(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
22 March 2007 (22.03.2007)

PCT

(10) International Publication Number
WO 2007/032015 A2

(51) International Patent Classification:
A46B 9/04 (2006.01)

(21) International Application Number:
PCT/IL2006/001089

(22) International Filing Date:
17 September 2006 (17.09.2006)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
170921 18 September 2005 (18.09.2005) IL
171055 22 September 2005 (22.09.2005) IL

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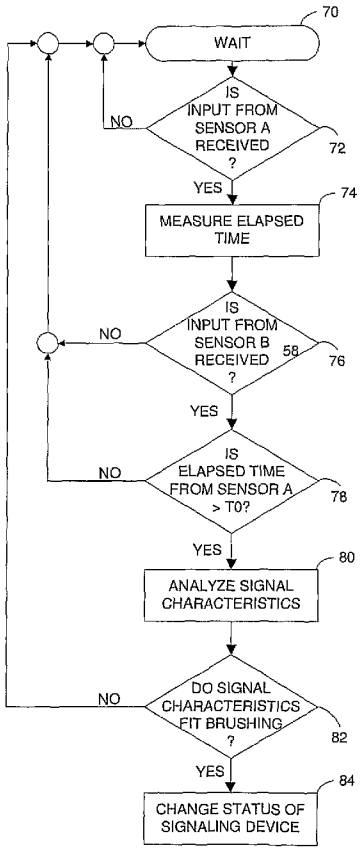
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LV, LY, MA, MD, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

[Continued on next page]

(54) **Title:** TOOTHBRUSH



(57) **Abstract:** An electrically powered sensing and monitoring system of a toothbrush for indicating brushing activity parameters to a user is disclosed. The brush uses one or more sensors for monitoring motion parameters in one or more dimensions. A clock measures elapsed time since beginning of motion, and calculates duration of activity and/or time elapsed since activity terminated. One or more signalling devices indicate to a user time dependent events.

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TOOTHBRUSH

FIELD OF THE INVENTION

The present invention relates in general to an apparatus and technique useful in dental care.

BACKGROUND OF THE INVENTION

Duration and repetition rate of teeth brushing are dependent on the attention and motivation of the user. Therefore such values have to be assimilated, especially by children. Various techniques indicating to a toothbrush user that the correct brushing time has elapsed are known.

European patent application EU0610072B1 discloses a toothbrush wherein the head, bristles and/or handle of which contain a dispersed thermochromic material that changes color due to heat transferred by a user while brushing his or her teeth. US patent 5,864,288 discloses a toothbrush holder including an automatically activated timer for measuring the time in which the toothbrush is taken off the holder. An alarm is activated when the brush is returned to its place before the correct brushing time elapsed.

US patent 5704087 discloses a toothbrush equipped with electronic means for measuring the time interval between a visit to the dentist and the time when the next visit is to take place. The toothbrush remains "dormant" during this time

interval. At the end of the interval, electronic means are activated to provide a visual and/or audible alert to the user of the toothbrush. The signal is delivered during actual use of the brush.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic description of a toothbrush according to a preferred embodiment of the present invention;

Fig. 2 is a block diagram of the electronic circuit shown in Fig. 1;

Fig. 3 is a flowchart of the process for indicating deviations from the elapsed brushing time from the desired value according to a preferred embodiment of the invention;

Fig. 4 is a flowchart of a process employing two sensors according to a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

The system and method in accordance with the present invention provide a teeth brushing monitoring system which is useful in educating a user, typically a child, to conduct repetitive and proper brushing of teeth. The method is useful in motivating a user to repeat proper brushing of teeth by means of visual signalling indicating that the elapsed time of a current teeth brushing session is sufficient. The visual indication remains unchanged until such time as a user, or a supervisor, is reminded that a new brushing of teeth session is due, as is further described infra. The system of the invention lends itself comparatively easily to incorporation in electrically operated tooth brushes, since such brushes already contain circuitry and energizing components.

Reference is first made to **Fig. 1** schematically showing a toothbrush according to a preferred embodiment of the present invention. Toothbrush **10** includes handle **11** and head **12** with bristles **13**. Visual signalling device **14** on the face of handle **11** is in such position as to be easily seen when taking the brush in hand. Inside handle **11** are housed sensor **15**, electrical circuitry including an integrated circuit (IC) and related discrete circuit elements collectively represented by rectangle **16** and battery **17**. Biasing springs and electric conducting wires, not shown, provide the electrical connection between battery **17**, and a conventional button cell, electrical circuitry **16**, sensor **15** and signalling device **14**. Optionally, battery **17** is chargeable and an electric circuit for inductively charging battery **17** is provided and housed inside handle **11**.

