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(54) **OSCILLATOR FOR A MOVEMENT FOR A WATCH**

(57) The invention relates to an oscillator (1) for a movement for a watch comprising a mass (2), a ground (4), one or more flexures (7) connecting the mass (2) to the ground (4) thus enabling the mass (2) to oscillate, and at least two anchor teeth (15) for alternately blocking and releasing the teeth (11) of an escape wheel (10). The

anchor teeth (15) are resilient and the oscillator mass (2), one or more of the flexures (7) and/or the ground (4) comprises a catch (23) for at least one anchor tooth (15) to pull the anchor tooth (15) away from the escape wheel (10) to release a tooth (11) of the escape wheel (10).

EP 4 535 090 A1

Description

[0001] The invention relates to an oscillator for a movement for a watch, in particular a wrist watch, comprising a(n oscillator) mass, a ground for securing the oscillator to e.g. a base plate, also known as pillar plate or platine, or a frame of a watch movement, one or more, preferably two or more, e.g. four flexures connecting the mass to the ground thus enabling the mass to oscillate, and at least two anchor teeth, traditionally also known as pallets or stones, for alternately blocking and releasing the teeth of an escape wheel, also known as escapement wheel. The invention also relates to an escapement for a watch movement and to a movement comprising an oscillator or escapement according to the present invention.

[0002] WO 2019/156552 discloses a mechanical watch oscillator comprising a platform provided with at least two vibratory masses that are individually suspended on the platform with at least one flexural member. The at least two vibratory masses are interconnected by two parallel flexural beams providing a direct torsion stiff connection between these at least two vibratory masses. A first mass of the at least two masses and the at least one flexural member that provides a connection of the first mass to the platform is mirror symmetric with reference to a second mass of the at least two masses and the at least one flexural member that provides a connection of the second mass to the platform.

[0003] EP 3 230 805 relates to a monolithic timepiece mechanism (indicated by reference signs 6, 7 in EP 3 230 805) made in a single plate of material, comprising a frame (12-15), a first elastic suspension (21) and an inertial regulating member (17) which is connected to the frame by the first elastic suspension so as to be able to oscillate, a blocking mechanism (6) having a blocking member (8) connected to the frame by a second elastic suspension (33). The blocking member is controlled by the regulating member to be able to regularly and alternately hold and release an energy distribution member (5) and to regularly transmit energy from the energy distribution member to the regulating member.

[0004] It is an object of the present invention to provide an improved oscillator, in particular an oscillator that provides more accurate time keeping.

[0005] To this end, in the oscillator according to the present invention, the anchor teeth are resilient, e.g. resiliently suspended from the ground or the oscillator mass, and the oscillator mass, one or more of the flexures and/or the ground comprises a catch, e.g. hook, for at least one, preferably a catch for each anchor tooth to pull the (respective) anchor tooth away from the escape wheel to release a tooth of the escape wheel.

[0006] In an embodiment, the anchor teeth are resiliently and preferably directly connected to, e.g. suspended from, either the ground or the mass, i.e. not to both.

[0007] In a refinement, the anchor teeth are suspended from either the ground or the mass by further flexures that

are connected either to the ground or to the mass.

[0008] In an embodiment, at least one of the anchor teeth has a first surface to block a tooth of the escape wheel and a second surface that is inclined relative to the rotation of the escape wheel, e.g. to the trajectory of the teeth of the escape wheel, such that before blocking an escape wheel tooth, the anchor tooth is pushed outwardly by that escape wheel tooth and thus pre-tensioned, typically by a constant amount.

[0009] The present invention provides a constant force escapement, in particular for a monolithic oscillator. The energy transfer to the oscillator is dependent on the pre-tensioning of the resilient(ly suspended) anchor teeth, i.e. typically on the stiffness of the suspensions and on the travel when the anchor teeth are pushed outwardly. Since this pre-tensioning is constant, the energy transferred to the oscillator will be constant between oscillations as well. This significantly reduces the sensitivity to torque variations on the escapement wheel, thus improving the accuracy of the watch as the oscillator will run more constant.

