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(54) **AUTONOMOUS, LOW-POWER SIGNAL PRODUCING UNIT, ASSEMBLY, AND METHOD FOR OPERATING SUCH A UNIT**

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Description

[0001] The invention relates to an autonomous, low-power signal producing unit, in particular a sensor and control unit. The invention further relates to a method for operating a low-power signal producing unit, in particular a sensor and control unit, according to the invention.

[0002] An autonomous, low-power remote control for controlling lights and other electronic components, is already known, e.g. from the United States patent application published as US2006/0091984. Each of these known remote controls comprises one or more low-power generators which makes the remote control self-powered and hence gives the remote controls the capacity to act autonomously. Each generator is configured as electromagnetic energy transducer configured to convert mechanical energy into electrical energy. To this end, the generator comprises a static coil wound around an assembly of a permanent magnet and a soft-magnetic (paramagnetic) element, wherein the permanent magnet and the soft-magnetic element can be pushed manually towards each other causing a change in magnetic flux which induces a voltage in the coil. The limited amount of harvested electrical energy is just sufficient to power electronics of the remote control in order to generate a simple radio signal to be transmitted in order to switch, for example, a light on or off. Although the known remote control works in a practical and reliable manner, there is, however, a need to develop an improved signal producing unit allowing a more comprehensive use of the remote control.

[0003] The international patent application WO 01/67580 discloses in particular an autonomous, low-power signal producing unit comprising a support structure, at least one electrical generator supported by said support structure, said generator comprising a stator and a rotor; at least one driving element configured to drive said generator, wherein the relative orientation of the driving element with respect to the support structure can be changed by an external power source, such as human power, in order to drive said generator, and; at least one signal processing circuit powered by said generator.

[0004] Further, similar types of autonomous, low-power signal producing units are described in the American patent documents US 3735412A, US 2014/191592A1 and US 2007/095634A1.

[0005] It is a first object of the invention to provide an improved autonomous, low-power signal producing unit.

[0006] It is a second object of the invention to provide a more sophisticated autonomous, low-power signal producing unit.

[0007] In accordance with the invention, an autonomous, low-power signal producing unit, as set forth in claim 1 and a corresponding method for operating a low-power signal producing unit, as set forth in claim 13 are provided. Further embodiments are inter alia disclosed in the dependent claims. In particular the low-power signal producing unit comprises: a support structure; at least

one electrical generator supported by said support structure, said generator comprising a stator and a rotor; at least one driving element configured to drive said generator, wherein the relative orientation of the driving element with respect to the support structure can be changed by an external power source, such as human power, in order to drive said generator, and; at least one signal processing circuit powered by said generator, said circuit comprising: at least one signal producing element, wherein this signal producing element is configured to produce at least one distinctive input signal related to the displacement of the same driving element with respect to the support structure, and, preferably, at least one signal processor, connected to at least one signal producing element of said signal producing elements, configured to receive the input signals produced by said at least one signal producing element and to transform at least one input signal into at least one output signal representative for the displacement of the driving element with respect to the support structure. Preferably, at least one rotary component of the signal producing unit forms at least a part of at least one signal producing element, such that this signal producing element is configured to produce a signal, the characteristics of which signal being dependent on the movement speed and/or the acceleration and/or the movement direction and/or the position and/or the incremental position of the driving element with respect to the support structure, wherein said rotary component is chosen from the group consisting of: a rotary driving element (if applied), a rotor of a generator, a transmission element, such as a gear wheel or friction wheel, positioned in between the driving element and a rotor of a generator, and any other rotary component. By using at least one rotary component as a signal producing element, or at least a part of a signal producing element, a plurality of characteristic input signals can be generated in a relatively efficient manner as will be explained in more detail below. It may also be advantageous, for example from an economic, constructive and/or practical point of view, that the driving element is not configured to act as signal producing element. Preferably, it is conceivable that multiple signal producing elements are used in the signal producing unit according to the invention. Here, the signal producing unit preferably comprises a plurality of signal producing elements, wherein at least a part of at least a first signal producing element is formed by a first rotary component, and wherein at least a part of at least a second signal producing element is formed by a second rotary component, wherein said each of the first rotary component and second rotary component is chosen from the group consisting of: a rotary driving element, a rotor of a generator, and a transmission element positioned in between the driving element and a rotor of a generator.

[0008] Application of a plurality of signal producing elements will facilitate to detect the direction of the movement of the driving element. Moreover, the application of a plurality of signal producing elements may significantly

increase the amount, the accuracy and reliability of the information collected during displacement of the driving element.

[0009] The signal producing unit according to the invention has several advantages. A first important advantage of the signal producing unit according to the invention is that a plurality of signal producing elements is applied, wherein each signal producing element is configured to produce at least one distinctive input signal related to the displacement of the same (common) driving element with respect to the support structure. Hence during displacement of the driving element one or multiple input signals can be generated which are related to the actual displacement of the driving element with respect to the support surface, such as the actual displacement speed of the driving element, the actual acceleration of the driving element, the (actual) position of the driving element, and if applicable, the magnitude and/or direction of displacement, in particular rotation, of the driving element with respect to the support surface. Hence, multiple parameters (e.g. position (orientation), displacement distance and/or displacement angle, displacement speed, acceleration, displacement direction, et cetera) related to the actual displacement of a driving element can be monitored as input signal(s) in order to generate one or more output signals related to the detected displacement of the driving element. These one or more output signals can be used for providing useful information, for example for monitoring purposes related to the detected displacement of the driving element, but can also be used e.g. to control one or more devices in a relatively detailed manner. More in particular, this unit according to the invention makes it possible to control a device in a specific manner selected from multiple options, dependent on the specific displacement of the driving element. For example, by displacing the driving element in a specific manner, a specific signal can be generated by a specific signal producing element which may lead to the (desired) specific control of the device. In a more detailed example, during displacement of the driving element from a starting position to an end position, multiple input signals may be generated successively and/or simultaneously by one or multiple signal producing elements, wherein a first input signal may for example be transformed into a first output signal embodying a command to switch on an external light, wherein a second input signal may for example be transformed into a second output signal embodying a command to adjust the intensity of said light, and wherein a third input signal may for example be transformed into a third output signal embodying a command to adjust the colour of said light. Hence, the signal producing unit according to the invention is configured to produce a plurality of input signals during displacement of the driving element relative to the support structure, wherein the input signals which are actually generated are dependent on the actual relative displacement of the driving element, and wherein the actually generated input signals lead to one or more output signals which can be used for infor-