The operating technique according to the present invention is hereinafter described with reference to **Figs. 2 – 3**. In **Fig. 2** a block diagram of the electrical circuit disposed in the handle is shown. Touch sensor **30** responds to touch by activating programmable controller **32**. The activated controller then reads the time provided by clock **34** and further analyzes the data stream provided by touch sensor **30** and by optional motion detection sensor **36**. Controller **32** measures the time of onset of brushing and brushing duration and issues an indication, relating to the brushing time by means of signalling device **38**. Touch sensor **30** is typically a membrane type touch switch positioned such as to be activated by a user's finger during use of the toothbrush. One type of touch sensor is a capacitive sensor indicating that a user holds the brush by measuring a change in capacitance resulting from the proximity of the hand. Optional motion detection device **36** typically uses a piezoelectric sensor, the output voltage of which is analyzed to indicate movements typical of the periodic vibrations associated with brushing of teeth. A light emitting diode (LED), or a miniature liquid crystal display (LCD) can be used by signalling device **38**. Memory **40** consisting of RAM, ROM and/or EPROM provides for storing programs, constants and/or programmable constants, and for working memory.

The controller is operative in measuring the elapsed time for each single session of brushing of teeth and in indicating the last brushing time. Optionally, the elapsed time between two successive sessions of brushing of teeth is also measured by the system and compared to a desired repetition cycle time. The system indicates to a user that the current brushing of teeth session has taken

place. Such an indication is given by alternately switching a LED between on and off states, or alternately designating a specific colour of the LCD to a specific state.

An exemplary scenario can better explain the method provided by the present invention is as follows. A user starts brushing his/her teeth employing a toothbrush of the invention. Touch sensor **30** activates the controller to measure and record the activation time. The elapsed time from the activation time is constantly compared to a stored constant value of prescribed brushing time. When the elapsed time exceeds the stored value, a LED changes its state from an "on" to an "off" state, or vice versa. Similarly the colour of the LCD changes from the one displayed hue, to a contrasting hue. The user, having observed a change in colour or illumination, can stop brushing his/her teeth and put the toothbrush back in place. The visual signal, namely the state of the LED or the hue of the LCD does not change until another session of teeth brushing takes place for a sufficient amount of time. Such visual signalling will not occur if the measured brushing duration does not reach the prescribed value. Therefore, a parent who knows that a prescribed morning brushing session changes the colour of the LCD to "red", for example, can easily see whether his/her child has provided the criteria for a change in LCD colour.

Signalling devices

Visual signalling can be provided by various low energy consuming display systems and/or lighting elements. Typical small sized and low energy consuming displays are LCD displays. Light emitting solid state devices such as LEDs can provide lighting at a small energy cost. Mechanical signalling

devices are well known in the art. Among them vibratory devices are well known in the art as producing signals for attracting the attention of users of communications terminals. Vibrating cellular phones and other electronic systems use buzzers, ringers or vibratory devices for attracting the attention of users. Sound generator signalling devices produce a higher frequency of mechanical vibration can be used as well for the purpose of attracting attention. Small piezoelectric sound generating devices are typically used as mechanical vibration generators.

Brushing sensors

In a simple embodiment of the invention, one sensor is implemented. The sensor in such a case is employed to sense and confirm the actual brushing of teeth as can be interpreted from the signal sent by one such sensor. The distribution of signals from the sensor in time can be used to more accurately confirm and characterize the brushing action. For example, an accelerometer is incorporated within the handle to sense vertical accelerations of the horizontal brush. To monitor rotational movement of a brush, a movement as may be recommended by dentists, a more complex combination of vertical and horizontal acceleration or movement sensors may be required. A cyclic (over time) brushing activity can be expected and interpreted as a cyclic (over time) series of accelerations whether in one, two or three dimensions. Another sensor preferably to be used is a pressure sensor that can sense the actual grip on the toothbrush, or the pressure of the brush against the teeth. A set of pressure sensors oriented in appropriate directions can be used instead of

accelerometers to determine quantitative aspects of the brushing movement in three dimensions. Such aspects are typically duration, cyclic parameters, and pressure. Yet another possible sensor is a contact sensor such as a touch switch, or an electronic circuitry such as a RC, or RLC circuits the voltage of which is sensitive to changes in the capacity values induced by a user holding the toothbrush. The use of piezoelectric units was discussed above.

