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(54) Title: SYSTEM FOR DETERMINING AMPLITUDE OF A POWER TOOTHBRUSH BRUSHHEAD IN THE MOUTH

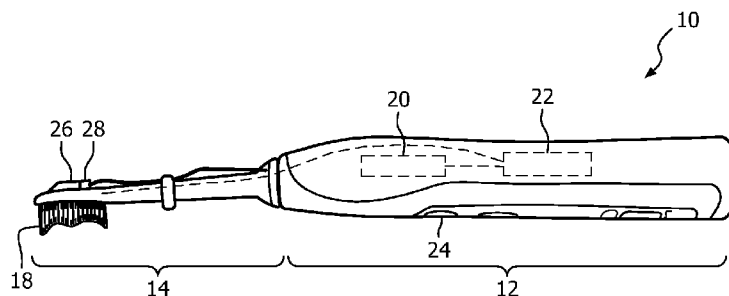


FIG. 1

(57) Abstract: The power toothbrush includes a handle (12), a brushhead (14) and a drive assembly (20) which includes a processor (22) for driving the brushhead at a selected frequency and amplitude. A miniature gyroscope (MEMS) (26) and an accelerometer (28) are mounted on the brushhead or on a portion of the drive assembly within the handle for detecting rotational velocity of the brushhead and orientation of the brushhead in the mouth during operation. Information from the gyroscope (rotational) and the accelerometer are then provided to the processor for determining amplitude of brushhead movement. The amplitude information is provided to the user, or can be further processed and fed back (30) to the drive assembly for control of brushhead movement.



SYSTEM FOR DETERMINING AMPLITUDE OF A POWER TOOTHBRUSH BRUSHHEAD IN THE MOUTH

This invention relates generally to power toothbrushes, and more specifically concerns the determination of rotational amplitude and/or other motion of a power toothbrush brushhead when the power toothbrush is operating within the mouth.

In the operation of a power toothbrush, it is important to determine the on-going performance of the toothbrush, *i.e.* the effectiveness of the brushing action. One way to maintain effectiveness is to maintain the desired pre-set frequency of operation of the toothbrush. This is done routinely in power toothbrushes, particularly resonant drive power toothbrushes, by action of the processor present in the toothbrush, typically in the handle portion thereof.

Another way to determine operational effectiveness is to determine the amplitude of movement of the brushhead. This is often done during testing following manufacture of the toothbrush by an *in vitro* process/arrangement, *i.e.* when the toothbrush is outside the mouth, using various known systems to measure both amplitude and frequency. However, such an *in vitro* system cannot be used for *in vivo* (in the mouth) determinations. A rotary encoder-based measurement system can be used, positioned near the handle coupling end of the brushhead. However, such a system does not take the brush neck structure into consideration and does not determine or measure displacement. There is no known effective structure/method for direct amplitude determination of the brushhead during actual/normal operation of the toothbrush in the mouth.

Accordingly, it is desirable for a power toothbrush to have an *in vivo* brushhead amplitude determination capability.

Accordingly, such a power toothbrush comprises: a handle; a brushhead; a drive assembly, including a processor, for driving the brushhead at a selected frequency and amplitude, the drive assembly being located within the handle; a miniature gyroscope mounted on the brushhead or on a portion of the drive assembly within the handle for detecting rotational velocity of the brushhead when the brushhead is operating in the mouth of a user; and wherein

the processor is capable of processing the rotational velocity information from the gyroscope to provide amplitude information of brushhead movement, wherein said amplitude information is provided to the user or used to control brushhead operation.

Figure 1 shows a simplified schematic view of a power toothbrush showing an *in vivo* amplitude determination system.

Figure 2 is a close-up view of a portion of the structure of Figure 1.

Figure 3 is a simplified feedback/control system for the power toothbrush using amplitude information.

Figure 4 is a simplified schematic view of an alternative embodiment of the brushhead amplitude determination system.