mation and/or control purposes. The electrical energy needed to power the signal producing unit is completely generated by means of at least one generator which comprises a stator and at least one rotor, said generator also referred to as a dynamo. As commonly known, the stator forms the stationary part of the generator, and the rotor forms the (axially) rotating part of the generator. Since the unit is completely powered by the at least one generator applied, the unit according to the invention is considered to be an autonomous unit. The generator used is a low-power generator configured to generate electrical power ranging from several milliwatt to typically 1 watt. The actual power generated is dependent on the relative displacement of the driving element. Commonly, at least 5 to 200 milliwatt is sufficient to generate an input signal and to transform said input signal into an output signal by using the signal processor. Due to the presence of the rotor, preferably a multipole rotor, more preferably an accelerated multipole rotor, this type of generator is configured to generate significantly more electrical energy compared to the static generator described in the already cited prior art US2006/0091984, which known generator does not make use of a rotor. The increased amount of electrical energy makes it possible to use standard communication protocols, e.g. Bluetooth and ZigBee, which significantly expands the applicability of the unit according to the invention. Moreover, an increased amount of electrical energy allows generation of multiple and/or more complex signals (input and output) in a reliable manner. A further advantage of the increased amount of electrical energy which can be produced by the unit according to the invention, is that this allows a listening mode, wherein the unit is configured to receive signals, such as a confirmation signals sent back by a distant receiver which has correctly received one or more output signals transmitted by the unit according to the invention. Furthermore, application of the constructively simple and cheap unit according to the invention, allows the generation of multiple input and output signals without needing additional components, such as switches, encoders, etcetera. Additionally, the output signals generated by a signal processor of a signal producing unit according to the invention may embody a command for waking-up of a device or putting a device to sleep, which leads to a reduction of the energy consumption of said device. It is also imaginable, and often advantageous, in case at least one input signal generated by at least one signal producing element is used to waking up and/or putting to sleep the signal processor of the signal producing unit. Moreover, the application of a rotor comprising generator has an additional advantage in that the rotor is ideally suitable to co-act with one or more other moving components, such as the driving element, of the signal producing unit. A further advantage of the application of a rotor comprising generator is that the generator is or may be configured to generate a (alternating current) sine wave or a (direct current) pulsating pattern, which is related to the displacement of the driving

element. Hence, also each generator comprising at least one rotor, may be considered and used as a signal producing element to generate an input signal.

[0010] The signal producing unit according to the invention is commonly used in a domestic or corporate environment, wherein the driving element of the unit is commonly actuated and driven manually (by human power). In addition to driving the driving element by a human hand, it is also imaginable that other body parts of a user can drive the driving element, wherein it is for example thinkable that a user leans against a driving element, sits on a driving element, and/or steps onto a driving element. Apart from a human power source and typical mechanical power source, it is conceivable that an object exerts a force to the driving element which may cause displacement of the driving element. The support structure may be configured to be attached to a wall, for example by using mechanical connection means, such as screws. Alternatively, the signal producing unit as such according to the invention may be portable and preferably be handheld. It is, however, also conceivable to apply the unit according to the invention in a (more) industrial environment, wherein the driving element may be driven mechanically by an external device or machine. The driving element may be supported by an external device or machine, though is commonly supported by and connected to the support structure, such that the orientation of the driving element with respect to the support structure can be changed.

[0011] The driving element can be configured to undergo a, preferably predefined, linear or non-linear movement. However, it is also possible that the driving element is rotatably connected to the support structure. In each embodiment, displacement (which includes a change in orientation) of the driving element with respect to the support structure may lead to driving the generator, in particular causes rotation of the rotor of the generator. In case the driving element is connected to the support structure, the driving element and the support structure may mutually enclose the generator at least partially. Here, the driving element may act as part of a housing of the unit covering said generator. Another part of the housing may be formed by the support structure. Here, it is imaginable that an inner side of a peripheral edge of the driving element is configured to co-act, either directly or indirectly, with at least a part of the generator. It is even thinkable that the driving element makes part of at least one rotor of at least one generator. However, commonly the driving element will co-act indirectly with the rotor of the generator via one or more transmission elements positioned in between said driving element and said rotor, as will be elucidated in more detail below. In the context of this patent document, the expressions "displacing the driving element with respect to the support structure", "moving the driving element with respect to the support structure", and "changing the orientation of the driving element with respect to the support structure" mean the same, and are exchangeable.

[0012] First of all, it is noted that the transmission element(s) can be of various nature. A transmission element may for example comprise at least one rotary wheel, such as a gear (wheel) or friction wheel, a spring, a belt, a chain, etcetera. Each rotary wheel, such as a gear wheel or friction wheel, is an axially rotatable wheel. A gear wheel, also referred to as cogwheel, commonly has a toothed profile, which meshes with another toothed profile to transmit torque. A friction wheel is commonly free of a toothed profile. By forming at least a part of at least one signal producing element by at least one rotary wheel, in particular a gear wheel (cogwheel) or friction wheel, acting as transmission element, the movement speed, acceleration, movement direction and (incremental) position of the driving element with respect to the support structure can be detected in a relatively simple and efficient manner. In a rotary component, like a rotary transmission element, such as a gear wheel or friction wheel, of the signal producing unit, one or more markers can easily be applied. By using the one or more markers the movement speed, acceleration, movement direction and/or incremental position of said rotary component can be detected easily, and hence the movement speed, acceleration, movement direction and/or incremental position of the driving element as such can be detected easily. This detection can be established, for example, by using one or more stationary detection elements, which are preferably positioned close to the rotary wheel provided with the one or more markers. The marker, also referred to as activation element, may be of various nature, and can, for example, be formed by a retaining element such as a bulge or recess, a spring, a magnet, an electrical coil, a conductive element, a piezo element. More details relating to this marker (activation element) are given below. The detection element may also be of various nature and can, for example, be formed by and/or may comprise a set of electrical contact points (configured to co-act with the one or more markers), as will be explained below in more detail.

