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(54) **HYBRID MECHANICAL WATCH MOVEMENT WITH INTEGRATED ELECTRONICS  
IMPLEMENTING WIRELESS COMMUNICATION, SENSORS AND DISPLAY**

(57) A hybrid mechanical watch movement comprising a mechanical watch movement comprising a plate and a bridge configured to hold in between of them mechanical parts of the mechanical watch movement, a plurality of electronic components comprising one or more from the list comprising a printed circuit board, a Lavet micro-motor, a rechargeable battery, and a microphone. The plurality of electronic components is part of the mechanical watch movement and is held in the mechanical watch movement between the plate and the bridge.

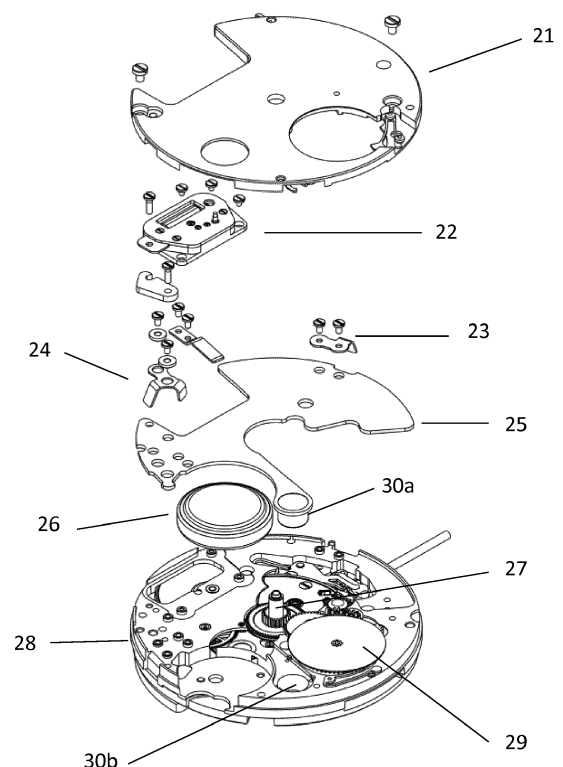


Figure 2

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## Description

### TECHNICAL FIELD

**[0001]** The present invention relates to a watch movement integrating both mechanical parts and electronics.

### BACKGROUND ART

**[0002]** Mechanical movements and quartz movements for watches have been known for a long time. Quartz movements with electronics features and wireless connectivity exist.

**[0003]** One example of prior art is a horological smartwatch made by FREDERIQUE CONSTANT® which integrates an electronic circuit boards and electromagnetic micro-motors. Detailed documentation on this smartwatch may be found for example at following urls:

- <http://frederiqueconstant.com/smartwatch/>
- <http://frederiqueconstant.com/smartwatch/wp-content/uploads/2016/09/GUIDE-FC-SMARTWATCH-7-GB-Web.pdf>

**[0004]** The smartwatch comprises Bluetooth® communication technology, a processor and an accelerometer.

**[0005]** Other prior art watches may integrate a mechanical movement and a number of electronic devices and features around the mechanical movement. One such example is the Hyetis Alpha® product described at the website

<https://www.xavierstuder.com/wp-content/uploads/2016/02/Workbook Light.pdf>.

**[0006]** In addition to an automatic movement, the watch comprises OLED screens, a UV dosimeter, Bluetooth® communication technology, a wireless charging and battery system, a speaker, as well as laser emitting beams and sensors such as biometric captors for heart rate and oxygen saturation measurement, and gyroscope, magnetometer, accelerometer, barometer, altimeter, hygrometer, and thermometer, a satellite positioning meter, all controlled by a microcomputer running a proprietary operating system.

**[0007]** While known systems that combine mechanical movement and electronics provide most features of both worlds, there is no real synergy between these worlds in that they fail to interact with each other.

### SUMMARY OF INVENTION

**[0008]** In a first aspect the invention provides a hybrid mechanical watch movement comprising a mechanical watch movement comprising a plate and a bridge configured to hold in between of them mechanical parts of the mechanical watch movement, a plurality of electronic components comprising one or more from the list com-

prising a printed circuit board, a Lavet micro-motor, a rechargeable battery, and a microphone. The plurality of electronic components is part of the mechanical watch movement and is held in the mechanical watch movement between the plate and the bridge.

**[0009]** In a preferred embodiment, the hybrid mechanical watch movement further comprises a shielding case configured to confine the plurality of electronic elements, whereby the shielding case comprises magnetically conductive material that is enabled to enclose magnetic fields inside the shielding, and to prevent the magnetic field from disturbing a proper operation of the mechanical watch movement.

**[0010]** In a further preferred embodiment the mechanical watch movement is configured to display mechanical time functions, by means of any one of the following list comprising an hours hand, a minutes hand, a date hand, a moonphase display.

**[0011]** In a further preferred embodiment, the hybrid mechanical watch movement comprises the microphone, whereby the microphone is placed in a dedicated cavity of the mechanical movement in proximity to mechanical parts generating the sound of the mechanical movement and the microphone is configured to record this sound.

**[0012]** In a further preferred embodiment, the hybrid mechanical movement comprises the printed circuit board, wherein the printed circuit board comprises an embedded processor that is configured to run an algorithm analysing the sound of the mechanical movement and compute a performance and a precision of a time function of the mechanical watch movement.

**[0013]** In a further preferred embodiment, the hybrid mechanical watch movement comprises the Lavet micro-motor and the printed circuit board, and further comprises a display for additional information, wherein the additional information is represented on the display using an additional hand driven by the Lavet micro-motor as controlled by a processor comprised in the printed circuit board.

**[0014]** In a further preferred embodiment, the hybrid mechanical watch movement further comprises a wireless communication interface that is configured to enable wireless communication with distinct external devices, which may be one or more of the list comprising a smart-phone, a tablet, a processor-based device.

**[0015]** In a further preferred embodiment the hybrid mechanical watch movement comprises the printed circuit board, wherein the printed circuit board is designed to execute a plurality of electronic functions; and the hybrid mechanical watch movement further comprises at least a sensor functionally connected to a processor of the printed circuit board, the processor being configured to allow an implementation of a plurality of electronic functions which comprise at least one of the following list:

- step counting using a step counting algorithm, whereby the at least one sensor comprises an accelerometer component,

- sleep monitoring using a sleep monitoring algorithm, whereby the at least one sensor comprises the accelerometer component,
- temperature measurement using one of the at least one sensors as appropriate,
- humidity measurement using one of the at least one sensors as appropriate,
- heart rate measurement using one of the at least one sensors as appropriate, and a heart rate monitoring algorithm, and
- UV measurement using one of the at least one sensors as appropriate.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0016]** The invention will be better understood through the description of preferred embodiments in reference to the figures, wherein

figure 1 shows two top views of a movement with display hands, a first set of display hands with a dial, and a second set of display hands without any dial; figure 2 shows the movement of figure 1 with its constitutive parts in an exploded view; figure 3 shows a Lavet micro-motor in a shielding case with details according to an example of the invention in an exploded view; figure 4 shows a block diagram of electronics according to an example embodiment of the invention; figure 5 shows a metal dial with an opening to enable an wireless interface; figures 6a and 6b show a top and a bottom view of the movement, wherein a number of main parts are hidden for a better readability in order to show a microphone and a mechanical elements generating a characteristic noise of the movement; figure 7 shows a possible implementation of the movement in a watch and a charger pod; figure 8 represents a block diagram of the architecture of the system analysing the sound of the mechanical movement; and figure 9 shows a recording of the sound of the mechanical movement recorded by the microphone.

## DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

**[0017]** One of the problems addressed by the invention is to integrate in a same watch movement,

- a mechanical movement displaying time and date and
- electronics realizing sensors, implementing wireless communication and driving micro-motors to display external or internal information.

**[0018]** A further one of the problems addressed by the invention is to integrate in a same watch movement

- mechanical parts realising mechanical movements that move hands showing time, date and moon-phase, sensitive to electro-magnetic fields and
- one or several Lavet micro-motors, creating electro-magnetic fields.

**[0019]** A further one of the problems addressed by the invention is to integrate in a same watch movement comprising a mechanical movement and electronics, a system that monitors the correct functioning of the watch movement.

**[0020]** The above enunciated problems are solved by providing a mechanical watch movement, also known as a caliber, and integrating into the mechanical watch movement electronic and electro-magnetic parts such as for example a Lavet micro-motor, a Printed Circuit Board (PCB), a battery, and one or more sensors. The electronic parts are truly part of the mechanical movement and cannot stand without it. As a whole a hybrid mechanical watch movement is obtained.

**[0021]** Referring to figure 2, the hybrid mechanical watch movement comprises a plurality of classical mechanical movement parts such as a bridge 21, a plate 28, wheels 27 and disks 29. It further comprises micro-motor parts 22, a rechargeable battery 26, battery contacts 23 and 24, and a populated Printed Circuit Board (PCB) 25.

**[0022]** Further referring to figure 2, the electronic components, i.e. the PCB 25, the battery 26, the microphone 30a and the Lavet motor 22 are held in the movement between the plate 28 and the bridge 21, in a manner similar as with traditional mechanical parts.

**[0023]** In a preferred embodiment the micro-motor is a Lavet type stepping motor, i.e., a special kind of single-phase stepping motor, well known from prior art.

**[0024]** The hybrid movement may display time in a manner similar to that of a classical mechanical watch movement. It may also mechanically display date and moonphase.

**[0025]** Figure 1 shows an example of a display where the movement displays time by means of an hours hand 13 and minutes hand 12, and display date by means of a date hand 14 and moonphase by means of a dedicated moonphase display 15.

**[0026]** The hybrid movement may in addition to the display similar to that of a classical mechanical watch further be enabled to display additional information by means of a micro-motor 11, which may for example be the micro-motor 22, 31-35 illustrated in figures 2 and 3, and rotate an additional hand driven by the micro-motor 11. This additional information is not displayed by mechanical parts.

**[0027]** Referring now to figure 3, the micro-motor comprises a bridge 31, a self and stator assembly 33, motor wheels 34 and a base 35. It further comprises a motor PCB 32 for connection purposes. The electro-magnetic parts, i.e. coil and stator 33, rotor and mobiles 34, are enclosed in a shielding case (as well known as Faraday

cage) composed of shield base 35 and a shield cover 31. The shielding case is made of magnetically conductive material to enclose the magnetic fields inside the shielding case 31, 35, and to prevent them from disturbing the proper operation of the mechanical parts of the hybrid movement.

**[0028]** Referring again to figure 2, the electronic parts comprise the PCB 25, which is powered by the rechargeable battery 26 through the battery connections 23 & 24. The PCB 25 is populated with electronics components (not shown in figure 2) realizing desired electronics functions. These components comprise for instance at least one of the list comprising

- at least an embedded sensor,
- at least an embedded processor,
- a wireless communication interface,
- a set of radio-frequency components.

**[0029]** In a preferred embodiment of the invention, the wireless interface is Bluetooth Low Energy®.

**[0030]** Referring again to figure 1, the electronic parts of the hybrid movement further comprise the at least one micro-processor (not illustrated in figure 1) that is configured to drive the micro-motor 11 in order to display the additional information. This additional information may be either or at the same time derived

- from measurements made with the at least one embedded sensor, using embedded algorithms to process the measurements by means of the at least one embedded processor; or
- from information received over the wireless communication information and processed by means of the at least one embedded processor.

**[0031]** The embedded processor may further realize the following functions:

- driving the Lavet micro-motor,
- reading the at least one embedded sensor,
- operate the wireless communication interface,
- data processing, such as for instance analysing an internal behaviour of the mechanical movement.

**[0032]** This list of functions given here is an example, and may well differ in further preferred embodiments, comprising further functions and/or not implementing a function already indicated.

**[0033]** Referring to figure 3, the contact PCB 32 enables to connect the Lavet micro-motor coil 33 to the electronic PCB 35, without letting the magnetic fields go out of the Faraday cage. Thanks to this connection, the processor 42 on the PCB drives the coil 33 to move the hand 11 and thus displays the information that the processor 42 is programmed to display.

**[0034]** Referring now to figure 4, this represents a block diagram of electronic parts according to an example em-

bodiment of the invention. Accordingly, the electronic parts 41-46 may in addition to the already mentioned

- at least one embedded sensor (shown here as "other sensors" 45),
- at least one embedded processor 42,
- wireless communication interface 41, and
- micro-motor 46,

10 further comprise

- a movement sensor 44, and
- a microphone 43.

15 **[0035]** The embedded processor 42 may be configured to count steps of the intended user wearing the hybrid movement watch, and to monitor sleep cycles.

**[0036]** For precision purposes a metal dial is usually preferred in watch industry. Figure 5 shows and example metal dial where an opening 51 is left to let the radio-frequency waves, generated and received by the wireless interface, go through. This opening is :

- either covered by painting or mother of pearl,
- 25 • or filled or covered with plastic or other non metallic material

**[0037]** The opening zone 51 is big enough to let enough waves go through and small enough not to impact the esthetics of the dial.

**[0038]** The opening zone 51 is placed above the location of the antenna circuit of the wireless interface to maximize the transmission of radio-frequency waves out of the watch dial and case.