Figure 5 is a simplified representation of a system in which brushhead amplitude information is provided to a base unit separate from the power toothbrush.

Figures 1 and 2 show a simplified view of the amplitude determination system disclosed herein. Figure 1 shows a power toothbrush 10 having a handle portion 12 and a removable brushhead portion 14 with a bristle field section 18 at the distal end thereof. Internally of the handle is a drive/power system 20 for the brushhead and a processor 22 for controlling the action of the drive/power system. Drive/power system 20 and processor 22 are generally conventional and well-known in the art of power toothbrushes. The toothbrush 10 is controlled by an on/off switch 24 and may include other conventional operation capability, including various modes of operation, controlled by processor 22.

In the embodiment of Figures 1 and 2, a MEMS (micro-electro-mechanical-system) gyroscope 26, such as manufactured by ST Microelectronics, and an accelerometer 28 are positioned on the brushhead 14 at the rear of the bristle field. Power is provided to the gyroscope 26 and the accelerometer 28 by drive/power system 20. Velocity data obtained during operation of the toothbrush is transmitted back through wires or other communication elements to the control processor. While gyroscope 26 and accelerometer 28 and connecting power/data lines 30 are visible in Figures 1 and 2, in a commercial toothbrush, they will typically be concealed. Line connections in a selected form are provided between brushhead 14

and the handle 12 to permit convenient removal and insertion of brushheads thereto. As indicated above, gyroscope 26 typically is a MEMS gyroscope such as manufactured by ST Microelectronics. MEMS gyroscopes are well-known commercial devices which use a pendulum vibrating element to measure rotational velocity of the brushhead as it moves. Presently available MEMS gyroscopes have the necessary amplitude measurement capability, with 6K degrees per second (dps) components. Higher values of dps components would increase performance of the system.

The rotational velocity information is provided to the control processor 22, which by a routine calculation converts the velocity information to an amplitude number. This is well-known in the art, using the known frequency of brushhead oscillation. A typical frequency for a resonant power toothbrush is 230-290 Hz, although this can be varied.

The processor 22 filters out user-imparted motion and other undesirable signals and determines the amplitude of motion, either peak or peak-to-peak thereof. With such a power toothbrush, to have effective brushing, peak-to-peak amplitude is typically within the range of 9-11°, with 10° being optimal, although again this value can be varied, depending upon the particular toothbrush.

The amplitude information determined by the processor can then be compared at 31 with a desired amplitude range and an output provided, indicating that the amplitude is within the desired range or outside thereof. Alternatively, or in addition, the amplitude information can be provided to the user, either by an auditory or visual representation, represented at 34 generally, either on the toothbrush itself or through a communications link 33 to a base unit 36 (Figure 5). Information can also be provided concerning the position of the brushhead relative to selected regions of the teeth. The communication to the base typically is RF communication. The user can use that information to change his/her brushing habits, such as decreasing the pressure of the bristles against the teeth, which could affect the amplitude of the brushhead. In this way, the user obtains direct information relative to the possible effectiveness (or ineffectiveness) of the brushing and his/her use of the toothbrush.

Alternatively, referring to Figure 3, the information from the processor can be used through a feedback line 30 to the drive assembly to change an aspect of the drive signal,

such as the frequency of the drive signal or the duty cycle of the drive signal to change the amplitude back to the desired value. This arrangement is useful when the user is generally brushing correctly, but due to other factors, such as a reduction in battery power, the brush effectiveness is below a desired value.

The purpose of the present system is to use *in vivo* brushhead amplitude information during actual brushing operation as a measurement of effective brushing. Amplitude information can be used by the system itself to maintain/improve the effectiveness of the brushing by maintaining the brushhead amplitude within a known desired range.

As indicated above, a MEMS gyroscope is used to obtain rotational velocity, which can be used to determine rotational amplitude. Rotational velocity can also be obtained by an accelerometer, although there are limitations. The gyroscope is immune to non-rotational forces.