[0013] In a preferred embodiment, at least one transmission element is configured to accelerate rotation of the rotor of at least one generator and/or at least one other transmission element. Acceleration of the rotation of the rotor will commonly lead to an increased number of revolutions per minute (rotational speed) of the rotor, and hence to an increased amount of generated electrical energy. This acceleration of the rotor can be established by using a compound gear, being a combined gear including a small diameter gear and a large diameter gear mounted on a common shaft (axle). Connecting the driving element, possibly indirectly, to said small diameter gear and the rotor of the generator with said large diameter gear will lead to an acceleration of the rotor during relative displacement of the driving element. In case the signal producing unit would comprise a plurality of transmission elements, then it is favourable that at least one transmission element is configured to accelerate rotation of at least one other transmission element being formed

by a rotary wheel, optionally a gear wheel, in particular a compound gear wheel. Acceleration of the rotation of said other transmission element will lead to an increased number of revolutions per minute (rotational speed) of said rotary wheel, which makes this rotary wheel commonly (very) suitable to act as, at least a part of, a signal producing element. The higher the number of revolutions of an (accelerated) rotary wheel or a generator rotor, the more input signals can be generated in a certain time interval (e.g. per second), which hence leads to more information in said time interval, which will commonly be in favour of the accuracy, distinctiveness, and number of output signals generated. For example, in case a gear ratio between a first transmission element, in particular a rotary wheel, and a second transmission element, in particular a rotary wheel, and/or a rotor would be $1:n$, wherein $n > 1$, e.g. $1:36$, then a single revolution of said first transmission element would result in n , e.g. 36, revolutions of said second transmission element and/or said rotor. In case the first transmission element, and the second transmission element (and/or the rotor) would be configured to act as (at least a part of) a signal producing element (with an equal number of markers per transmission element), then the second transmission element would provide n times, e.g. 36 times, more information than the first transmission element. Hence, for example, a 10 degrees turn or $1/10$ displacement of the - optionally rotary - driving element may result in one or more input signals. By selecting and tuning the gear ratio as well as the number and configuration of signal producing elements, the desired driving element displacement related information can be obtained in a relatively accurate and reliable manner. The signal producing unit is preferably configured to successively generate a plurality of input signals by a signal producing element being at least partially formed by a rotary component, during an uninterrupted movement of the driving element (i.e. movement of the driving element in a single direction).

[0014] In a preferred embodiment, at least one transmission element comprises at least one torque limiting element, in particular a slip clutch, which preferably comprises at least one spring. The torque limiting element, such as a slip clutch, automatically protects the moving parts, including the rotor, and hence the generator, from injury (damage) due to excessive torque while excess torque conditions prevail. In these excessive circumstances the rotor will be uncoupled from the driving element, until the torque has dropped below a predefined threshold value. Commonly, an applied slip clutch is a spring-loaded friction clutch, comprises multiple - commonly two - gears in between which at least one spring element is positioned allowing the gears to mutually engage or to mutually slip, dependent on the torque exerted onto a gear.

[0015] It is also conceivable that at least one transmission element comprises a resilient body, in particular formed by a spring, such as a leaf spring or spiral spring. The resilient body may be used for providing a resilient

transmission between the driving element and at least one generator, wherein interrupting means may be provided for at least substantially interrupting the transmission between said driving element and said generator as a function of the spring tension of said resilient body. The resilient body is commonly positioned between two mutually moving or moveable parts, such as for example two gears or other rotary wheels. The resilient body is configured to transfer forces between said moving or moveable parts in a shock-absorbing manner in order to prevent injury of one or more moving components of the unit according to the invention. Moreover, in case a displacement limiting element, such as a torque limiting element or other retaining means, is applied in the unit according to the invention, this displacement limiting element will impede displacement of at least one moving component of the unit, which leads to the situation that during displacement of the driving element, the spring tension of a resilient body will increase until the spring force (and/or torque) exceeds a holding force (and/or torque) exerted by the displacement limiting element. In this embodiment, the electrical energy pulses will be released interruptedly in the course of time. By build-up of energy in the spring and by releasing said energy after having reached a predetermined spring tension, it can be assured that sufficient electrical energy is released to power the signal producing unit as such. In case the driving element would be displaced very slowly, then the electrical power will commonly be too weak to power the unit as such. The aforementioned preferred embodiment prevents this undesired situation. In order to increase the spring tension irrespective of the direction of displacement of the driving element, it is favourable to apply at least one mechanical rectifier. A mechanical rectifier may also be used to assure rotation of at least one rotor of a generator in a predefined single direction, which may be favourable, for example, in case the generator is used as signal producing element. Commonly, a mechanical rectifier comprises multiple gears (or other wheels) mounted on a common shaft, wherein at least two gears are mounted (substantially freely) rotatably with respect to each other in a (single) predefined rotation direction. In between said mutually rotatable gears, commonly at least one spring, or spring element, is positioned which allows mutual rotation of said gears in said predefined rotational direction, and which prevents said gears to mutually rotate in an opposite direction.

