replaced.

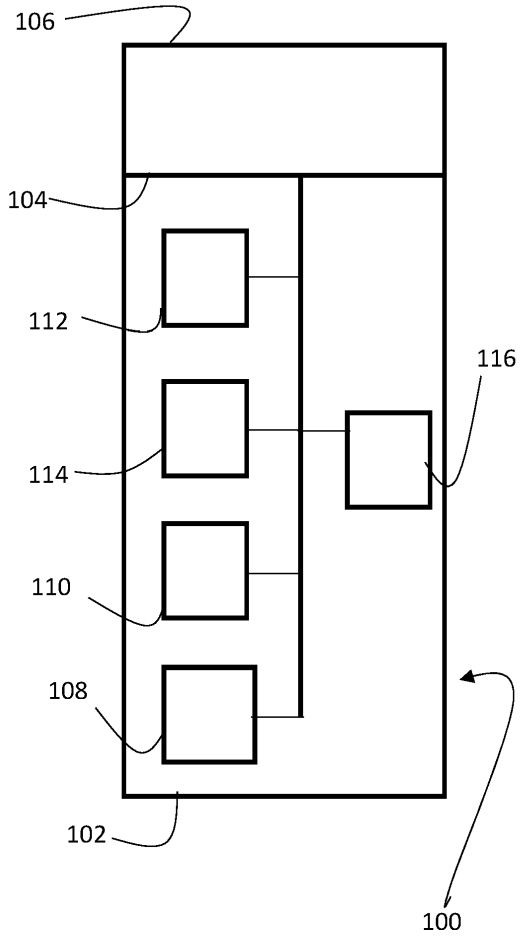

Figure 1

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Description

FIELD OF THE INVENTION

[0001] The subject-matter of the present disclosure relates to personal care appliances and determining when an operational head of a personal care appliance requires replacing, plus transitory, or non-transitory, computer-readable media.

BACKGROUND OF THE INVENTION

[0002] Personal care appliances, such as hair cutting devices, often include a cutter. The cutter, when first installed to the personal care appliance, is sharp and cuts or shaves hair well. However, over time, the cutter or shaving device becomes more blunt and requires replacing.

[0003] Generating a replacing signal for a user can be difficult because different users have different hair types. For example, one user may have a dense beard with thick hair. Another use may have a sparse beard with finer hair. The former will blunt the cutter quicker than the latter.

[0004] It is an aim of the subject-matter of the present disclosure to improve on the prior art.

SUMMARY OF THE INVENTION

[0005] According to a first aspect of the present invention, there is provided a computer-implemented method of determining when an operational head of a personal care appliance requires replacing, the computer-implemented method comprising: monitoring an operational parameter sensed by a sensor of the personal care appliance, the operational parameter associated with operating the operational head; determining values of the operational parameter over time for each use; determining that the operational head needs replacing based on changes of the values of the operational parameters of a subsequent use compared to a previous use; and sending a signal indicating that the operational head needs to be replaced in response to the determining that the operational head needs to be replaced. By determining that the operational head needs replacing based on changes of the values of the operational parameters of a subsequent user compared to a previous use, the determination is based on how the personal care appliance operates on that specific user. In this way, the determination is tailored to the specific user.

[0006] In an embodiment, the determining the values of the operational parameter over time for each use comprises, for each use: measuring, using the sensor, real time values of the operational parameter; and subtracting a free-running value of the operational parameter from the real time values of the operational parameter.

[0007] In an embodiment, the subtracting the real time values of the operational parameter from the free-running value of the operational parameter comprises: monitoring a real time free-running value of the operational parameter; and subtracting the real time value of the operational parameter from the real time free-running value of the operational parameter over time.

[0008] In an embodiment, the monitoring the real time free-running value of the operational parameter comprises determining the real time free-running value of the operational parameter by: using a low-pass filter on the real time values of the operational parameter to discard values above a threshold; and/or calculating a moving minimum value from the real time values of the operational parameter; and/or calculating a moving n^{th} percentile value from the real time values of the operational parameter.

[0009] In an embodiment, the determining that the operational head needs replacing based on changes of the values of the operational parameters of a subsequent use compared to a previous use, comprises: computing, for each use, a maximum moving average of the values of the operational parameter and a minimum moving average of the values of the operational parameter; computing, for each use, a difference between the maximum and minimum moving averages; comparing the difference between the maximum and minimum moving averages for each subsequent use to the difference between the maximum and minimum moving average of the first use multiplied by a multiplication factor; and determining that the operational head needs replacing based on the comparing.

[0010] In an embodiment, the determining that the operational head needs replacing based on the comparison comprises: determining that the operational head needs replacing when the difference between the maximum and minimum moving averages for one or more of the subsequent uses is greater than the difference between the maximum and minimum moving averages for the first use.