[0010] To reduce or even avoid bouncing of the escape wheel tooth on the anchor tooth that was just pushed outwardly, in an embodiment at least one of the anchor teeth comprises, between the first and second surfaces, a third surface or indentation causing the anchor tooth to lock, e.g. move (slightly) towards the escape wheel, after the anchor tooth and its suspension have been pre-tensioned.

[0011] In an embodiment, at least one of the anchor teeth, preferably each anchor tooth, comprises a catch, e.g. a protrusion or hook, located in the trajectory of a catch on the oscillator mass, on one or more of the flexures and/or on the ground.

[0012] In an embodiment, each of the anchor teeth is resiliently suspended from the ground by at least two flexures, thus more robustly defining the path of the anchor teeth.

[0013] The invention also relates to an escapement comprising an oscillator as described above as well as an escape wheel comprising a plurality of teeth and positioned between at least two anchor teeth of the oscillator, such that during oscillation, the anchor teeth alternately block and release the teeth of the escape wheel.

[0014] In an embodiment, the oscillator defines an aperture that accommodates the escapement wheel.

[0015] In another embodiment, the oscillator is monolithic and/or wherein at least one of the escape wheel and the oscillator is shaped by means of etching, such as reactive ion etching or deep reactive ion etching, lithography, electroplating, molding, or laser cutting and/or is made from silicon or metal.

[0016] In an embodiment, the oscillator has and/or the anchor teeth have an amplitude in a range from 0,1° to 50° preferably smaller than 30°, preferably smaller than 20°, preferably smaller than 15°, e.g. in range from 3° to 10°, and/or the oscillator has a natural frequency of 8 Hertz (Hz) or higher, preferably 10 Hz or higher, prefer-

ably 25 Hz or higher, preferably 30 Hz or higher, preferably in a range from 10 to 400 Hz, preferably in a range from 30 to 70 Hz.

[0017] The invention also relates to a movement for a watch comprising a base, an energy storage, a gear train to transmit torque and energy to an escape wheel, and an escapement or oscillator as described above.

[0018] In an embodiment, providing improved efficiency and/or facilitating high frequencies, the escape wheel has a torque of less than 800 nanoNewton-meter (nNm), preferably less than 600 nNm, preferably less than 300 nNm, preferably less than 200 nNm, preferably less than 150 nNm.

[0019] The invention also relates to a wristwatch comprising such a movement.

[0020] In an example, the oscillator has a frequency of 40 Hz and an amplitude of 6°.

[0021] In an embodiment, the oscillator and/or the escape wheel has been shaped by means of etching, such as reactive ion etching or deep reactive ion etching, lithography, electroplating, molding, or laser cutting and/or is made from silicon or metal and/or may have a thickness smaller than 700 µm, preferably smaller than 550 µm, preferably in a range from 50 µm to 500 µm, preferably in a range from 100 µm to 300 µm.

[0022] It is preferred that at least the oscillator comprises an oscillating mass and flexures suspending the mass from a ground or frame, and anchor teeth on/in the mass and/or flexures, and that the mass and flexures and preferably also the ground and/or anchor teeth are monolithic, i.e. made from a single piece, and/or form a compliant mechanism.

[0023] The invention also relates to a wristwatch comprising a movement obtained by means of the method or kit described above.

[0024] EP 3 210 082 relates to a mechanical watch movement regulating member (reference sign 1 in EP 3 210 082) comprises an escape-wheel (5) and a vibrating oscillator (3) provided with at least two vibrating arms (31', 32') and pallets (4, 4') firmly joined to said vibrating arms and comprising two members (40) arranged to interact directly with the teeth of the escape-wheel (5), maintaining the periodic alternations of the vibrating oscillator (3) and causing the escape-wheel (5) to advance with each oscillation alternation.

[0025] US 1,097,637 relates to an escapement for clocks, in particular the combination with the pendulum and escape wheel, of a one legged gravity arm, a pair of juxtaposed stop pallets for the escape wheel, whereby successively to intercept the same tooth of the escape wheel, pendulum actuated means for lifting one of said pallets and means independent of the pendulum for lifting the other of said pallets.