Brushing sensor interpretations and signalling algorithms

The signalling device of the invention is associated with time dependent events related to brushing of teeth. The signals of the sensors that interpret physical parameters are used by the algorithms implemented in the controller to indicate usage characteristics of the toothbrush.

In such cases in which the system includes a motion detection device/sensor, its output signal is analyzed to check whether it has characteristics of a cyclic motion, which are typical for tooth brushing such as the average cycle time and its variance, and/or mean values and ranges of voltage amplitudes. If such measured features are different than corresponding stored values, the system returns to check whether the brush is being used.

In **Fig. 3** a flowchart of the interpretation algorithm of a single sensor embodiment is shown. Initially, the system is in a standby **50**. An input signal sent by a pressure sensor activates the controller in step **52**, invoking reading of the time value. As long as a signal is received the processor measures the elapsed time in step **54**. If the elapsed time surpasses a certain predefined period T_0 as verified in step **56**, the processor changes the status of the

signalling device in step **58** to indicate usage and to indicate reuse requirement after several hours. Such reuse requirement, indicating the need for an evening brush for example, is implemented for example, by blinking, activating an additional LED or by displaying specific symbol while employing same colour coding, in cases in which a LCD is employed, or a rhythmic signal if a mechanical signal is set off.

The process concludes by signalling the end of a prescribed brushing time and the controller returns to the standby state. Optionally the controller records the time of the end of a current brushing duration by which the brushing repetition cycle is compared to the stored desired value. When the duration exceeds a certain stored desired value, optical or audible signalling takes place.

In a more complicated algorithm, two sensors are implemented to monitor the actual brushing, and to increase the confidence level in the analysis of the brushing. Reference is made to **Fig. 4** showing a flowchart of the process according to a preferred embodiment of the present invention. The system waits in step **70** for an input to be received **72** from sensor A, indicating that the toothbrush is in use. Such input invokes the measurement of time elapsed in step **74**. The system then checks for input from sensor B which is, for example, a motion detection sensor or a pressure sensor, in step **76**. If such input has not been received the system returns to step **70** to wait for the next input. If input from the motion detection sensor is received the system checks in step **78** if time elapsed exceeds T_0. If not, the system returns to step **70**. When elapsed time reaches the value of T_0 an analysis of the signals from sensor B is carried out in step **80** and its characteristics are compared in step **82** to stored

characteristic values corresponding to a model of brushing of teeth. If matching the measured and stored values fit within predefined limits, the status of the signalling device is changed in step **84**, providing an indication that brushing of teeth has been accomplished. If this matching fails the system returns in step **70** to wait for new input from sensor A. The use of a more complex layout of motion detectors and or pressure detectors can be used to monitor brushing movements and evaluate the quality of brushing.

In another embodiment of the invention a sound signal is activated when the duration of brushing the teeth has passed a predefined value. Such that the user brushing the teeth can hear a sound signal or feel a vibration announcing the time appropriate for cessation of the brushing activity. Moreover, the sensors may be used to monitor the actual movements of the brush so that a specific combination of horizontal and vertical movement can be calculated and used as a threshold for announcing sufficiency of the brushing activity, with or without taking in account the time spent for brushing.

Finally, if a period of time elapses since the morning brush which is longer than the prescribed time for the onset of evening brush, the system can be set for providing an alarm for the user or supervisor (e.g. a parent). To increase the severity of the alarm, a blinking or flaring visual signal can be applied in such cases rather than the mere changing of colour or hue.

CLAIMS

1. A toothbrush for monitoring brushing activity comprising
   - at least one sensor for sensing brushing parameters;
   - a clock for measuring elapsed time;
   - at least one signalling device for indicating a user of time dependent events;
   - a control unit for receiving signals from said at least one sensor,
   - an electrical battery for energizing said sensor and said at least one signalling device.

2. A toothbrush as in claim 1, further comprising at least a contact detection sensor.

3. A toothbrush as in claim 1, wherein said sensor is selected from a group of devices including a membrane type switch and a capacitive sensor.