35 **[0039]** Referring to figures 6a and 6b which represent a preferred embodiment, a microphone 61 may be placed in a cavity 63 dug for example inside the main plate 60 of the movement. The cavity 63 is placed as close as possible to the source of the mechanical elements creating the characteristic noise of the mechanical movement, which incidentally comprises

- an escapement wheel 62,
- a fork 64, and
- 45 • a balance 65.

**[0040]** The cavity 63 goes through the whole thickness of the plate 60 to enable an improved circulation of the noise from the mechanical elements to the microphone 61.

50 **[0041]** Referring to figure 4, a microphone signal 43 measured with the microphone 61 (not shown in figure 4) is acquired by a processor 42. The processor 42 filters the microphone signal 43 to keep the information coming from the mechanical beat. An algorithm in the processor 41 calculates the beat frequency of the movement and thus the precision in time of the movement. This information is either displayed on the Lavet motor display 11

(not represented in figure 4) or sent via a wireless interface as illustrated in an example manner by a Bluetooth Low Energy® processing 41 and antenna 40.

**[0042]** Referring to figure 8, the microphone 81 picks up the sound of the mechanical movement. In a preferred embodiment of the invention, the rest of the treatment chain is embedded in a processor 89. A first ADC block 82 (Analog to Digital Converter) acquires the signal from the microphone 81. The data from the acquired signal is then either stored in memory 88 or sent to a filter 83. The filtered signal output from filter 82 is sent to the algorithm 84. The algorithm 84 computes from the input signal a beat period 85, a beat frequency 86, and a time drift 87—the actual time given by the movement compared to the perfect official time. The time drift 87 gives the unprecision of the movement or its error in giving the time. The beat period 85, the beat frequency 86, and the time drift 87, but also a sound recording 88 are sent via a wireless interface 83 to an external connected device, for example a smartphone companion application in a preferred embodiment of the invention.

**[0043]** Referring to figure 9, the signal 91 picked up by the microphone 81 recording the sound of the beat of the mechanical movement, is digitized and analyzed by the processor 89. The algorithm 84, according to parameters such as A, determines a series of measurements T1, T2, T3, etc.

**[0044]** The algorithm computes values T (period of the movement), F (beat frequency of the movement) and Drift (drift of the time function given by the movement):

$$T=f(A,Ta,T2,T3,...)$$

$$F=1/T$$

$$\text{Drift} = K*(T_{th}-T)$$

where:

- f is a mathematical function with the parameters A, T1, T2, T3, etc.,
- K is a constant, and
- Drift the drift of the time function of the movement in seconds/day.

**[0045]** As illustrated in figure 4, the signal of the microphone 43 is sent over the wireless interface 41 to be analyzed and computed by a device connected to the movement via the wireless interface. In a preferred embodiment the movement is connected to a companion application running on a smartphone, tablet or computer based platform, analyzing the sound recording of the microphone 43 and, computing and displaying the precision in time of the movement.

## Claims

1. A hybrid mechanical watch movement comprising a mechanical watch movement comprising a plate (28) and a bridge (21) configured to hold in between of them mechanical parts of the mechanical watch movement, a plurality of electronic components comprising one or more from the list comprising a printed circuit board (25), a Lavet micro-motor (22), a rechargeable battery (26), and a microphone (30a), whereby the plurality of electronic components is part of the mechanical watch movement and is held in the mechanical watch movement between the plate (28) and the bridge (21).
2. the hybrid mechanical watch movement of claim 1, further comprising a shielding case configured to confine the plurality of electronic elements, whereby the shielding case comprises magnetically conductive material that is enabled to enclose magnetic fields inside the shielding, and to prevent the magnetic field from disturbing a proper operation of the mechanical watch movement.
3. The hybrid mechanical watch movement of claim 1 wherein the mechanical watch movement is configured to display mechanical time functions, by means of any one of the following list comprising an hours hand (13), a minutes hand (12), a date hand (14), a moonphase display (15).
4. The hybrid mechanical watch movement of claim 1 comprising the microphone, whereby the microphone (30a,61) is placed in a dedicated cavity (30b,63) of the mechanical movement in proximity to mechanical parts (62,64,65) generating the sound of the mechanical movement and the microphone is configured to record this sound.
5. The hybrid mechanical movement of claim 4 comprising the printed circuit board, wherein the printed circuit board (25) comprises an embedded processor (42) that is configured to run an algorithm analysing the sound of the mechanical movement and compute a performance and a precision of a time function of the mechanical watch movement.
6. The hybrid mechanical watch movement of claim 1, comprising the Lavet micro-motor and the printed circuit board, and further comprising a display for additional information, wherein the additional information is represented on the display using an additional hand driven by the Lavet micro-motor (11; 22) as controlled by a processor (42) comprised in the printed circuit board (25).
7. The hybrid mechanical watch movement of claim 1,

further comprising a wireless communication interface that is configured to enable wireless communication with distinct external devices, which may be one or more of the list comprising a smartphone, a tablet, a processor-based device.

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8. The hybrid mechanical watch movement of claim 1, comprising the printed circuit board, wherein the printed circuit board (25) is designed to execute a plurality of electronic functions; and  
the hybrid mechanical watch movement further comprises at least a sensor (43, 44, 45) functionally connected to a processor (42) of the printed circuit board (25), the processor being configured to allow an implementation of a plurality of electronic functions which comprise at least one of the following list:

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- step counting using a step counting algorithm, whereby the at least one sensor comprises an accelerometer component (44),
- sleep monitoring using a sleep monitoring algorithm, whereby the at least one sensor comprises the accelerometer component (44),
- temperature measurement using one of the at least one sensors (45) as appropriate,
- humidity measurement using one of the at least one sensors (45) as appropriate,
- heart rate measurement using one of the at least one sensors (45) as appropriate, and a heart rate monitoring algorithm, and
- UV measurement using one of the at least one sensors (45) as appropriate.