[0026] US 739,245 relates to a clock-escapement, in particular the combination with an escape-wheel, of a pendulum, an impulse-arm provided with a lug adapted to engage with said pendulum, a pallet-arm secured to said impulse-arm, said pallet-arm being provided with a pallet

through which impulse is given to said impulse-arm in one direction, a pallet on said impulse-arm and means for giving an impulse to said impulse-arm in the opposite direction, substantially as described.

5 **[0027]** Figure 1 shows a top plan view of a first example of an oscillator according to the present invention.

[0028] Figures 2A to 2D show four stages of the oscillation of the oscillator shown in Figure 1.

10 **[0029]** Figure 3 shows a top plan view of a second example of an oscillator according to the present invention.

[0030] Figure 1 shows a monolithic oscillator 1 comprising a substantially disc-shaped mass 2 that comprises two halves 2A, 2B that are compliantly interconnected by a set of flexures 3. Each of the halves is connected to a ground 4 by means of a plurality of further flexures, i.e. two radially extending flexures 7 for each half, four flexures in total, enabling the mass to oscillate. In the present example, the oscillator has a natural frequency in a range from 20 to 100 Hz, e.g. 40 Hz, and an amplitude in a range from 3° to 10° (in each direction, i.e. both in the CW direction and in the CCW direction), e.g. 5°. The ground has e.g. two openings 8 for screws or the like. Further, the halves 2A, 2B define an aperture 9 that accommodates an escapement wheel 10 comprising a plurality of teeth 11.

15 **[0031]** The oscillator comprises two anchor teeth 15, traditionally known as pallets. During oscillation, these anchor teeth alternately block and release the teeth 11 of the escape wheel 10.

20 **[0032]** In this example, each of the anchor teeth 15 is resiliently suspended from the ground 4 by means of at least two flexures 16. Each of the anchor teeth has a first surface 20 (enlarged portion of Figure 2A) to block a tooth of the escape wheel and a second surface 21 that is inclined relative to the rotation or tangent of the escape wheel, such that before blocking an escape wheel tooth, the anchor tooth is pushed outwardly by that escape wheel tooth. Further, each of the anchor teeth 15 comprises a catch 22 located in the trajectory of a catch 23 on the flexures 7 of the oscillator mass 1 on either side of the escape wheel 10.

25 **[0033]** The mass, flexures, ground, anchor teeth 25, and other components, excepting the escape wheel, are monolithic and form a compliant mechanism, which in this example, is made from a silicon wafer by means of DRIE.

30 **[0034]** Figures 2A to 2D show four stages of an oscillation. In Figure 2A, one of teeth 11 of the escapement wheel 10 rests on one of the anchor teeth 15, in the drawing on the lefthand side of the escape wheel. In this position, the anchor tooth has been pushed outwardly by the tooth of the escape wheel and, in consequence, the flexures 16 suspending the anchor tooth 15 have been pre-tensioned.

35 **[0035]** The oscillator mass 2 rotates clockwise ("CW"; as indicated by the arrows), during which rotation the catch 23 in the flexure 7 on the lefthand side will

engage the catch 22 on the anchor tooth 15 and will pull the anchor tooth 15 away from the escape wheel 10, unlocking the escape wheel tooth 11, as shown in Figure 2B, and further tensioning the flexures 16.

[0036] When the escape wheel 10 unlocks it will accelerate and hit the other anchor tooth 15, on the righthand side of the escape wheel, as shown in Figure 2B. More specifically, the escape wheel tooth 11 nearest the anchor tooth 15 on the other side of the escape wheel will hit and subsequently slide along and push outwards the second surface 21 on the anchor tooth, which surface is inclined relative to the rotation of the escape wheel. The escape wheel tooth 11 thus pre-tensions the flexures 16 suspending that anchor tooth 15, i.e. energy is transferred from the escape wheel to the flexures, before being blocked by the first surface 20 on the anchor tooth 15, as shown in Figure 2C.