[0016] In a preferred embodiment of the unit according to the invention, and as already briefly indicated above, the unit comprises retaining means for generating orientation-selective holding torque and/or holding force in rendering at least one moving element self-holding. This holding torque and/or holding force can be felt and observed by a person manually operating the driving element, which will provide the person touch based feedback about the actual displacement of the driving element. By applying one or more retaining means at predefined, orientation-selective locations, the person can

be provided with information that a preferred orientation of the driving element has been reached once the holding torque and/or holding force is observed by said person. This preferred orientation may be related to an orientation in which a predefined signal producing element generates an input signal. For example, in case the driving element is configured as a turning knob (rotary knob) supported by the support structure, a person may feel a holding torque every n degrees of rotation, leading to $360/n$ preferred orientations of the knob, in particular 20 degrees of rotation, leading to 18 preferred orientation of the knob, which may be related to one or more signal producing elements. The retaining means preferably comprises at least one first retaining element and at least one complementary second retaining element configured to co-act with said at least one first retaining element, wherein at least one moving component is provided with said at least one first retaining element, and at least one other component is provided with said at least one second retaining element. Here, preferably at least one retaining element is supported by the support structure, and another complementary retaining element is applied onto a moving component, such as the driving element or an (intermediate) transmission element. At least one retaining element preferably comprises at least one bulge and at least one complementary retaining element is preferably provided with at least one recess configured to accommodate said bulge at least partially. The retaining element, comprising the bulge and/or the recess, may be resilient at least partially to facilitate co-action between the bulge and recess. Here, the mechanical retaining elements are commonly configured to allow passing of the bulge after exceeding a retaining force exerted by the complementary retaining element onto the bulge.

[0017] It is also imaginable to apply magnetism based retaining means. Here, preferably at least one retaining element comprises at least one first magnet and at least one complementary retaining element comprises at least one magnetisable element and/or at least one second magnet configured to magnetically co-act with said at least one first magnet. Magnetisable elements are also referred to as soft-magnets of paramagnetic elements, and are at least partially made of a material which can be magnetized, such as iron, nickel, and cobalt. In a particular preferred embodiment at least one rotor of at least one generator forms at least first retaining element and a stator of said generator forms at least one second retaining element. To this end, preferably use is made of at least one generator, wherein the stator comprises a field winding, in particular a coil, which is arranged in the axial direction outside the radial projection of the rotor, and claw-pole-like magnetoconductive sheets, preferably 12, 14, or 16 sheets, guided axially in the radial projection of the rotor. The rotor is preferably at least partially surrounded by the stator.

[0018] The retaining means may comprise multiple first retaining elements and/or multiple second retaining ele-

ments, such that co-action between at least one first retaining element and at least one second retaining element may take place at different predefined relative orientations of at least one moving element of the unit. Examples of applicable retaining elements have already been described above.

[0019] In a preferred embodiment, at least one signal producing element comprises at least one electromechanical switch, and wherein switch components are preferably positioned at predefined locations in the unit. These predefined locations may correspond and/or may be related to one or more locations where one or more retaining elements are located, as already indicated above. The electromechanical switch may comprise the following switch components: at least one set of electrical contact points connected to the signal processor, and at least one activation element configured to allow an electrical current to run between both contact points, wherein the mutual orientation of said set of contact points and said activation element, and hence the connecting or interrupting of the contact points, is dependent on the relative orientation of the driving element with respect to the support structure. At least one set of electrical contact points and/or at least one activation element is preferably applied onto a moving component of the unit. Here, at least one activation element may be formed by an electrical bridge which is at least partially made of an electrically conductive material. It is commonly preferred from a practical point of view to apply the activation element, in particular said conductive bridge, onto said moving component and to let the contact points be supported by the support structure. The (stationary) set of contact points acts as sliding contacts against and along which the activation element may slide in order to connect both contact points resulting in at least one input signal. By applying multiple sets of contact points at different predefined locations, such that the activation is configured to successively co-act with said sets of contact points, multiple input signals can be generated from which information relating to the actual displacement, such as direction of displacement and the speed of displacement, of the moving component, and hence of the driving element, can be deduced.

[0020] It is also imaginable that the set of contact points comprises a first contact point and a second contact point, wherein said first contact point comprises a resilient arm, and wherein the at least one activation element is configured to push said resilient arm of said first contact point onto said second contact point. In this embodiment, the activation element can, for example, be formed by a bulge protruding with respect to (an edge or surface of) a moving component, such as the driving element and/or a transmission element and/or retaining means. Alternatively, it is also imaginable that at least one set of contact points and/or at least one activation element comprises at least one piezo element configured to generate an electrical energy upon mechanical deformation. Here, the piezo element can be configured to mutually connect

the contact points. The piezo element is commonly formed by a deformable strip at least partially made of piezo-electric material. Commonly, upon deformation caused by the activation element, the piezo element will generate a voltage difference between said contact points. Also in this embodiment, the activation element may be formed by a bulge protruding with respect to (an edge or surface of) a moving component, such as the driving element and/or a transmission element and/or retaining means.

[0021] In an alternative preferred embodiment, at least one signal producing element comprises at least one electromagnetic switch, and wherein switch components are preferably positioned at predefined locations in the unit. These predefined locations may correspond and/or may be related to one or more locations one or more retaining elements are located, as already indicated above. The electromagnetic switch preferably comprises the following switch components: at least one electromagnetic coil comprising at least one set of electrical contact points, and at least one permanent magnet acting as activation element, said magnet being configured to induce a voltage in said electromagnetic coil during mutual displacement of said coil and said magnet. It is preferable from a practical point of view, that said at least one coil is a stationary coil supported by the support structure, wherein said at least one magnet is applied onto at least one moving component. The moving component is commonly either the driving element or a transmission element. In an alternative embodiment, at least one electromagnetic switch comprises at least one permanent and/or inducible magnet and/or at least one switch, in particular a reed relay or piezo element, and/or at least one sensor, in particular a Hall sensor, possibly connected to another permanent and/or inducible magnet or magnetisable element, wherein said switch and/or sensor are configured to be activated by said (first mentioned) magnet as soon as this magnet is positioned sufficiently close to said switch. In each of these embodiments, the magnet is preferably applied onto a moving component, while each of the reed relay, the Hall sensor, and the piezo element are stationary and supported by the support structure. A reed relay is a type of relay that uses a magnet to control one or more reed switches. The contacts are of magnetic material and the magnet acts directly on them without requiring an armature to move them. A Hall sensor, also referred to as Hall effect sensor, consists basically of a thin piece of rectangular p-type semiconductor material such as gallium arsenide (GaAs), indium antimonide (InSb) or indium arsenide (InAs) passing a continuous current through itself. When the sensor is placed within a magnetic field, the magnetic flux lines exert a force on the semiconductor material which deflects the charge carriers, electrons and holes, to either side of the semiconductor slab. This movement of charge carriers is a result of the magnetic force they experience passing through the semiconductor material. As these electrons and holes move sideward a voltage