The system can also include an accelerometer 28 (Figure 2) with the gyroscope. The accelerometer can be used to determine a change of position of the brushhead in the mouth (apart from rotational movements), so that amplitude can be correlated with selected regions of the mouth. The combination of the MEMS gyrometer and the accelerometer enables the system to determine both rotational and translational motion. The combination of accelerometer information and the MEMS gyroscope information (after processing) provides information concerning the effectiveness of the brushing over the entire oral region. It should be understood, however, that the MEMS gyroscope alone provides the desired information with respect to amplitude determination (after processing). The same is true for the accelerometer alone, with some limitations.

Figures 1 and 2 show the gyroscope and the accelerometer positioned on the brushhead, typically at the base of the bristle field. However, the gyroscope and/or the accelerometer can be positioned on other locations on the brushhead and also can be positioned within the handle. Figure 4 shows an arrangement where the gyroscope and accelerometer are positioned on a “hub” portion of the drive system, *i.e.* a portion of the drive system, such as a base portion of the driveshaft 40 in the handle 42 which connects with the brushhead. In this arrangement, there is no requirement for data or power lines between the brushhead and the

handle portions, since all the elements are within the handle. Alternatively, one element, *e.g.* the gyroscope, could be on the brushhead and the other, *e.g.* the accelerometer in the handle or vice versa.

Accordingly, a system has been disclosed which uses a miniature gyroscope (MEMS) to measure angular velocity of a power toothbrush brushhead, from which amplitude of the brushhead movement can be determined. An accelerometer could also be used, although with limitations, since it is subject to non-rotational forces. The system is capable of measuring angular velocity *in vivo*, *i.e.* within the mouth, when the toothbrush is operating. Amplitude information is important relative to the effectiveness of the brushing.

The information obtained can also be stored for later analysis. The storage member, represented generally at 36 in Figure 3, can be in the handle, the brushhead or the base unit.

Although a preferred embodiment of the invention has been disclosed for purposes of illustration, it should be understood that various changes, modifications and substitutions may be incorporated in the embodiment without departing from the spirit of the invention, which is defined by the claims which follow.

CLAIMS:

1. A power toothbrush, comprising:
 - a handle (22);
 - a brushhead (14);
 - a drive assembly (20), including a processor (22), for driving the brushhead at a selected frequency and amplitude, the drive assembly being located within the handle;
 - a miniature gyroscope (26) mounted on the brushhead or on a portion of the drive assembly within the handle for detecting rotational velocity of the brushhead, when the brushhead is operating in the mouth of a user; and
 - wherein the processor is capable of processing the rotational velocity information from the gyroscope to provide amplitude information of brushhead movement, wherein said amplitude information is provided to the user or used to control brushhead operation.
2. The toothbrush of claim 1, wherein the amplitude information is provided both to the user and to control brushhead operation.
3. The toothbrush of claim 1, wherein the information provided to the user is either audible or visible to the user.
4. The toothbrush of claim 1, including a storage system (36) for storing the information for later analysis.
5. The toothbrush of claim 1, including a comparison circuit (31) for comparing the amplitude information with a pre-established range of values, and if the amplitude information is outside of said range, a feedback control signal (30) is provided to the drive assembly to change a characteristic of the drive signal in order to alter the amplitude to the selected range.
6. The toothbrush of claim 5, wherein the characteristic is the frequency of the drive signal or the duty cycle of the drive signal.
7. The toothbrush of claim 1, wherein the amplitude information is peak-to-peak amplitude.

8. The toothbrush of claim 1, wherein the amplitude information is peak amplitude.

9. The toothbrush of claim 1, including a base display unit (36) separate from the toothbrush for displaying the amplitude information and a communication capability (33) between the toothbrush and the base display.

10. The toothbrush of claim 1, further including an accelerometer (28) which provides information as to the orientation of the brushhead in the mouth of the user.