[0011] In an embodiment, the one or more of the subsequent uses comprises a predefined number of consecutive subsequent uses.

[0012] In an embodiment, the predefined number of subsequent uses is two or more consecutive subsequent uses.

[0013] In an embodiment, the multiplication factor is at least 1.2.

[0014] In an embodiment, the personal care appliance comprises a motor to operate the operational head, and wherein the operational parameter comprises power or current of the motor in operating the operational head.

[0015] In an embodiment, the personal care appliance is a user, and the operational head is a trimmer, wherein each use is a shave.

[0016] In an embodiment, the sending a signal indicating that the operational head needs to be replaced when the determining that the operational head needs to be replaced comprises sending a signal to a display device to display a notification to a user to replace the operational head.

[0017] In an embodiment, the display device is a remote device, or a display device mounted to the personal care appliance.

[0018] According to an aspect of the present invention, there is provided a transitory, or non-transitory, computer-readable medium, having instructions stored thereon that when executed by one or more processors, cause the one or more processors to perform the computer-implemented method of any preceding aspect or embodiment.

[0019] According to an aspect of the present invention, there is provided a personal care appliance comprising: a handle; a sensor coupled to the handle; an attachment for attaching an operational head to the handle; and a controller having a processor and storage, wherein the storage has instructions stored thereon that, when executed by the processor, cause the processor to perform the computer-implemented method of any preceding aspect or embodiment.

[0020] These and other aspects of the present invention will be apparent from and elucidated with reference to the embodiment(s) described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The embodiments of the present inventions may be best understood with reference to the accompanying figures, in which:

Fig. 1 shows a block diagram of a personal care appliance according to one or more embodiments;

Fig. 2 shows a series of parameter values captured over time for respective new and worn operational heads of the personal care appliance;

Fig. 3 shows operational values measured from a sensor of the personal care appliance over time, and their breakdown into a component attributable to operating the operational head and a component attributable to a free-running motor of the personal care appliance, according to one or more embodiments;

Fig. 4 shows a graph for use in determining the free-running values from the measured values, according to one or more embodiments;

Fig. 5 shows a graph for use in clustering operational parameter values for use in determining whether the operational head needs replacing; and

Fig. 6 shows a flow chart summarising a computer-implemented method of determining whether an operational head of a personal care appliance requires replacing.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0022] At least some of the example embodiments described herein may be constructed, partially or wholly, using dedicated special-purpose hardware. Terms such as 'component', 'module' or 'unit' used herein may include, but are not limited to, a hardware operational head, such as circuitry in the form of discrete or integrated components, a Field Programmable Gate Array (FPGA) or Application Specific Integrated Circuit (ASIC), which performs certain tasks or provides the associated functionality. In some embodiments, the described elements may be configured to reside on a tangible, persistent, addressable storage medium and may be configured to execute on one or more processors. These functional elements may in some embodiments include, by way of example, components, such as software components, object-oriented software components, class components and task components, processes, functions, attributes, procedures, subroutines, segments of program code, drivers, firmware, microcode, circuitry, data, databases, data structures, tables, arrays, and variables. Although the example embodiments have been described with reference to the components, modules and units discussed herein, such functional elements may be combined into fewer elements or separated into additional elements. Various combinations of optional features have been described herein, and it will be appreciated that described features may be combined in any suitable combination. In particular, the features of any one example embodiment may be combined with features of any other embodiment, as appropriate, except where such combinations are mutually exclusive. Throughout this specification, the term "comprising" or "comprises" means including the component(s) specified but not to the exclusion of the presence of others.

[0023] With reference to Fig. 1, a personal care appliance 100 according to one or more embodiments includes a handle 102, an attachment 104, an operational head 106, a power source 108, a controller 110, a motor 112, a sensor 114, and a display 116.

[0024] The personal care appliance 100 may be a hair removal appliance such as a trimmer or a shaver, for example. The operational head 106 is a device that performs and operation, e.g. hair removal. The operational head may be a trimmer. The trimmer includes a guard and a cutter. The cutter and the guard each comprise teeth which cut hair therebetween when the cutter moves reciprocally over the guard.

[0025] The attachment 104 attaches the operational head 106 to the handle 102.

[0026] The power source 108 may be a battery, e.g. a secondary, or rechargeable, battery.

[0027] The controller 110 may include storage and one or more processors. The storage includes electronic data in the form of instructions. The instructions, when executed by the one or more processors, may cause the one or more processors to perform the computer-implemented methods described herein. In this way, the storage may be non-transitory computer readable media. The instructions may also be provided as transitory computer-readable media when provided as a download to be stored on the storage.

[0028] The motor 112 may consume energy from the

power source 108 when operating. This energy may be sensed by the sensor 114. The sensor sensed an operational parameter associated with operating the operational head. The operational parameter being current or power.