difference is produced between the two sides of the semiconductor material by the build-up of these charge carriers. With the application of at least one piezo element, in particular a piezomagnetic element, possibly connected to a magnet and/or magnetisable element, stress is produced in (antiferromagnetic) crystals of the piezomagnetic element as a result of an applied magnetic field, which leads to a deformation of said piezo element, and hence to a electromechanical effect (voltage difference) which is considered as input signal for the signal processor. Due to the magnetic interaction between a magnet and a piezo element, possibly connected to a magnet and/or magnetisable element, this combination of element will or may realise a holding torque or holding force, which can possibly be observed by a user driving the driving element. Hence, said combination of a magnet and a piezo element, possibly connected to a magnet and/or magnetisable element, may be considered as (magnetic) retaining means.

[0022] As already indicated above, at least one signal producing element can be formed by and/or may comprise at least one generator. This generator can be an alternator configured to generate an alternating current (AC). This sine wave alternating current is directly related to the rotation speed of the rotor of the generator, and hence to the displacement of the driving element, and can be (analysed and) transformed by the signal processor into at least one output signal which is representative for the detected (measured) displacement of the driving element. The fact that the output signal is representative for the displacement of the driving element means that the output signal is related to the displacement of the driving element, and hence that based upon the output signal at least a part of the displacement, such as position, distance of displacement, direction, speed, acceleration, of the driving element can be deduced. In a particular preferred embodiment, at least one generator embodies at least a part of a plurality of signal producing elements, wherein said generator is a multiphase alternator configured to generate alternating currents of multiple different phases. One may also considered this multiphase alternator as (multifunctional) single signal producing element, or at least a part thereof. If separate mutually displaced stators and/or coils are used then several simultaneous input signals can be generated. For example, by applying two coils and/or stators with a phase separation of 90°, two distinctive sine waves, with a phase difference of 90°, are generated, while by applying three coils with a phase shift of 90° or 120°, three distinctive sine waves, with a phase difference of 90° or 120° are generated. By generating different sine waves with a phase difference, the rotation direction - clockwise or counter clockwise - of the rotor can be deduced, which may influence, and commonly influences the output signal(s) to be generated by the signal processor. A two-phase alternator is sufficient to detect the rotation direction of the rotor. A three-phase alternator is commonly more efficient in that for the same mechanical power a

greater total electrical output is obtained.

[0023] In an alternative embodiment, at least one signal producing element is formed by at least one direct current (DC) generator. Rather than oscillating back and forth, a direct current generator provides a constant voltage or current. A direct current can be generated in a number of ways, for example by equipping an alternator with a so-called commutator or by the use of a rectifier which converts AC to DC. Direct current is defined as the unidirectional flow of current; current only flows in one direction. Voltage and current can vary over time so long as the direction of flow does not change. This variation in voltage and current is directly related to the rotation speed of the rotor, and hence to the displacement of the driving element, and may therefore act as input signal (to be) fed to the signal processor for transformation. Furthermore, the voltage polarity is directly related to the direction of rotation of the rotor, which may also be used as input signal (to be) fed to the signal processor for transformation.

[0024] Preferably, at least one signal producing element comprises at least one detection element for detecting at least one actual use related parameter value and/or at least one environmental parameter value. This particular detection element is configured to detect at least one parameter not related to the displacement of the driving element. Hence, this particular detection element provides additional information, embodied by an additional input signal, which may be taken into account during conversion of the input signals received by the signal processor into at least one output signal. Said output signal is still representative for the displacement of the driving element, though may also be influenced by the detected additional information (additional parameter value(s)) and may even additionally be representative for the detected parameter value(s). The detection element can, for example, be configured to detect the actual temperature, the air humidity, the environmental pressure, and/or the presence of carbon monoxide or carbon dioxide and/or the air composition. For example, in case the driving element is configured as push button, a user pushing the button and hence the driving element will cause (i) the rotor to rotate to generate electrical energy, (ii) generation of at least one input signal related to the displacement of the driving element, (iii) generation of at least one additional input signal related to the actual use and/or at least one environmental parameter related to the unit as such, and (iv) transformation one of both input signals into one or more output signals. In case e.g. the detection element is a temperature sensor, and the temperature exceeds a predetermined threshold value, this may influence the output signal, such that a warning can be deduced from the output signal by a person confronted with said output signal, either directly or indirectly (via a device, such as a light source, to be controlled by said output signal), which may for example be expressed by repetitively switching said device, in particular a light source, on and off.

[0025] In a preferred embodiment, the signal processing circuit comprises at least one ammeter connected to said signal processor and/or at least one voltmeter connected to said signal processor and/or making part of said signal processor. The ammeter and/or voltmeter may be used to pre-transform an input signal generated by at least one input signal generating element into a current value and/or voltage value related to said input signal, which may be used by the signal processor for transformation into at least one output signal.