11. The toothbrush of claim 10, wherein both the accelerometer and the gyroscope are on the brushhead.

12. The toothbrush of claim 10, wherein both the accelerometer and the gyroscope are in the handle.

13. The toothbrush of claim 10, wherein one of the gyroscope and the accelerometer is in the brushhead and the other is in the handle.

14. A power toothbrush, comprising:

a handle (22);

a brushhead (14);

a drive assembly (20), including a processor (22), for driving the brushhead at a selected frequency and amplitude, the drive assembly being located within the handle;

an accelerometer (28) mounted on the brushhead or on a portion of the drive assembly within the handle for detecting forces present on the accelerometer due to motion of the brushhead, including rotational velocity of the brushhead, when the brushhead is operating in the mouth of a user; and

wherein the processor is capable of processing the rotational velocity information from the accelerometer to provide amplitude information of brushhead movement, wherein said amplitude information is provided to the user or used to control brushhead operation.

15. The toothbrush of claim 14, wherein the amplitude information is provided both to the user and to control brushhead operation.

16. The toothbrush of claim 14, including a comparison circuit (31) for comparing the amplitude information with a pre-established range of values, and if the amplitude information is outside of said range, a feedback control signal (30) is provided to the drive assembly to change a characteristic of the drive signal in order to alter the amplitude to the selected range.

17. In a power toothbrush which includes a handle (22), a brushhead (14), a drive assembly(20) for driving the brushhead at a selected frequency and amplitude, the drive assembly being located within the handle and a miniature gyroscope (26) mounted on the brushhead or on a portion of the drive assembly within the handle for detecting rotational velocity of the brushhead when the brushhead is operating in the mouth of a user:

a processor (22) located in the drive assembly, capable of processing the rotational velocity information from the gyroscope to provide amplitude information of brushhead movement, wherein in operation of the power toothbrush, said amplitude information is provided to the user, or to the drive assembly to control brushhead operation.

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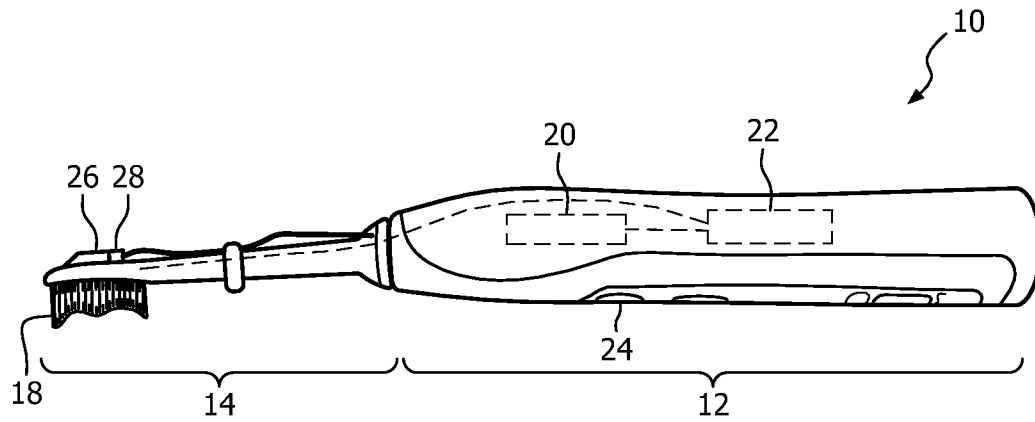