[0029] The display 116 may be mounted to an exterior surface of the handle 102 and communicatively linked to the controller so as to display indications generated by the controller.

[0030] With reference to Fig. 2, both graphs show operational parameter values cycling between values associated with cutting hair and values associated with a free-running motor. The values of a free-running motor are associated with the troughs 202 and the values of cutting hair are associated with the peaks 204. Also shown on each graph is an average value line 206, a value plus 10% of the average value 208, and a value minus 10% of the average value 210. The upper figure is associated with a brand-new cutter. The lower figure is associated with a worn cutter. It can be seen that the amplitude between values associated with cutting hair and values associated with a free-running motor is larger for the worn cutting element, and therefore the +10% lines 208, 210, are farther apart.

[0031] Therefore, it can be seen that the operational parameter values can be used for determining when the operational head needs replacing since there are differences between worn and brand-new cutters.

[0032] Embodiments provide a computer-implemented method of determining when an operational head of a personal care appliance requires replacing that addresses this need. The method includes monitoring an operational parameter sensed by a sensor of the personal care appliance, the operational parameter associated with operating the operational head; determining values of the operational parameter over time for each use; determining that the operational head needs replacing based on changes of the values of the operational parameters of a subsequent use compared to a previous use; and sending a signal indicating that the operational head needs to be replaced in response to the determining that the operational head needs to be replaced.

[0033] With reference to Fig. 3, the determining the values of the operational parameter over time for each use comprises, for each use: measuring, using the sensor, real time values of the operational parameter; and subtracting the real time values 302 of the operational parameter from a free-running value 306 of the operational parameter. The result of the subtraction is the values of the operational parameter 304.

[0034] This method is shown in Fig. 3 when the free-running value 306 is constant. This is an approximation method.

[0035] With reference to Fig. 4, a more accurate method is provided where the wherein the subtracting the real time values of the operational parameter from the free-running value of the operational parameter comprises: monitoring a real time free-running value 402 of the operational parameter; and subtracting the real time value 404 of the operational parameter from the real time free-running value of the operational parameter over time. The result of the subtraction is the real time values 406. The method associated with Fig. 4 is more accurate than the method associated with Fig. 3 because the free-running values are in real-time, i.e. they are continually updated and not assumed to be constant.

[0036] It is possible to obtain the real-time free running value 402 in various ways. For instance, it is possible to determine the real time free-running value of the operational parameter by using a low-pass filter on the real time values 404 of the operational parameter to discard values above a threshold. The threshold may be set at what is known to be a free-running value of a motor for example. Another way is to calculate a moving minimum value from the real time values of the operational parameter. The moving minimum uses a time window which moves with time. A minimum real time value 404 in the window is obtained and is used as the real-time free running value 402. Another way is to calculate a moving nth percentile value from the real time values of the operational parameter. The nth percentile may be a 1st, 2nd or even a 3rd percentile, for example, although other percentiles may be used too.

[0037] With reference to Fig. 5, the determining that the operational head needs replacing based on changes of the values of the operational parameters of a subsequent use compared to a previous use comprises computing, for each use, a maximum moving average of the values of the operational parameter and a minimum moving average of the values of the operational parameter.

[0038] The minimum moving average, $\overline{P}_{\min\_n}$, and a maximum moving average, $\overline{P}_{\max\_n}$, as well as a minimum standard deviation, $\sigma_{\min\_n}$, and a maximum standard deviation, $\sigma_{\max\_n}$, are calculated as follows for each, n^{th}, use.

[0039] At a first step, a start-up time, $t_{start\text{-}up}$, is defined as a time period when the motor has reached a steady state after the personal care appliance has been switch one. Any readings of the operational parameter, in this case power, before $t_{start\text{-}up}$ are disregarded. The time period may be around 5 seconds.

[0040] After $t_{start\text{-}up}$, a moving, or walking, average, $\overline{P}_{walk\_n}$, is obtained over a time window of around 0.5 seconds, which equates to a sample size of 16 power measurements when sampling at 32 Hz. This window may be adjusted depending on the sampling frequency, for example. In addition, a moving, or walking, standard deviation, σ_{walk_n}, obtained over a time window of 0.5 seconds.

[0041] As an initial condition, a first moving average, $\overline{P}_0$, is calculated, with its first standard deviation, σ_0.

[0042] The minimum moving average, $\overline{P}_{\min\_n}$, the maximum moving average, $\overline{P}_{\max\_n}$, as well as the minimum standard deviation, $\sigma_{\min\_n}$, and the maximum standard deviation, $\sigma_{\max\_n}$, are set as the first moving average, $\overline{P}_0$, and the first standard deviation, σ_0, respec-

tively.