[0037] Subsequently, the direction of rotation reverses and, as shown in Figure 2D, the anchor tooth 15 and anchor flexures 16 will pull the catch 23 on the main flexure 7 and the thus the oscillator mass 2 in CCW direction and transfer all energy resiliently stored in the anchor flexures 16 to the oscillator mass 2 and main flexures 7 until this anchor 15 and anchor flexures 16 reach an essentially non-tensioned state, i.e. the state shown in Figure 2D.

[0038] Figure 3 shows another example of an oscillator, wherein the anchors 15 comprise, between the first and second surfaces, a third surface 25 or indentation causing the anchor tooth to lock, e.g. move (slightly) towards the escape wheel 10, after the anchor tooth 15 and the anchor flexures 16 have been pre-tensioned. This reduces or even avoid bouncing of the escape wheel tooth on the anchor tooth that was just pushed outwardly.

[0039] The oscillators described above provide a constant force escapement, i.e. the energy transfer to the oscillator is dependent on the pre-tensioning of the flexures resiliently suspending the anchor teeth. Since this pre-tensioning is constant, the energy transferred to the oscillator will be constant between oscillations as well. This significantly reduces the sensitivity to torque variations on the escapement wheel, thus improving the accuracy of the watch as the oscillator will run more constant.

[0040] The invention is not limited to the embodiment as described above, which can be varied in several ways within the scope of the claims.

Claims

1. Oscillator (1) for a movement for a watch comprising a mass (2), a ground (4), one or more flexures (7) connecting the mass (2) to the ground (4) thus enabling the mass (2) to oscillate, and at least two anchor teeth (15) for alternately blocking and releasing the teeth (11) of an escape wheel (10), **characterised in that** the anchor teeth (15) are resilient and

the oscillator mass (2), one or more of the flexures (7) and/or the ground (4) comprises a catch (23) for at least one anchor tooth (15) to pull the anchor tooth (15) away from the escape wheel (10) to release a tooth (11) of the escape wheel (10).

2. Oscillator (1) according to claim 1, wherein the anchor teeth (15) are resiliently connected to either the ground (4) or the mass (2).

3. Oscillator (1) according to claim 2, wherein the anchor teeth (15) are suspended from either the ground (4) or the mass (2) by further flexures (16) that are connected either to the ground (4) or to the mass (2).

4. Oscillator (1) according to any one of the preceding claims, wherein at least one of the anchor teeth (15) has a first surface (20) to block a tooth (11) of the escape wheel (10) and a second surface (21) that is inclined relative to the rotation of the escape wheel (10), such that before blocking an escape wheel tooth (11), the anchor tooth (15) is pushed outwardly by that escape wheel tooth (11).

5. Oscillator (1) according to claim 4, wherein at least one of the anchor teeth (11) comprises, between the first and second surfaces (20, 21), a third surface (25) or indentation causing the anchor tooth (15) to lock after the anchor tooth (15) and its suspension (16) have been pre-tensioned.

6. Oscillator (1) according to any one of the preceding claims, wherein at least one of the anchor teeth (15) comprises a catch (22) located in the trajectory of a catch (23) on the oscillator mass (2), on one or more of the flexures (7) and/or on the ground (4).

7. Oscillator (1) according to any one of the preceding claims, wherein each of the anchor teeth (15) is resiliently suspended from the ground (4) by at least two flexures (16).

8. Escapement comprising an oscillator (1) according to any one of the preceding claims and an escape wheel (10) comprising a plurality of teeth (11) and positioned between at least two anchor teeth (15) of the oscillator (1), such that during oscillation, the anchor teeth (15) alternately block and release the teeth (11) of the escape wheel (10).

9. Escapement according to claim 8, wherein the oscillator (1) defines an aperture (9) that accommodates the escapement wheel (10).