[0026] The signal processor is commonly a control unit configured to transform at least one input signal into at least one output signal representative for the displacement of the driving element with respect to the support structure. Commonly this transformation process is based upon computation, which is defined as any type of calculation that follows a well-defined model understood and expressed as, for example, an algorithm, or a protocol. Various embodiments are given below. In a preferred embodiment, the signal processing circuit comprises a preprogrammed and/or programmable signal processor, in which preferably at least one cross-reference between at least one input signal related characteristic and at least one output signal related characteristic are stored, wherein the processor is configured to transform at least one input signal into at least one output signal by making use of said preprogrammed and/or programmable signal processor. For each of n predefined input signals, wherein $n \geq 1$, preferably $n \geq 2$, a predefined output signal is defined and stored as cross-reference in (some kind of) a database. A simplified example is shown in the table below:

Input signal value	Output signal value
1	A
2	B
3	C

[0027] Alternatively, in the preprogrammed signal processor at least one cross-reference may be stored between a combination of multiple input signal related characteristics and a single output signal related characteristic, wherein an example is given in the table below:

Input signal values	Output signal value
1+2	D
2+3	E
1+2+3	F

[0028] The it is also conceivable that in the preprogrammed signal processor at least one cross-reference is stored between a predefined order of successively produced input signal related characteristics and at least

one output signal related characteristic. An example of this embodiment is given below:

Input signal values	Output signal values
1+2	G
2+1	H
3	I

[0029] In an alternative preferred embodiment, the signal processing circuit comprises a preprogrammed and/or a programmable signal processor in which at least one algorithm is or can be programmed configured to transform at least one input signal related characteristic into at least one output signal related characteristic. Starting from an initial state and initial input signal (perhaps empty), algorithm instructions prescribe a computation that, when executed, proceeds through a finite number of well-defined successive states, thereby generating at least one output signal at a final ending state. The transition from one state to the next is not necessarily deterministic; some algorithms, known as randomized algorithms, incorporate random input, though this latter is commonly less preferred in the unit according to the invention. At least one analysis algorithm can be formed by a decision-tree based algorithm, such as a Boolean ("yes"/"no" or "true"/"false") based structure, wherein during successive decision steps, yes-no decisions are made, which successively exclude possible output signals until (at least) one output signal to be generated and/or information relating to said at least one output signal is left. The algorithm can also be defined by a preprogrammed or programmable set of (successive) switches, which also serve to transform at least one input signal into at least one output signal. In case of a programmable signal processor, this programming may be done before first use, or before each use, of the unit according to the invention, though it is also imaginable that this programming process can be done by a user of the unit according to the invention, which allows said user to customize the output signals (relative to the displacement of the driving element). The signal processor may form integral part of the unit according to the invention, in particular of the signal processing circuit of the unit according to the invention, during first sale or shipment, though it is also imaginable that the unit is initially marketed without a signal processor, wherein the signal processor is applied afterwards before first use.

[0030] As already indicated, the signal processor may be configured to receive the input signals produced by the signal producing elements and to transform multiple input signals into at least one output signal representative for the displacement of the driving element with respect to the support structure. The signal producing unit may be configured as control, preferably remote control, wherein the signal processor is configured to transform

at least one input signal into at least one output signal representing at least one command to control a device, preferably an external device.

[0031] The signal processing circuit preferably comprises at least one electronic transmitter configured to transmit at least one output signal of the signal processor to an external receiver. More preferably, the transmitter is configured for wireless communication. This makes it possible to use the signal producing unit as remote unit, in particular remote control. The signal processing circuit may (also) comprise at least one electronic receiver configured to receive signals from an external transmitter, preferably via wireless communication. This receiver may be integrated with the signal processor. The received signals may be transformed by the signal processor e.g. into an output signal which can be observed by a person. Examples of such output signals are visual signals and/or audio signals. To this end, the unit preferably comprises at least one light generating source and/or at least one sound generation source.

[0032] It is commonly advantageous that the unit comprises at least one urging element, preferably a spring, to urge the driving element back to its original orientation. This can be favourable in case of a linearly displaceable driving element as well as in case of a rotary displaceable driving element. During the process of urging the driving element back to its original position, the driving element may co-act, directly or indirectly, with the rotor of at least one generator, which provides electrical energy which can be used and/or stored in a capacitor, which may optionally make part of the unit, in particular of the signal processing circuit.

[0033] Although the signal producing unit is commonly configured to be hand-held and/or to be attached to a wall or other surface, it is also imaginable that the unit according to the invention is configured to be inserted at least partially in a (physical) housing or casing, such as a flush-mounting box or junction box. Each of these boxes is a container for electrical connections, usually intended to conceal them from sight and deter tampering.

[0034] In an alternative preferred embodiment, the signal producing unit comprises at least one electrical generator supported by the supported structure, and a plurality of driving elements, each driving element being configured to drive at least one generator, and at least one signal processing circuit configured to be powered by any generator. Here, it is thinkable that each driving element is configured to co-act with its own generator. In this manner a more complex signal producing unit can be realised which provides more possibilities and flexibilities to produce driving element(s) dependent output signals.

[0035] The invention also relates to an assembly of at least one signal producing unit according to the invention and at least one signal receiving device configured to receive, and subsequently to transmit and/or to process the output signals produced by said signal producing unit. Optionally, the receiving device is also configured to

transmit signals (back) to the signal producing unit, which may be processed by the signal processor. The receiving device may comprise a simple display for displaying the signal(s) received. However, the output signals generated by the signal producing unit may also embody commands to be sent to the receiving device, for example for controlling said receiving device. Here, the signal producing unit may for example be as control unit or control panel for controlling a safe acting as receiving device. The receiving device and the signal producing unit may be connected mutually by means of a wired connection. However, preferably, at least one signal producing unit and at least one signal receiving unit are configured to communicate wirelessly, which expands the possibilities for application tremendously. The receiving device may for example comprise at least one light generating device, sound generating device, and/or motor which is controllable by at least one signal producing unit. Alternatively, the receiving device may be configured as receiving hub (router) to receive signals and to control further devices connected to said hub. It is well thinkable that multiple signal producing units according to the invention may communicate (simultaneously) with the central receiving hub.

[0036] The invention further relates to a signal receiving device for use in an assembly according to the invention. Various embodiments of the receiving device are already described above.