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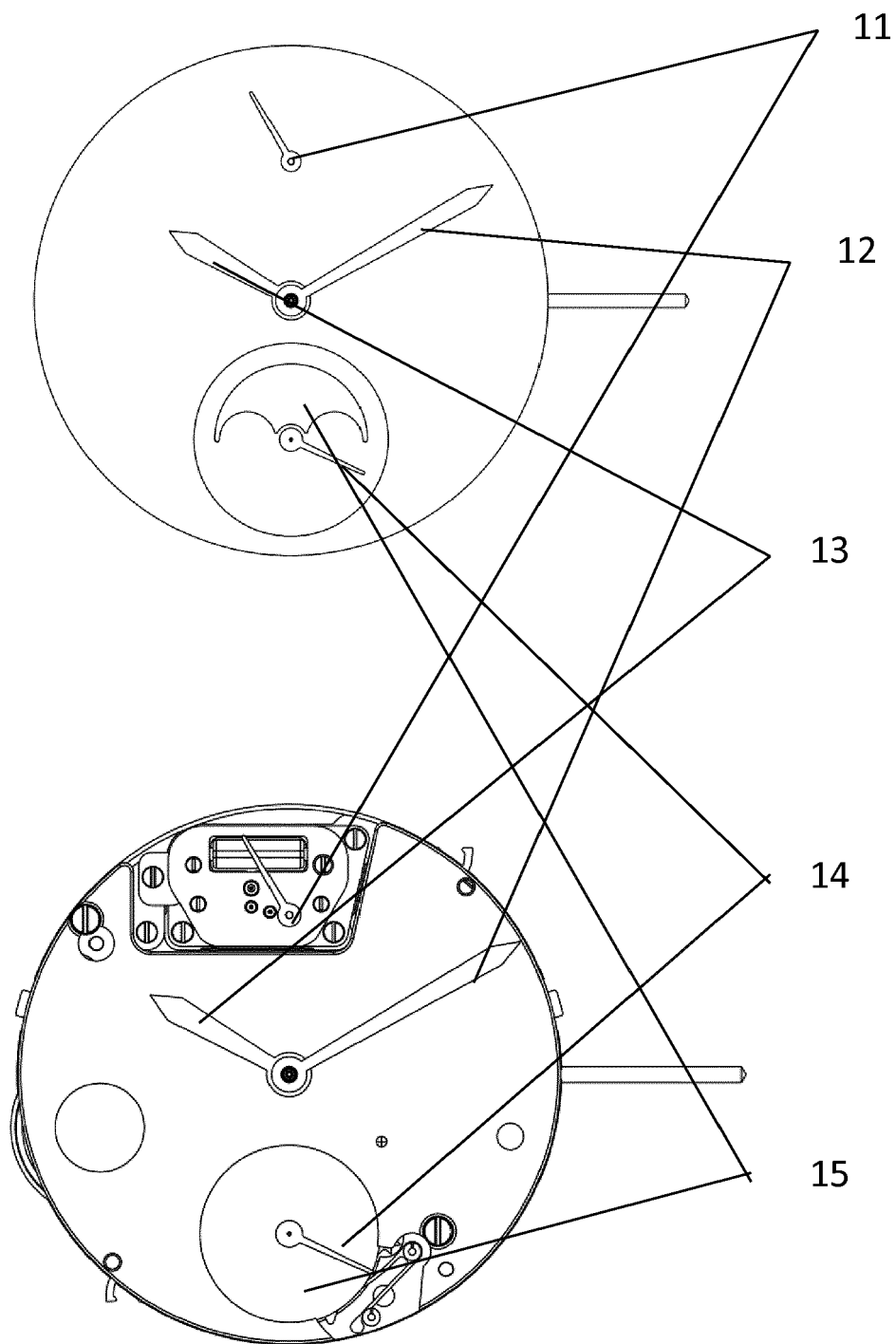