10. Oscillator (1) or escapement according to any one of the preceding claims, wherein the oscillator (1) is monolithic and/or wherein at least one of the escape wheel (10) and the oscillator (1) is shaped by means

of etching, such as reactive ion etching or deep reactive ion etching, lithography, electroplating, molding, or laser cutting and/or is made from silicon or metal.

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11. Oscillator (1) or escapement according to any one of the preceding claims, wherein the oscillator (1) has and/or the anchor teeth (15) have an amplitude in a range from 0,1° to 50° preferably smaller than 30°, preferably smaller than 20°, preferably smaller than 15°, e.g. in range from 3° to 10°. 10
12. Oscillator (1) or escapement according to any one of the preceding claims, wherein the oscillator has a natural frequency of 8 Hertz (Hz) or higher, preferably 10 Hz or higher, preferably 25 Hz or higher, preferably 30 Hz or higher, preferably in a range from 10 to 400 Hz, preferably in a range from 30 to 70 Hz. 15
13. Movement for a watch comprising a base, an energy storage, a gear train to transmit torque and energy to an escape wheel, and an escapement or oscillator (1) according to any one of the preceding claims. 20
14. Movement according to claim 13, wherein the escape wheel (10) has a torque of less than 800 nanoNewtonmeter (nNm), preferably less than 600 nNm, preferably less than 300 nNm, preferably less than 200 nNm, preferably less than 150 nNm. 25
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15. Wristwatch comprising a movement according to claim 13 or 14. 35

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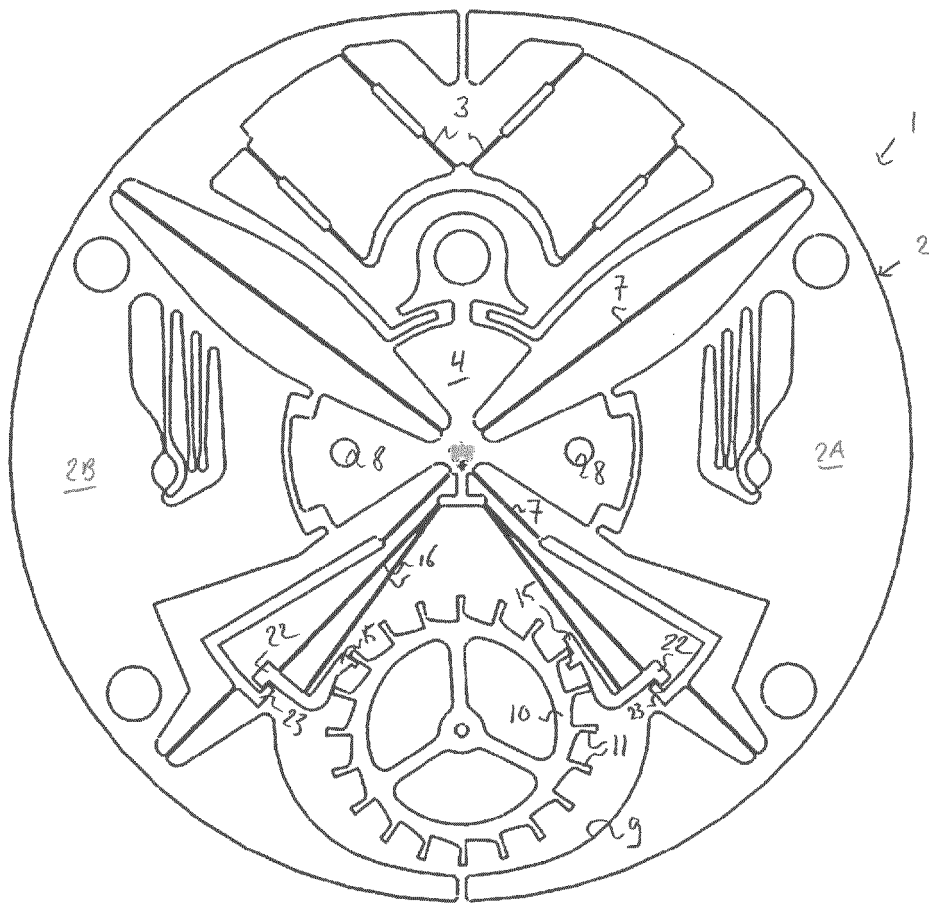