[0043] In other words:

$$\overline{P}_{\min\_n} = \overline{P}_0 \; ; \sigma_{\min\_n} = \sigma_0$$

$$\overline{P}_{\max\_n} = \overline{P}_0 \; ; \sigma_{\max\_n} = \sigma_0$$

[0044] Next, the minimum moving average, $\overline{P}_{\min\_n}$, the maximum moving average, $\overline{P}_{\max\_n}$, as well as the minimum standard deviation, $\sigma_{\min\_n}$, and the maximum standard deviation, $\sigma_{\max\_n}$, are updated by comparing the moving, or walking, average $\overline{P}_{walk\_n}$ with the current values for the minimum moving average, $\overline{P}_{\min\_n}$, the maximum moving average, $\overline{P}_{\max\_n}$.

[0045] In other words:

If $\overline{P}_{walk\_n} < \overline{P}_{\min\_n}$ then $\overline{P}_{\min\_n} = P_{walk\_n}$ and $\sigma_{\min\_n} = \sigma_0$
If $\overline{P}_{walk\_n} < \overline{P}_{\max\_n}$ then $\overline{P}_{\max\_n} = \overline{P}_{walk\_n}$ and $\sigma_{\max\_n} = \sigma_0$

[0046] In other words, the method comprises computing, for each use, a difference between the maximum and minimum moving averages; comparing the difference between the maximum and minimum moving averages for each subsequent use to the difference between the maximum and minimum moving average of the first use multiplied by a multiplication factor; and determining that the operational head needs replacing based on the comparing. The determining that the operational head needs replacing based on the comparison comprises: determining that the operational head needs replacing when the difference between the maximum and minimum moving averages for one or more of the subsequent uses is greater than the difference between the maximum and minimum moving averages for the first use. The one or more subsequent uses comprises a predefined number of consecutive subsequent uses. The predefined number may be three consecutive uses. In other words, when the difference between minimum and maximum moving averages, ΔP_n, for three consecutive uses is greater than $1.2 \times \Delta P_1$, the operational head needs replacing. It should be noted that 1.2 is the multiplication factor and should be at least 1.2.

[0047] Finally, the sensing the signal indicating that the operational head needs to be replaced when the determining that the operational head needs to be replaced comprises sending a signal to the display 116 (Fig. 1) to display a notification to a user to replace the operational head. The display in Fig. 1 is a display mounted to the personal care appliance but the display may also be a display of a remote device.

[0048] With reference to Fig. 6, a computer-implemented method of determining when an operational head of a personal care appliance requires replacing is summarised as including the steps of: monitoring 700 an operational parameter sensed by a sensor of the personal care appliance, the operational parameter associated with operating the operational head; determining 702 values of the operational parameter over time for each use; determining 704 that the operational head needs replacing based on changes of the values of the operational parameters of a subsequent use compared to a previous use; and sending 706 a signal indicating that the operational head needs to be replaced in response to the determining that the operational head needs to be replaced.

[0049] While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive; the invention is not limited to the disclosed embodiments.

[0050] Other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. A single processor or other unit may fulfil the functions of several items recited in the claims. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measured cannot be used to advantage. Any reference signs in the claims should not be construed as limiting the scope.

Claims

1. A computer-implemented method of determining when an operational head (106) of a personal care appliance (100) requires replacing, the computer-implemented method comprising:

   monitoring (700) an operational parameter sensed by a sensor (114) of the personal care appliance, the operational parameter associated with operating the operational head;
   determining (702) values of the operational parameter over time for each use;
   determining (704) that the operational head needs replacing based on changes of the values of the operational parameters of one or more subsequent uses compared to a previous use; and
   sending (706) a signal indicating that the operational head needs to be replaced in response to the determining that the operational head needs to be replaced.

2. The computer-implemented method of Claim 1, wherein the determining the values (406) of the operational parameter over time for each use comprises, for each use:

measuring, using the sensor, real time values (404) of the operational parameter; and
subtracting a free-running value (402) of the operational parameter from the real time values of the operational parameter.

3. The computer-implemented method of Claim 2, wherein the subtracting the real time values of the operational parameter from the free-running value of the operational parameter comprises:

monitoring a real time free-running value of the operational parameter; and
subtracting the real time value of the operational parameter from the real time free-running value of the operational parameter over time.

4. The computer-implemented method of Claim 3, wherein the monitoring the real time free-running value of the operational parameter comprises determining the real time free-running value of the operational parameter by:

using a low-pass filter on the real time values of the operational parameter to discard values above a threshold; and/or
calculating a moving minimum value from the real time values of the operational parameter; and/or
calculating a moving n^{th} percentile value from the real time values of the operational parameter.

5. The computer-implemented method of any preceding claim, wherein the determining that the operational head needs replacing based on changes of the values of the operational parameters of a subsequent use compared to a previous use, comprises:

computing, for each use, a maximum moving average of the values of the operational parameter and a minimum moving average of the values of the operational parameter;
computing, for each use, a difference between the maximum and minimum moving averages;
comparing the difference between the maximum and minimum moving averages for each subsequent use to the difference between the maximum and minimum moving average of the first use multiplied by a multiplication factor; and
determining that the operational head needs replacing based on the comparing.