Figure 1

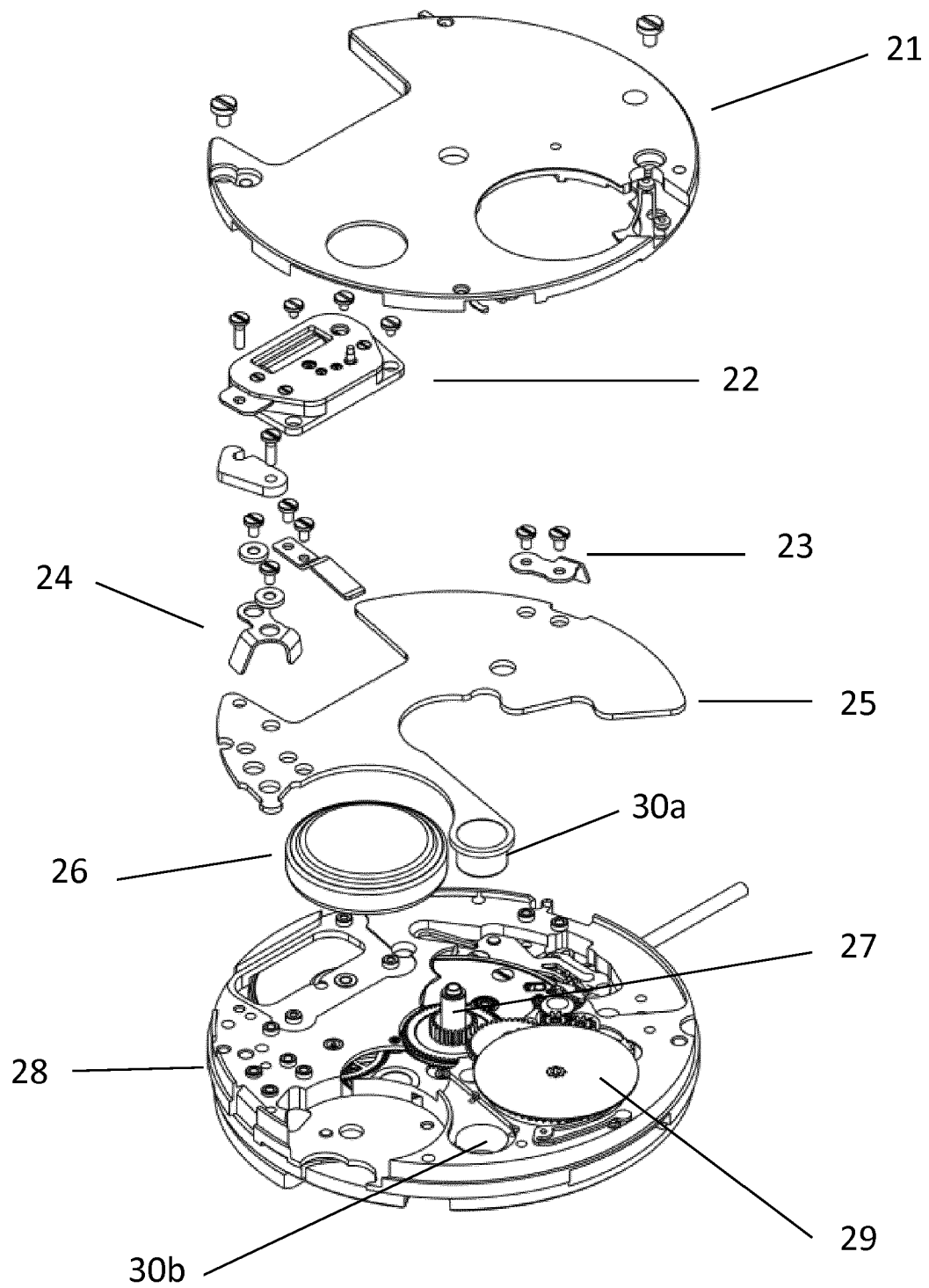


Figure 2

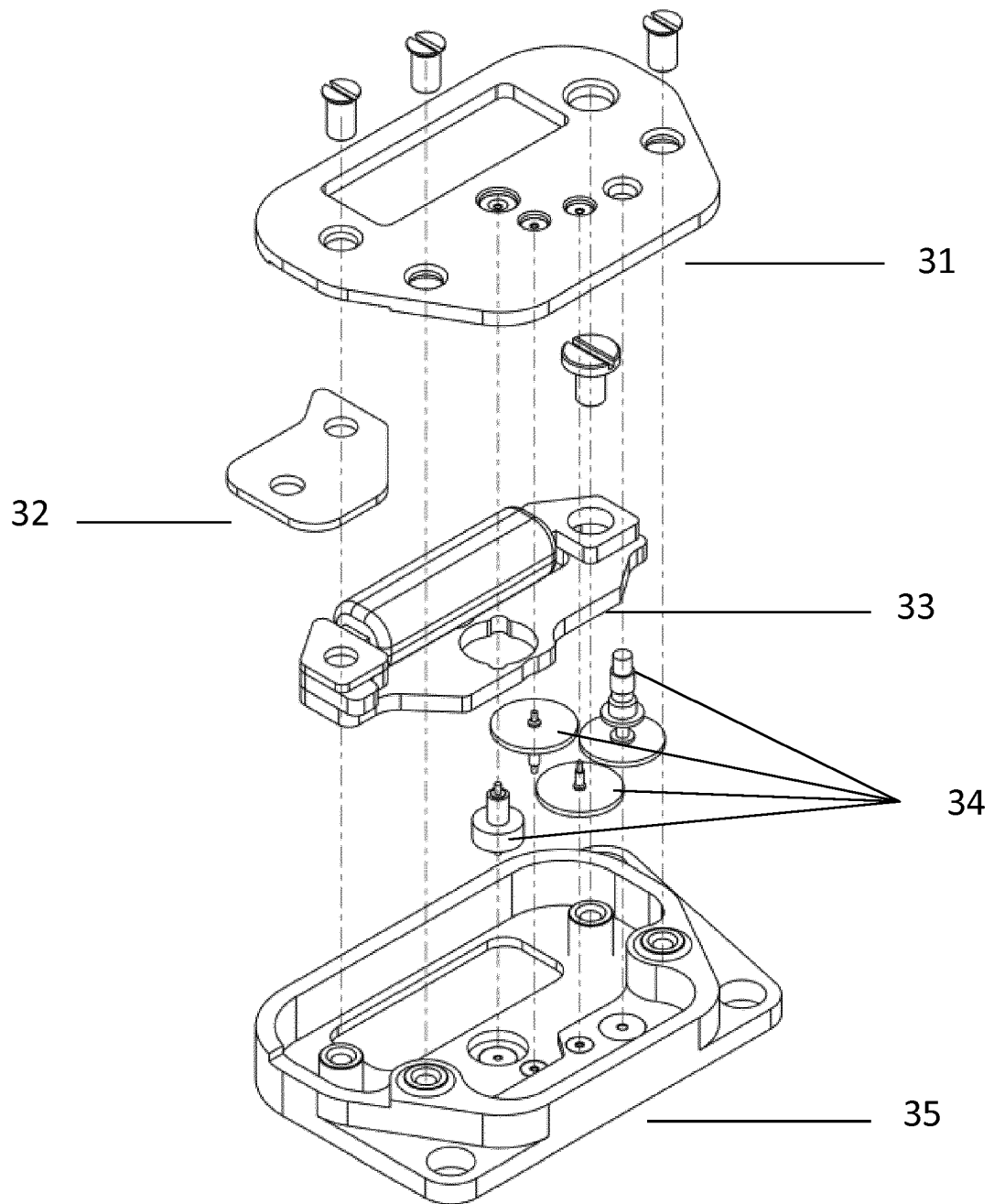


Figure 3

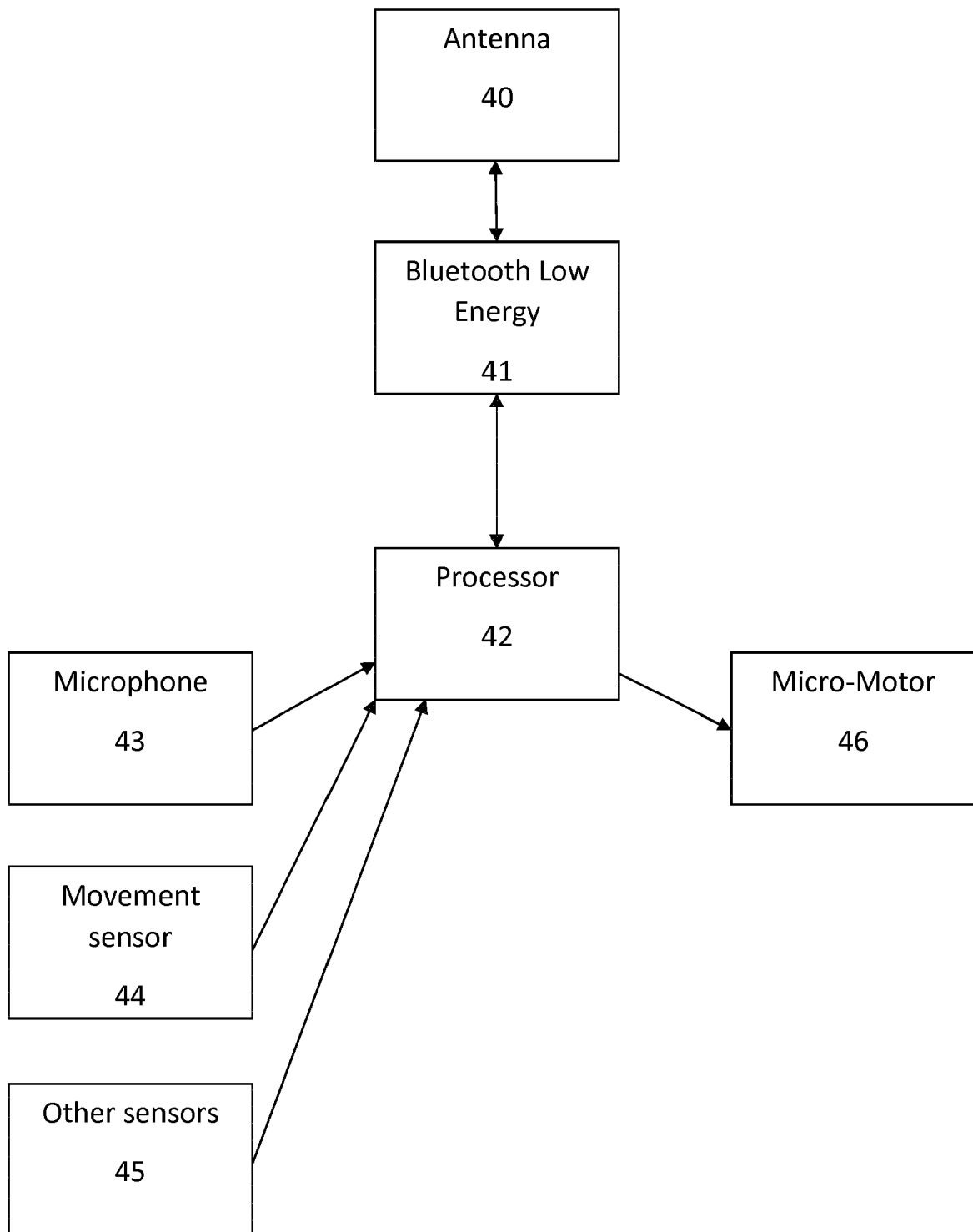


Figure 4

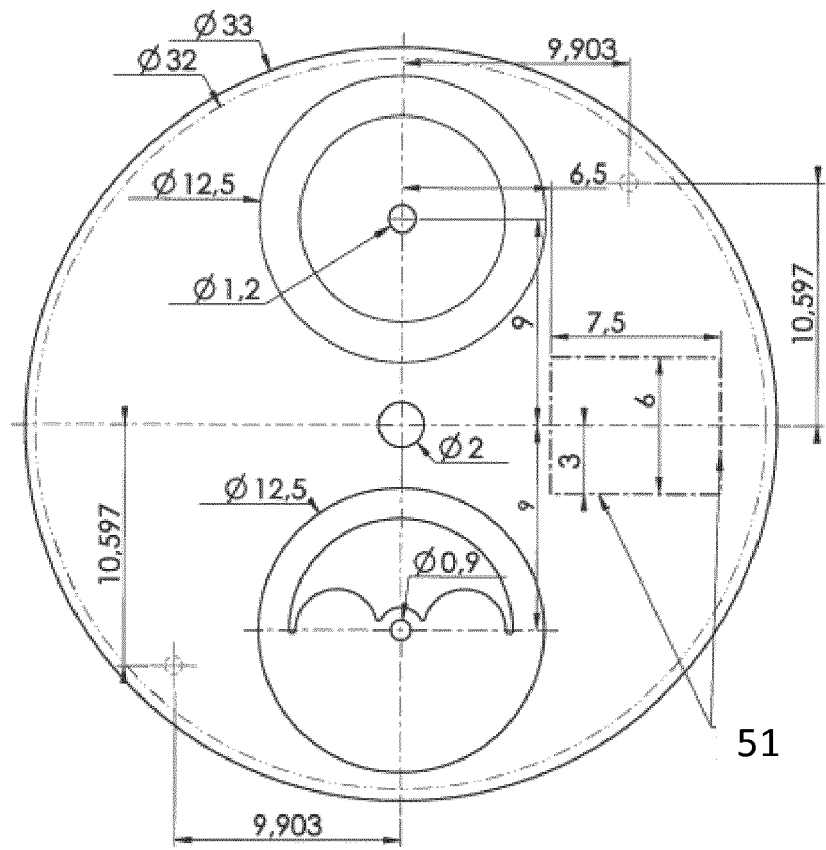


Figure 5

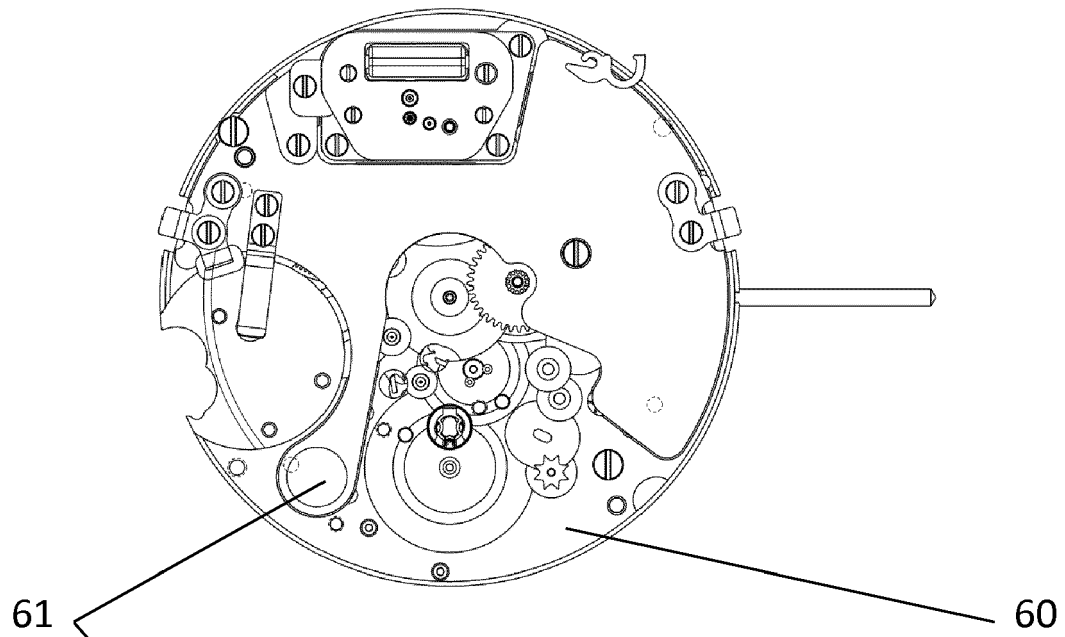


Figure 6a

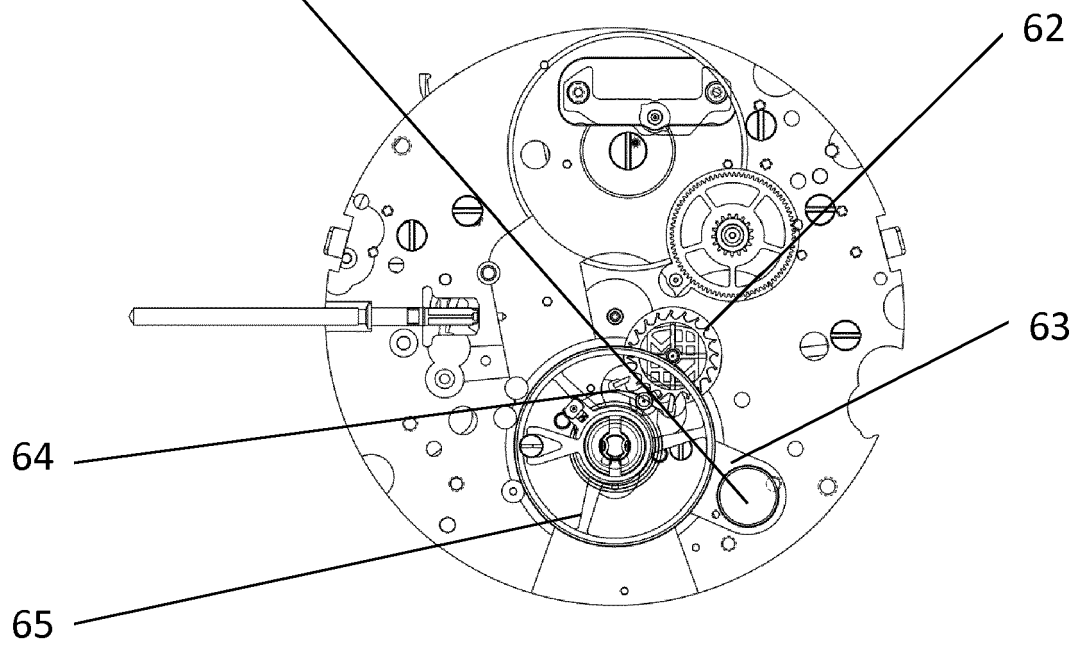


Figure 6b

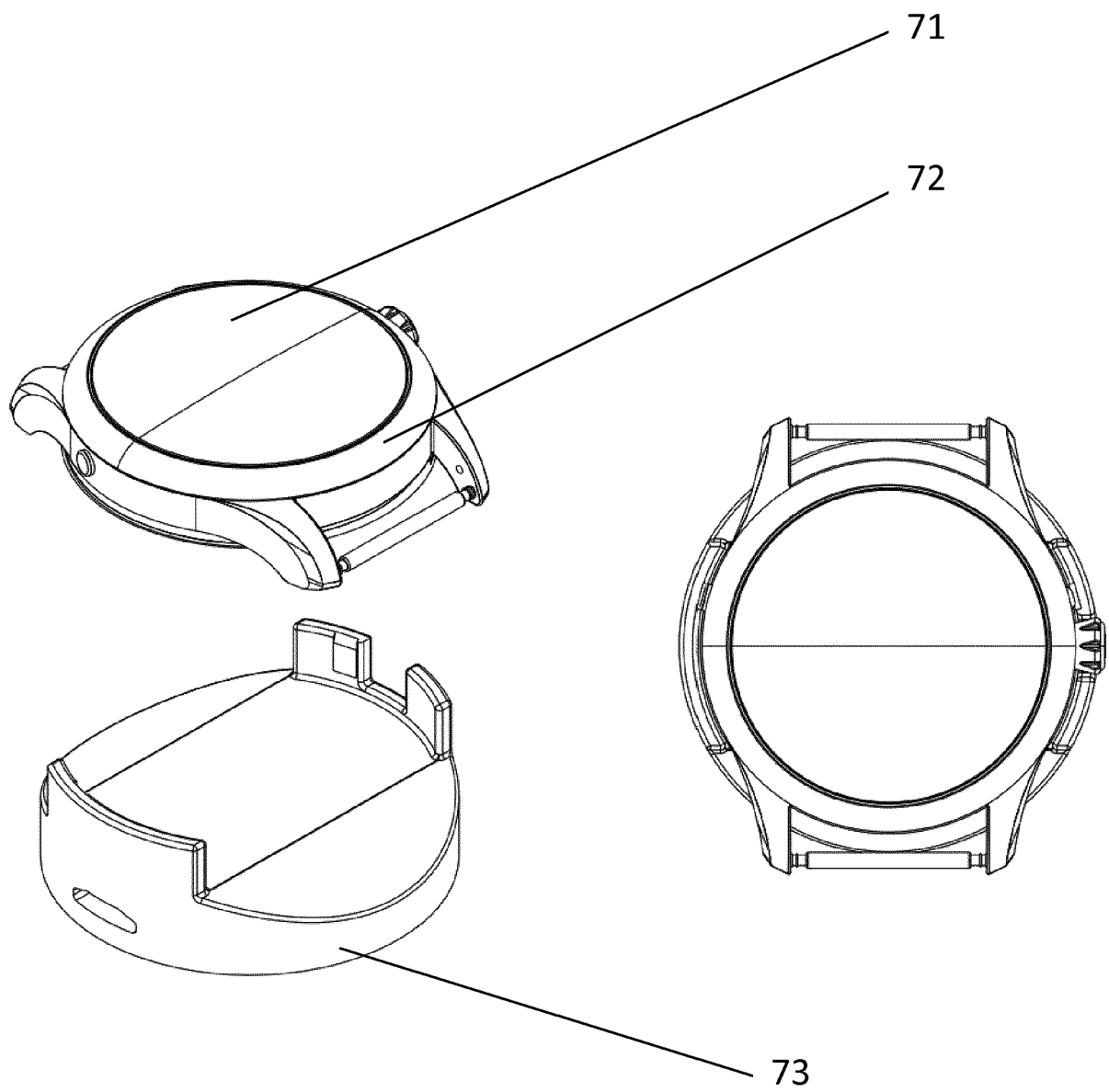


Figure 7

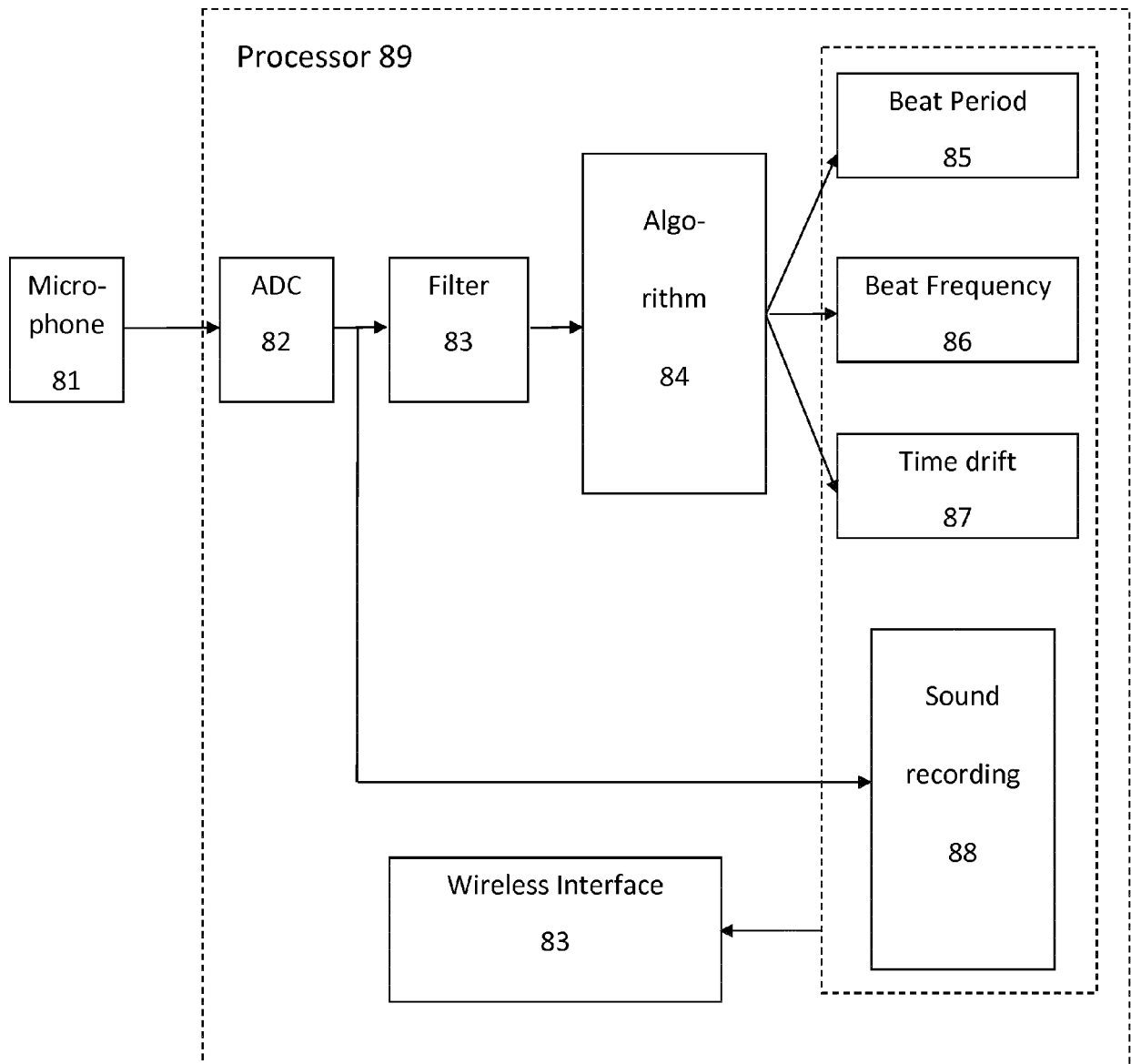


Figure 8

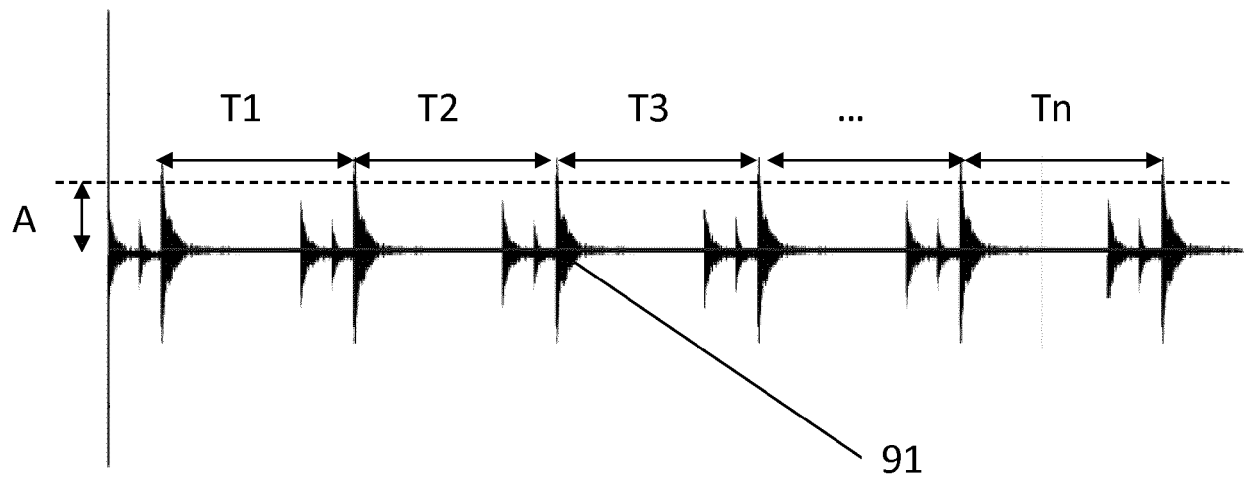


Figure 9



## EUROPEAN SEARCH REPORT

Application Number  
EP 16 20 1542

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| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                    |                                                                                                                                                                         |                                                                                                                                                                                                                                                                              |                                                          |
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| Category                                                                                                                                                                                                                                               | Citation of document with indication, where appropriate, of relevant passages                                                                                           | Relevant to claim                                                                                                                                                                                                                                                            | CLASSIFICATION OF THE APPLICATION (IPC)                  |