4. A toothbrush as in claim 1, wherein said at least one signalling device is a visual signalling device

5. A toothbrush as in claim 4, wherein said at least one signalling device is selected from a group of devices including light emitting diode (LED) and liquid crystal display (LCD).

6. A toothbrush as in claim 1, wherein said at least one signalling device is a mechanical signalling device.

7. A toothbrush as in claim 6, wherein said at least one mechanical signalling device is a sound generator.

8. A toothbrush as in claim 2, wherein said motion detection device is a piezoelectric device.

9. A toothbrush as in claim 1, wherein said battery is chargeable.

10. A toothbrush as in claim 1 wherein said toothbrush is an electrical toothbrush.

11. A toothbrush for monitoring the quality of brushing activity comprising

- at least a sensor for sensing the movement of said brush;
- a clock for measuring elapsed time;
- a control unit for receiving signals from at least said movement sensor and said clock,
- an electrical battery for energizing said sensor and said at least one signalling device.

12. A method for indicating usage characteristics of a toothbrush over time, said method comprising:

- sensing onset of use;
- measuring the elapsed time of a toothbrush employed for said brushing of teeth over time, and;
- visually signalling when the time associated with said brushing exceeds a prescribed brushing time.

13. A method for indicating usage characteristics as in claim 12 and wherein said usage indication refers to rotational activity.

14. A method for indicating usage characteristics of a toothbrush, said method comprising:

- sensing movement of said toothbrush in at least one direction;
- calculating the movements in said at least one direction, and
- mechanically signalling when the time associated with said brushing exceeds a prescribed brushing time.

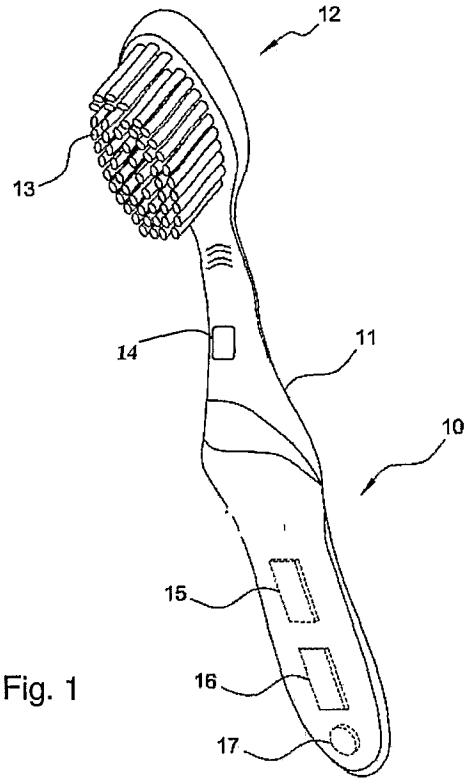
12
13
14
11
10
15
16
17

Fig. 1

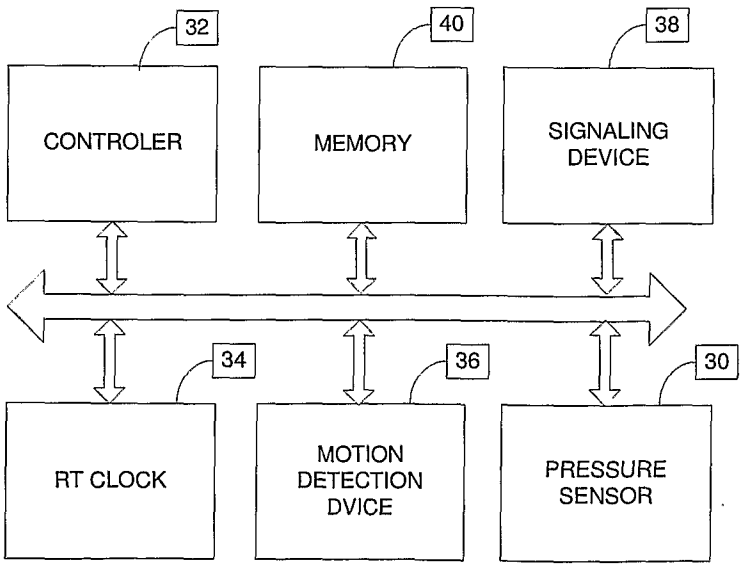
32
40
38
CONTROLER
MEMORY
SIGNALING DEVICE
34
36
30
RT CLOCK
MOTION DETECTION DVICE
PRESSURE SENSOR