FIG. 1

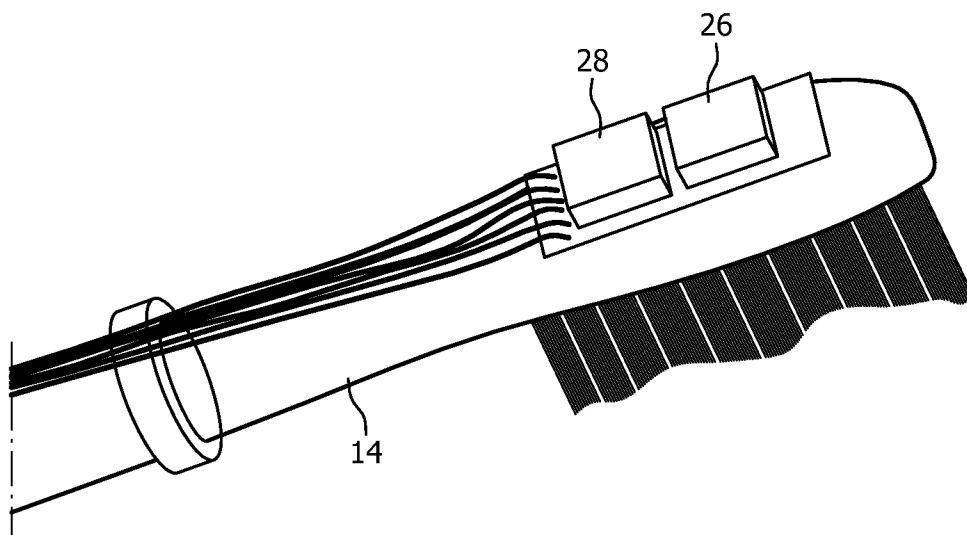


FIG. 2

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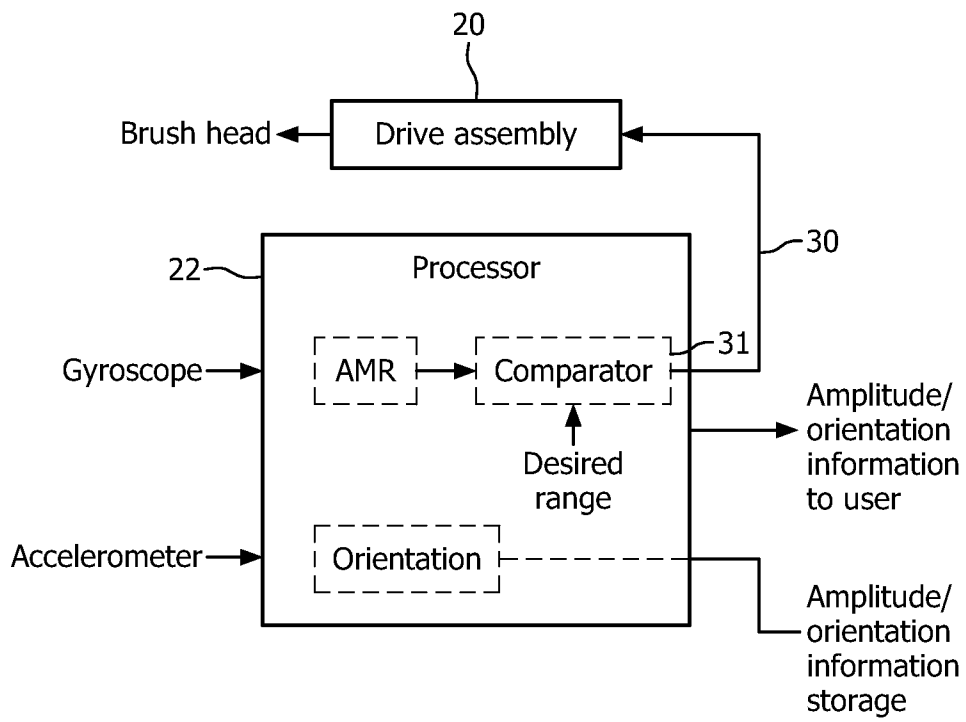