| X                                                                                                                                                                                                                                                      | WO 2016/141393 A1 (ABRAMOV ANDREY [US])<br>9 September 2016 (2016-09-09)                                                                                                | 1-3,6-8                                                                                                                                                                                                                                                                      | INV.<br>G04G21/04<br>G04B43/00<br>G04B47/00<br>G04B47/06 |
| A                                                                                                                                                                                                                                                      | * paragraph [0012] - paragraph [0014] *<br>* paragraph [0024] *<br>* paragraph [0038] - paragraph [0052] *<br>* figures 2,8,11 *                                        | 4,5                                                                                                                                                                                                                                                                          |                                                          |
| X                                                                                                                                                                                                                                                      | US 7 306 364 B2 (BORN JEAN-JACQUES [CH] ET AL) 11 December 2007 (2007-12-11)<br>* column 3, line 14 - line 41 *<br>* column 5, line 22 - line 42 *<br>* figures 4-6,8 * | 1,3                                                                                                                                                                                                                                                                          |                                                          |
| A                                                                                                                                                                                                                                                      | KR 2016 0062776 A (ELENTEC CO LTD [KR])<br>3 June 2016 (2016-06-03)<br>* paragraph [0010] *<br>* paragraph [0021] *                                                     | 1,4                                                                                                                                                                                                                                                                          | TECHNICAL FIELDS SEARCHED (IPC)<br><br>G04G<br>G04B      |
| The present search report has been drawn up for all claims                                                                                                                                                                                             |                                                                                                                                                                         |                                                                                                                                                                                                                                                                              |                                                          |
| Place of search<br><b>The Hague</b>                                                                                                                                                                                                                    |                                                                                                                                                                         | Date of completion of the search<br><b>18 May 2017</b>                                                                                                                                                                                                                       | Examiner<br><b>Goossens, Ton</b>                         |
| CATEGORY OF CITED DOCUMENTS<br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document |                                                                                                                                                                         | T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>& : member of the same patent family, corresponding document |                                                          |

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**ANNEX TO THE EUROPEAN SEARCH REPORT  
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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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EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82