[0037] The invention moreover relates to a method for operating a low-power signal producing unit, in particular a sensor and control unit, according to the invention, comprising the steps of: A) displacing at least one driving element with respect to the support structure by means of an external power source, such as human power and/or mechanical power, B) generating electrical energy in the generator co-acting with the driving element during displacement of the driving element, C) powering a signal processing circuit by the electrical energy generated by the generator according to step B), which allows: C1) the production of at least one input signal by at least one signal producing element, said input signal being related to the displacement of the same driving element with respect to the support structure, and C2) preferably, the transformation of at least one produced input signal into at least one output signal by a signal processor, wherein the output signal is representative for the displacement of the driving element with respect to the support structure. Various embodiments of the method have already been described above in a comprehensive manner.

[0038] The invention will be elucidated on the basis of non-limitative exemplary embodiments shown in the following figures. Herein:

- Figure 1 shows a schematic view of a signal producing unit 1 according to the invention;
- Figures 2-5 show a schematic view of different embodiments of a signal producing unit according to

the invention;

- Figure 6 shows a schematic view of a driving element for use in a signal producing unit according to the invention;
- Figures 7-19 show different embodiments of signal producing elements for use in a signal producing unit according to the invention;
- Figure 20 shows an assembly of a preferred embodiment of a signal producing unit according to the invention and multiple external devices controlled by said unit;
- Figures 21 en 22 show alternative preferred embodiments of a signal producing unit according to the invention;
- Figure 23 shows a detailed view of a part of a signal producing unit according to the invention;
- Figure 24a shows a perspective view of a generator which may be used in a signal producing unit according to the invention; and
- Figures 25a, 25b show time-voltage charts of different generators which may be used in a signal producing unit according to the invention.

[0039] Figure 1 shows a schematic view of a signal producing unit 1 according to the invention. The unit 1 comprises a support structure 2, which may comprise and/or be formed by a printed circuit board, a frame, or any other structure configured to support and/or carry components of the unit 1. The unit 1 also comprises an electrical generator 3 supported by said supported structure 2, said generator 3 comprising a stator 3a and a rotor 3b, in particular a multipole rotor 3b. The rotor 3b is at least partially enclosed by said stator 3a. In this example, the stator 3a comprises a field winding which is arranged in the axial direction outside the radial projection of the rotor 3b, and claw-pole-like magnetoconductive sheets, preferably 12, 14, or 16 sheets, guided axially in the radial projection of the rotor. An example of such a generator is disclosed as part of a water turbine in EP 1 147 594, which is hereby incorporated by reference. Due to a claw-poles comprising stator 3a, (magnetic) retaining forces will occur between the stator 3a and the rotor 3b, which provides the generator 3 with a holding torque, which will or may be felt by a user during initial rotation of the rotor 3b with respect to the stator 3a. Said retaining forces require sufficient force/torque to drive the unit 1, which subsequently assures that the initial speed of the rotor 3b will be such that sufficient energy is generated to power at least the unit 1. The rotor 3b co-acts with a gear box (transmission) comprising multiple compound gears 4, 5. Each compound gear 4, 5 comprises a small diameter gear 4a, 5a (often referred to as pinion), and a large diameter gear 4b, 5b (often referred to as gear wheel) mounted on a common shaft 6, 7 (axle). Each shaft is supported by the support structure 2. The large diameter gear 4b of one gear 4 co-acts with the small diameter gear 5a of the other gear 5, wherein the large diameter gear 5b of the last mentioned gear 5 co-acts with the

rotor 3b of the generator 3. The small diameter gear 4a of the compound gear 4 positioned at a distance from the generator 3 co-acts with a toothed profile 8a of a substantially linearly displaceable driving element 8. The displacement direction of the driving element 8 is indicated with arrow A. The driving element 8 is supported by the support structure 2. A return spring 9 co-acts with both the support structure 2 and, in this example an outer end (section) 8b of, the driving element 8, and is configured to urge the driving element 8 to its initial position (as shown in figure 1). An opposite outer end (section) 8c of the driving element 8 is configured as push button for a user or external device/apparatus/object. Once the push button 8c is manually (or mechanically) pushed downwardly, the compound gears 4, 5 will be rotated causing an accelerated axial rotation of the rotor 3b (with respect to the stator 3a), which generates electrical energy to be used to power at least a signal processor 10 (supported by the support structure 2) of the unit 1 as will be explained below. In case the driving element 8 is pushed too quickly in a downward direction, a slip clutch 11, provided onto the compound gear 4 positioned at a distance from the generator 4, disengages the driving element 8 from the generator 3 to control the transmission of motion of the rotor 3b in order to prevent injury and/or failure of the moving part of the unit 1, such as the rotor 3b of the generator 3. The driving element 8 is provided with a bulge (protrusion) 12, which is configured to co-act with and to move a leaf spring 13 during downward movement. As shown in figure 1, the leaf spring 13 defines an accommodating space for accommodating at least a part of the bulge 12 in a downward position of the driving element 8. A user will feel once the bulge 12 is positioned in said accommodating space, which thus indicates that the driving element 8 has reached or is positioned nearby a lowest point of the driving element 8. By making the bulge 12 to co-act with the leaf spring 13, the leaf spring 13 will be pushed in a direction away from the gear box, which causes the leaf spring 13 to close (connect) a set of electrical contact points of a signal producing element 14, wherein at least one input signal is produced which is led to the signal processor 10 (see dotted line). To this end, the contact points make part of an electrical (or electronic) signal processing circuit, which circuit also comprises said signal processor 10. The complete circuit is powered by the generator 3. The unit 1 comprises a further signal producing element 15, connected to the processor 10, said further signal producing element 15 being configured to generate one or more input signals which is/are, directly or indirectly, related to environmental or other parameters, such as temperature, humidity, environmental light intensity, other moving parts of the unit, etc. The input signal produced by said signal producing element 14 is characteristic for the (bottom) position of the driving element 8. This typical input signal, possibly combined with one or more input signals, including an (input) signal generated by the generator 3 and including an input signal generated by said