Fig. 2

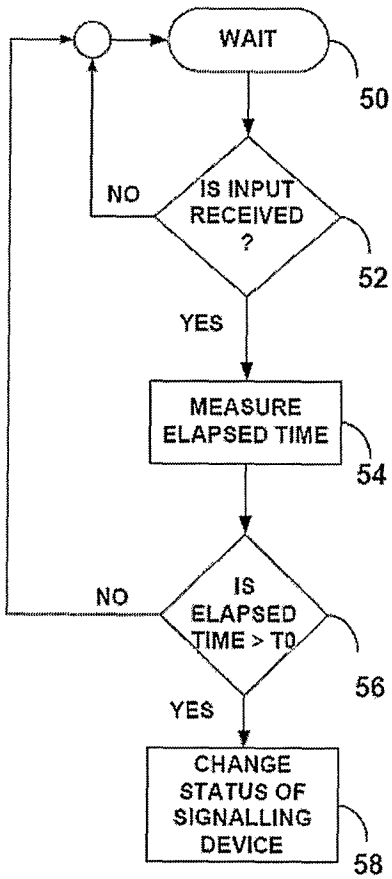
WAIT
50
IS INPUT RECEIVED ?
NO
52
YES
MEASURE ELAPSED TIME
54
IS ELAPSED TIME > T0
NO
56
YES
CHANGE STATUS OF SIGNALLING DEVICE
58

Fig. 3

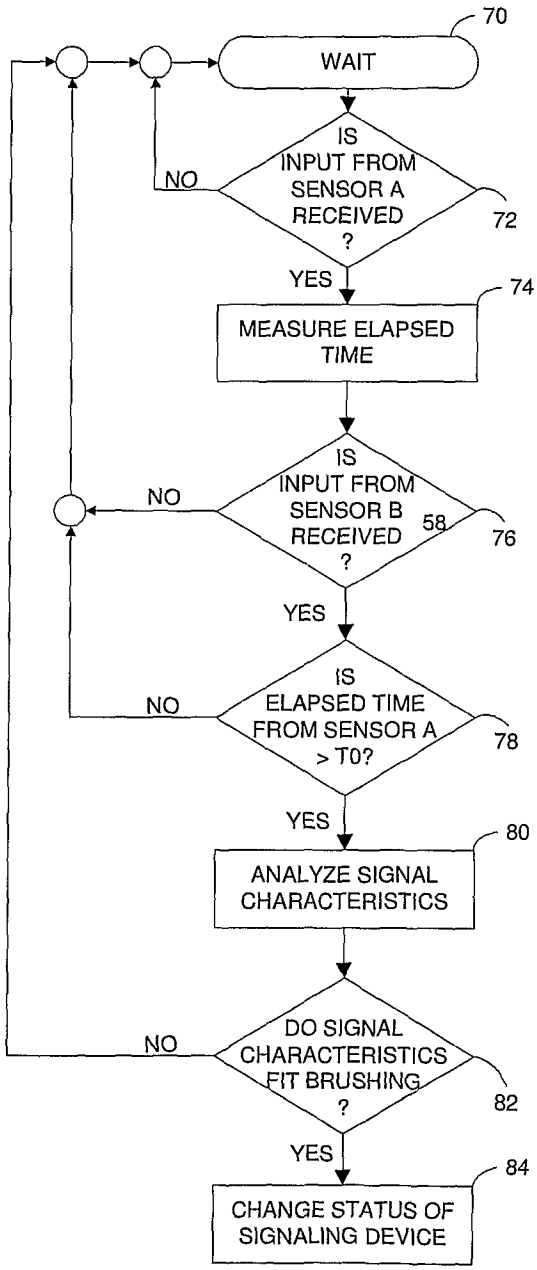
70
WAIT
IS INPUT FROM SENSOR A RECEIVED ?
NO
72
YES
74
MEASURE ELAPSED TIME
IS INPUT FROM SENSOR B RECEIVED ?
58
NO
76
YES
IS ELAPSED TIME FROM SENSOR A > T0?
NO
78
YES
80
ANALYZE SIGNAL CHARACTERISTICS
DO SIGNAL CHARACTERISTICS FIT BRUSHING ?
NO
82
YES
84
CHANGE STATUS OF SIGNALING DEVICE

FIG. 4