Fig. 1

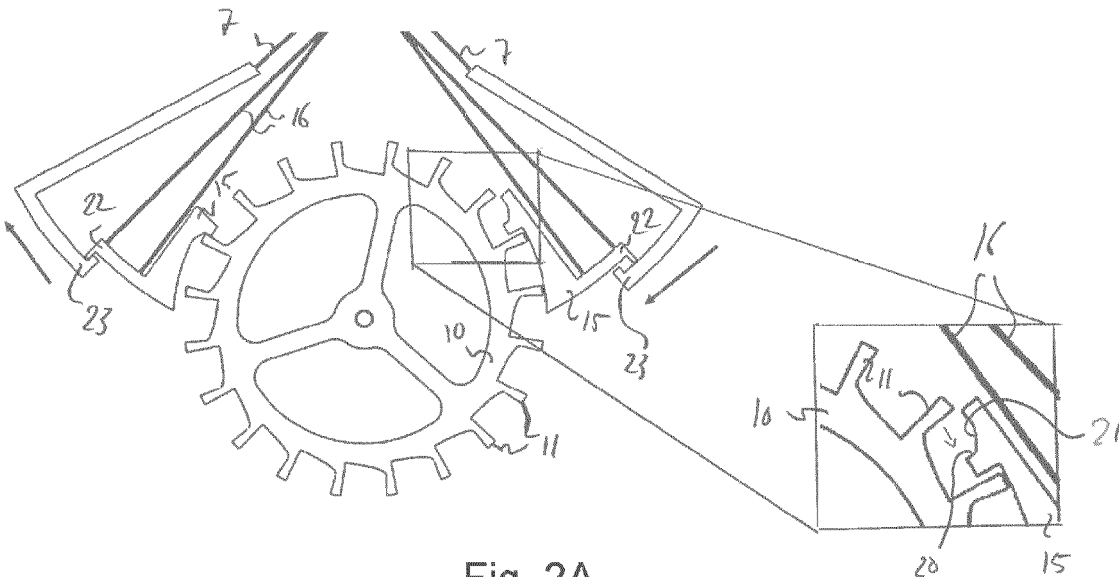


Fig. 2A

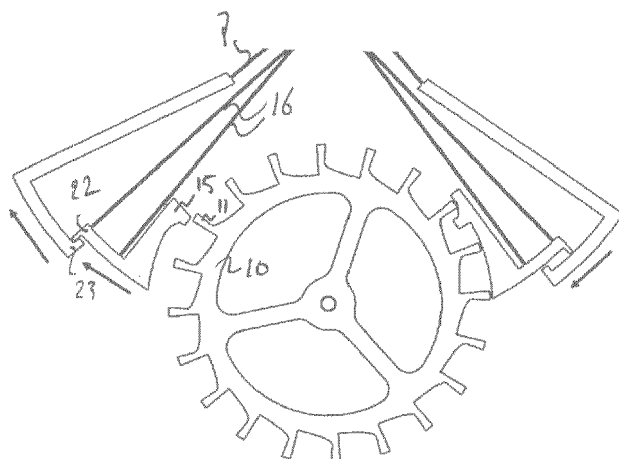


Fig. 2B

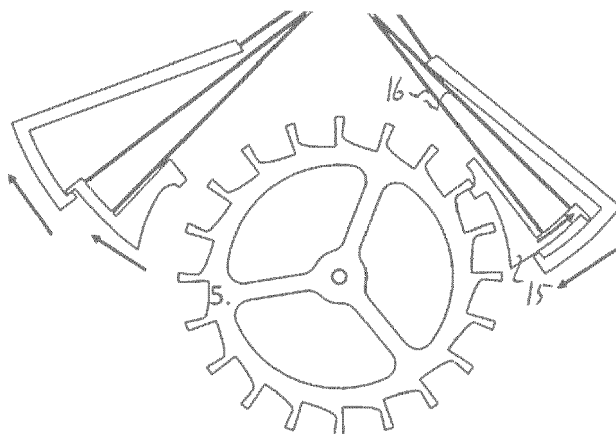


Fig. 2C

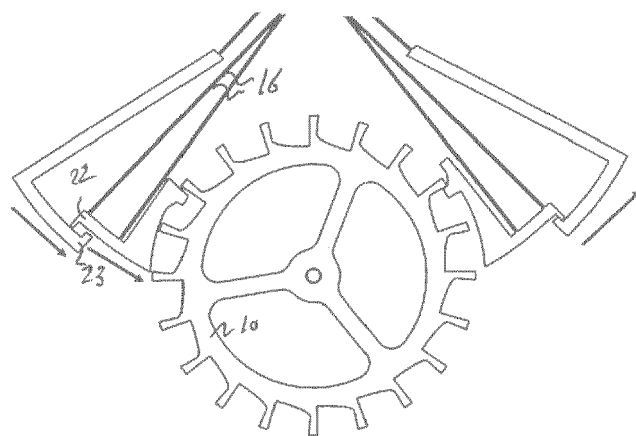


Fig. 2D

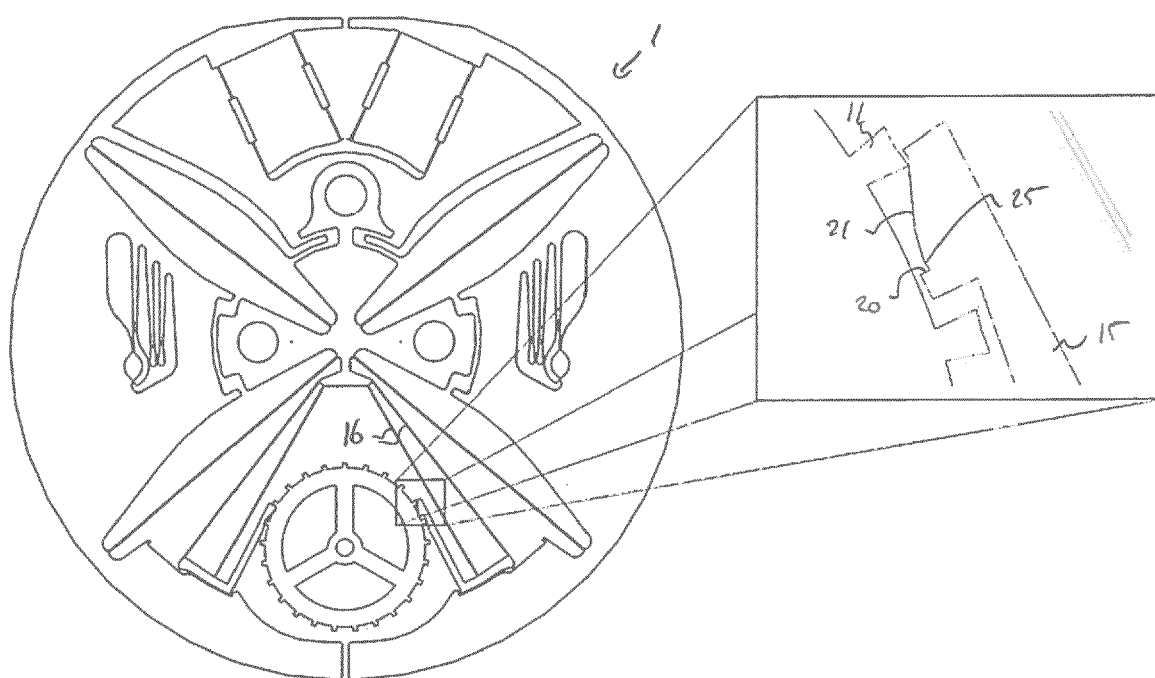


Fig. 3



EUROPEAN SEARCH REPORT

Application Number

EP 23 20 1662

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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
The Hague		29 February 2024	Pirozzi, Giuseppe
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