FIG. 3

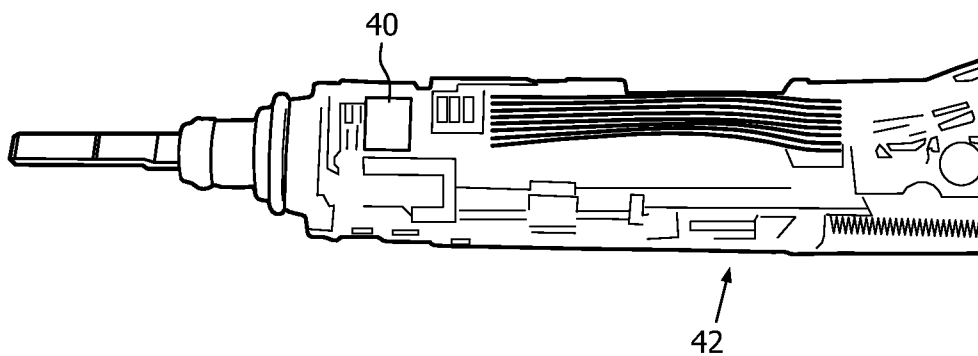


FIG. 4

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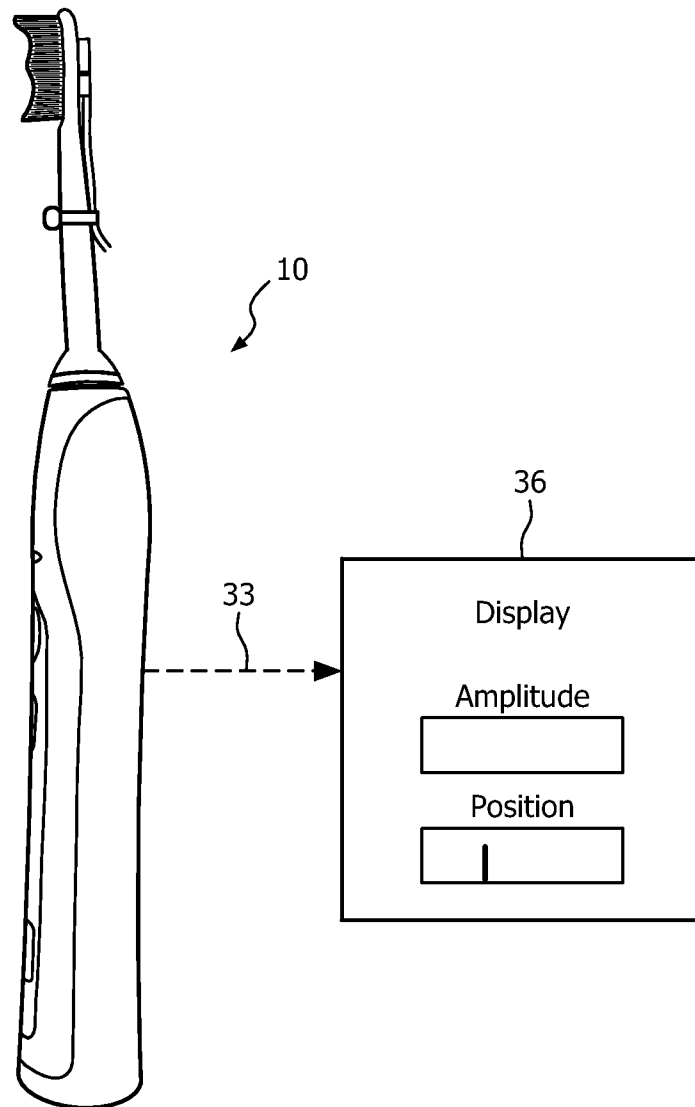


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2012/055656

A. CLASSIFICATION OF SUBJECT MATTER INV. A61C17/22 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) A61C A46B		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2011/041269 A1 (IWAHORI TOSHIYUKI [JP]) 24 February 2011 (2011-02-24) paragraphs [0011], [0013], [0077], [0096] - [0098], [0102] - [0117]; figures 1, 2, 6	1-17
A	----- US 2011/010876 A1 (IWAHORI TOSHIYUKI [JP] ET AL) 20 January 2011 (2011-01-20) pages 1-13; figures 1, 2, 18 -----	1-17
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
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Date of the actual completion of the international search 18 February 2013	Date of mailing of the international search report 26/02/2013	
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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