6. The computer-implemented method of Claim 5, wherein the determining that the operational head needs replacing based on the comparison comprises:
determining that the operational head needs replacing when the difference between the maximum and minimum moving averages for one or more of the subsequent uses is greater than the difference between the maximum and minimum moving averages for the first use.

7. The computer-implemented method of Claim 6, wherein the one or more of the subsequent uses comprises a predefined number of consecutive subsequent uses.

8. The computer-implemented method of Claim 7, wherein the predefined number of subsequent uses is two or more consecutive subsequent uses.

9. The computer-implemented method of any of Claims 5 to 8, wherein the multiplication factor is at least 1.2.

10. The computer-implemented method of any preceding claim, wherein the personal care appliance comprises a motor (112) to operate the operational head, and wherein the operational parameter comprises power or current of the motor in operating the operational head.

11. The computer-implemented method of any preceding claim, wherein the personal care appliance is a user, and the operational head is a trimmer, wherein each use is a shave.

12. The computer-implemented method of any preceding claim, wherein the sending a signal indicating that the operational head needs to be replaced when the determining that the operational head needs to be replaced comprises sending a signal to a display device (116) to display a notification to a user to replace the operational head.

13. The computer-implemented method of Claim 12, wherein the display device is a remote device, or a display device mounted to the personal care appliance.

14. A transitory, or non-transitory, computer-readable medium, having instructions stored thereon that when executed by one or more processors, cause the one or more processors to perform the computer-implemented method of any preceding claim.

15. A personal care appliance (100) comprising:

a handle (102);
a sensor (114) coupled to the handle;
an attachment (104) for attaching an operational head (106) to the handle; and
a controller (110) having a processor and storage, wherein the storage has instructions stored thereon that, when executed by the pro-

cessor, cause the processor to perform the computer-implemented method of any of Claims 1 to 13.

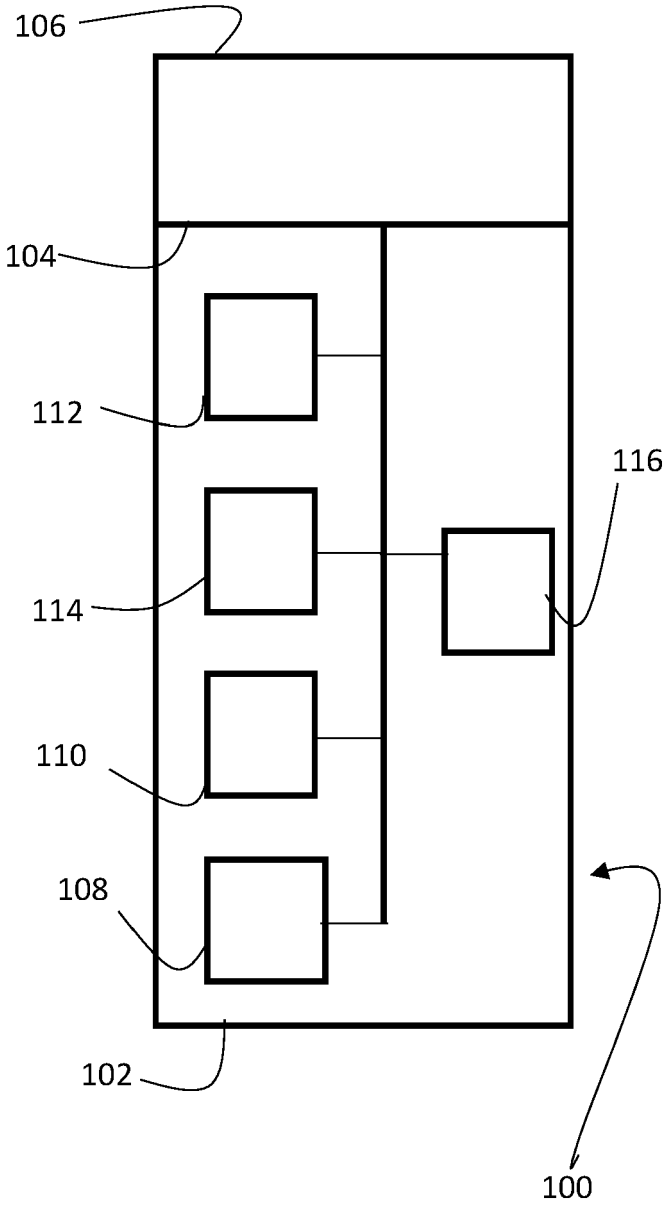

Figure 1

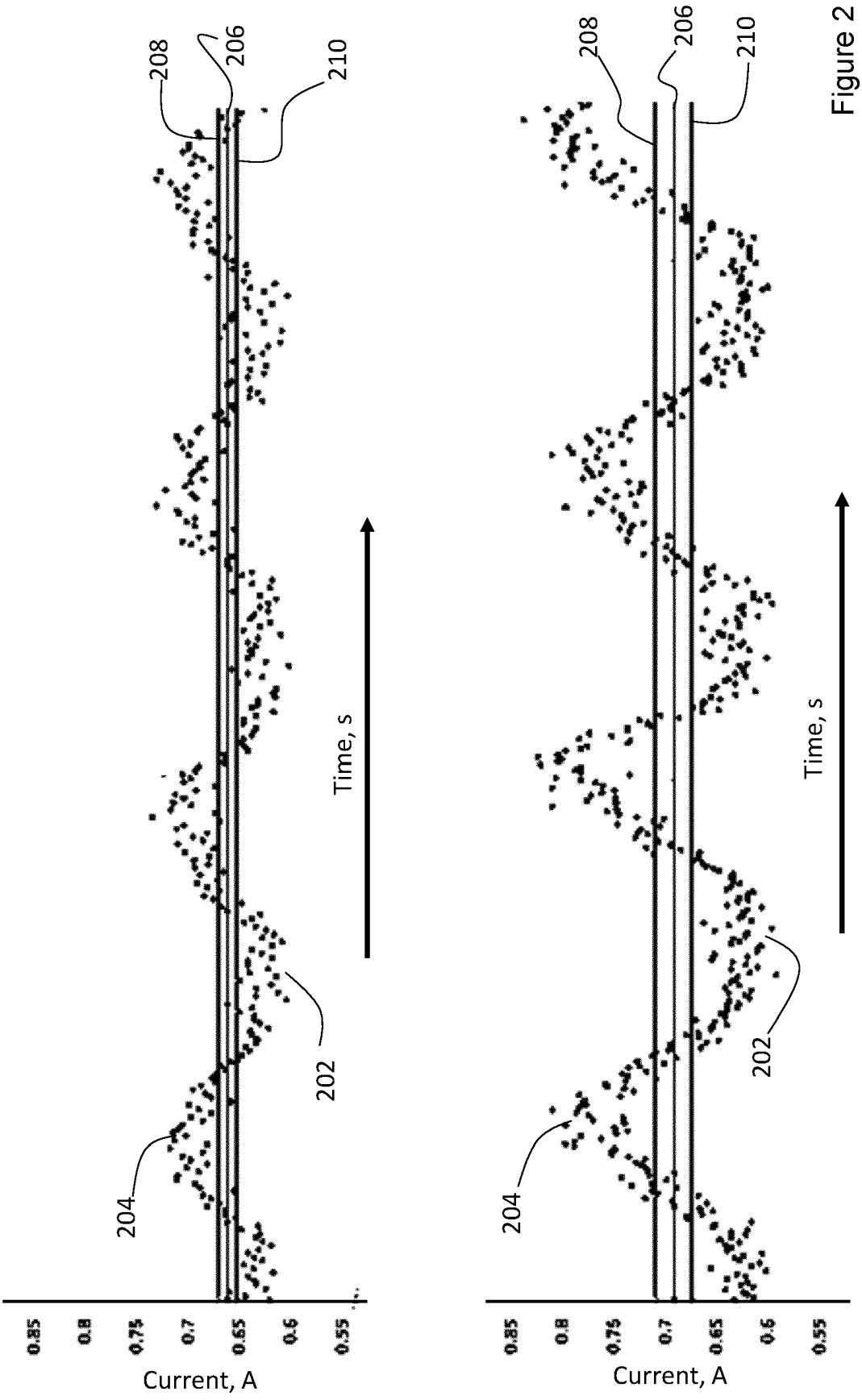

Figure 2

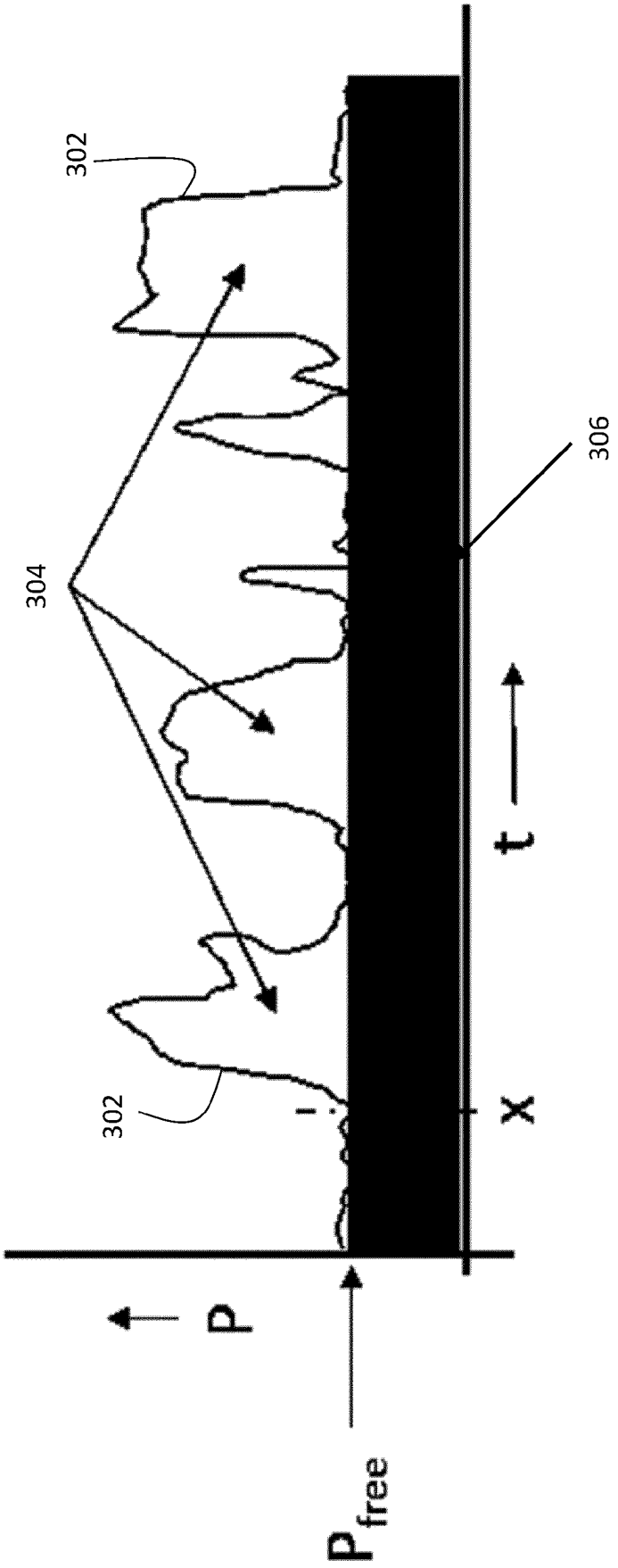

Figure 3

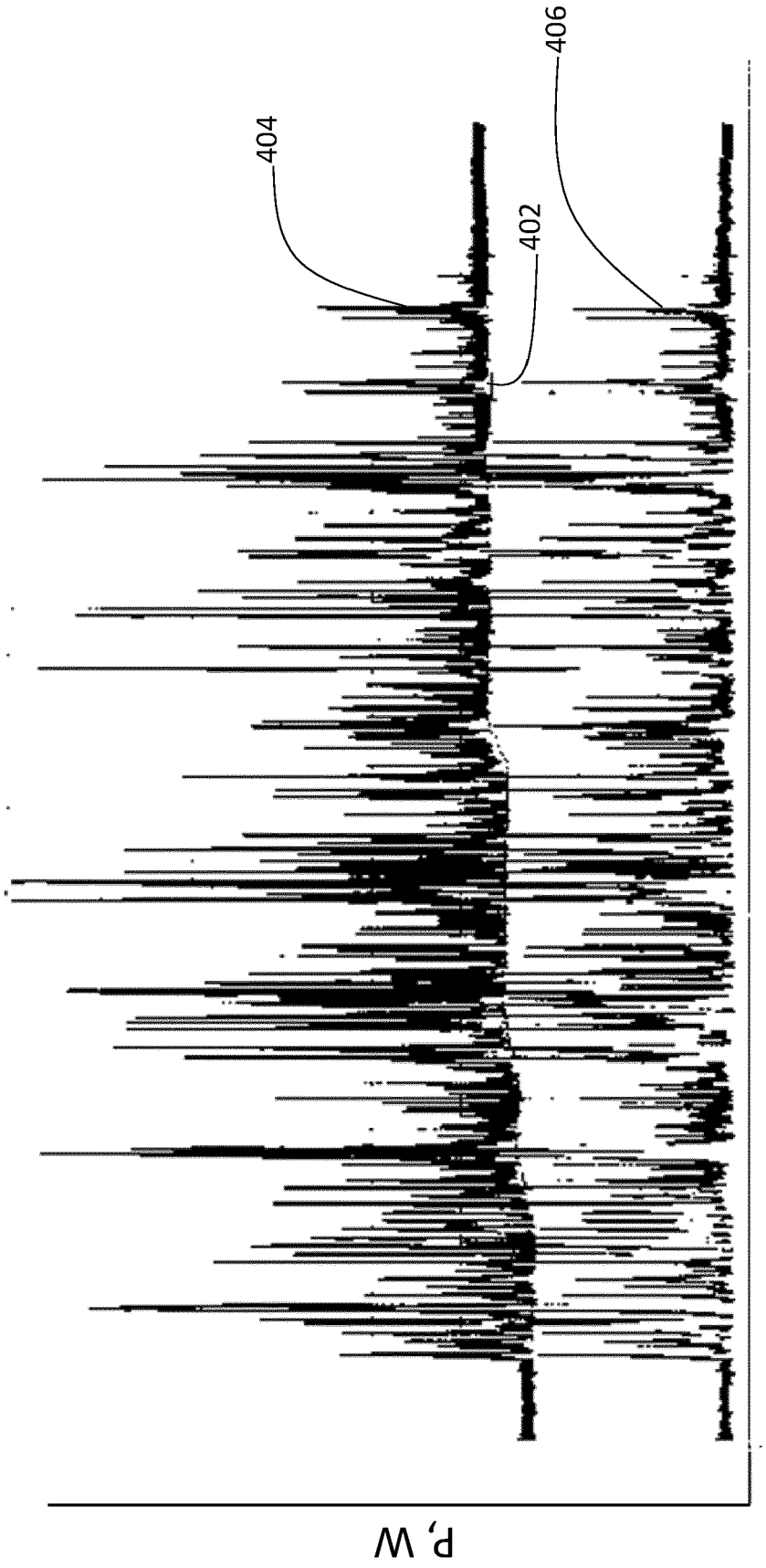

Figure 4

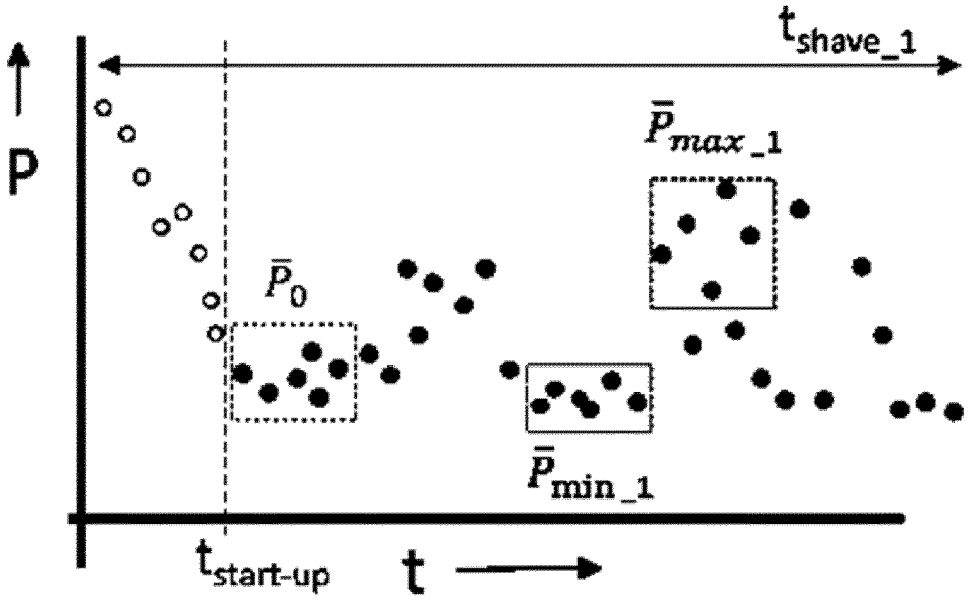

Figure 5

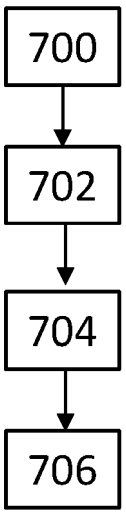

Figure 6

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EUROPEAN SEARCH REPORT

Application Number
EP 23 20 5042

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2018/236674 A1 (VOORHORST FOKKE ROELOF [NL] ET AL) 23 August 2018 (2018-08-23) * paragraphs [0006] - [0014], [0022], [0037] - [0042], [0049] * * claims 1,2,5-7 * * figures 2,3,10 *	1-15	INV. B26B19/38
A	US 2023/034605 A1 (NEYER CHRISTIAN [DE] ET AL) 2 February 2023 (2023-02-02) * paragraphs [0011] - [0022], [0043] - [0062] * * figures 1-5 *	1-15	
A	US 2017/099199 A1 (BAUER MATTHEW STEPHEN [US] ET AL) 6 April 2017 (2017-04-06) * paragraphs [0001], [0002], [0017], [0019] - [0027], [0040] - [0050] * * figures 1,2,7-9 *	1-15	
A	US 2004/098862 A1 (ORLOFF GLENNIS J [US]) 27 May 2004 (2004-05-27) * paragraph [0068] * * claims 1,25,37 *	1-15	TECHNICAL FIELDS SEARCHED (IPC) B26B
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	16 February 2024	Schouten, Adri

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 23 20 5042

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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