further signal producing element 15, can be transformed by the signal processor 10 into at least one output signal which is led to a communication element, such as a transmitter (not shown), wherein the output signal is preferably representative for the displacement of the driving element 8 with respect to the support structure 2, and in particular representative for having reached (a position close to) the bottom position of the driving element 8. This output signal can be used for various purposes, such as, for example, providing information to the user of the unit 1 and/or for wired or wireless control of a device, such as a motor, a lamp, or a sound speaker. In addition to the aforementioned signal producing element 14, the unit 1 comprises two further signal producing elements 16, 17, each of which is configured to co-act with the driving element 8, a gear 4, 5, and/or the generator 3 respectively in order to produce one or more (further), preferably distinctive, input signals related to the relative displacement of the driving element 8. One of the further signal producing elements 16 can for example be configured to produce input signals related to the displacement direction (upward or downward) of the driving element 8, while the other signal producing element 17 can for example be configured to produce input signals related to the speed of displacement of the driving element 8. Also the further signal producing element 16, 17 are connected to the signal processor 10 and make part of the signal processing circuit. The signal processor 10 may be configured to produce (generate) one or more output signals related to one or more input signals received, wherein the one or more output signals are representative for the displacement of the driving element 8 (in broad sense). In case the output signal of the signal processor 8 would be intended to control a lamp for example, pushing the driving element 8 in downward direction may produce another output signal, for example switching the lamp on, than urging back the driving element 8 in upward direction to its initial position, for example switching the lamp off. Also the speed of displacement of the driving element 8 may influence the lamp characteristics, such as the intensity (brightness) and/or colour. In subsequent drawings, the working principle of the signal producing elements 14, 16, 17 is illustrated in more detail.

[0040] The unit 1 according to the invention may form integral part of a larger device, such as a safe, a sensor, a light generating device, and/or a sound generating device, though it is also thinkable that the unit 1 is configured as remote control, which may be handheld and/or mountable to a wall. The unit 1 is referred to as an autonomous unit, since it is not powered by means of other electricity sources (battery or mains electricity). The generator 3 typically generated an electrical power in the magnitude of 5-1.000 milliwatt, and is therefore classified as a low power generator 3, which makes the unit 1 as such also a low-power unit 1.

[0041] Figure 2 shows a schematic view of another signal producing unit 20 according to the invention. The unit

20 is predominantly similar to the unit 1 shown in figure 1 with the most important difference that a rotary driving element 21 rather than a linearly displaceable driving element 8 is applied in the unit 20. The unit 20 further comprises a carrier 22 acting as support structure, onto which the driving element 21 is rotatably mounted, and onto which all other components of the unit 20 are also mounted, either directly or indirectly. The driving element 21 is ring-shaped (annular shaped) wherein an inner peripheral side 21a is provided with a profiled surface (toothed surface). Said driving element 21 is also referred to as a ring gear or toothed rim. The toothed surface 21a co-acts with a plurality of mutually co-acting (compound) gears 23, 24 configured to drive a axially rotatable rotor 26a of a generator 26 in an accelerated way, which in co-action with a surrounding stator 26b is configured to generate electrical energy. The gear 23 directly engaging the driving element 21 is provided with a slip clutch 27 to prevent damaging the moving part of the unit 20, such as the rotor 26a of the generator 26, in case of an excessive force or torque caused by the driving element 21. A mechanical holding torque and/or force retaining means is provided, formed by the co-action of a leaf spring 25 and a bulge 28 provided to outer edge of the gear 24 directly engaging the generator 26, to impede orientation-dependent rotation of the driving element 21, which can be observed/felt by a user during use of the unit 20, and which provides the user touch based feedback about the magnitude of rotation (degree of rotation). Moreover, the magnetic retaining forces require sufficient force/torque to drive the unit 1, which subsequently assures that the initial speed of the rotor 3b will be such that sufficient energy is generated to power the unit 1. Also this unit 20 comprises a plurality of signal producing elements 29, 30, 31 which are connected to a signal processor 32. The signal producing elements 29, 30, 31 and the signal processor 32, together with the generator 26, form or make part of a signal processing circuit. Here, the generator 26 may also act as signal producing element. Each signal producing element (26,) 29, 30, 31 is configured to produce at least one distinctive input signal related to the displacement of the common driving element 21 with respect to the support structure 22. The signal processor, also referred to as control unit, chip, or (micro)computer, is configured to receive the input signals produced by the signal producing elements (26,) 29, 30, 31 and to transform at least one input signal into at least one output signal representative for the displacement of the driving element 21 with respect to the support structure 22. Activation of the different signal producing elements 29, 30, 31 to allow production of a signal may occur at the same and/or at different moments in the time, and may be the result of the detection of various displacement related parameters, such as orientation (position), direction of rotation, speed of rotation, and acceleration during rotation of the driving element 21. The at least one output signal will be related hereto, and will therefore be representative for at least a part of the actual use, in particular

displacement, of the driving element 21.

[0042] Figure 3 shows a schematic view of another signal producing unit 40 according to the invention. The unit 40 is predominantly similar to the unit 1 shown in figure 1 with the most important difference that two gears 41a, 41b of a transmission, positioned in between and co-acting with a substantially linearly displaceable driving element 42 and - indirectly - with a rotor 43a of a generator 43, are configured to act as mechanical rectifiers securing a predefined unidirectional rotation of the rotor 43a. In between said rectifiers 41a, 41b and said generator 43, a compound gear 44 is provided. Said compound gear 44 comprises a small gear 44a and a larger gear 44b which are mutually connected by means of a spiral spring 44c. Due to the applied rectifiers 41a, 41b, said compound gear 44 will rotate in one direction only. During rotation of the small gear 44a of said compound 44 gear, the spiral spring 44c will be wound leading to an increase of spring tension. As soon as this spring tension exceeds a holding torque of the generator 43, the larger gear 44b of the compound gear 44, and hence the rotor 43a directly co-acting with said larger gear 44b will initiate to rotate (instantaneously). This makes the unit 40 speed independent, also the spring 44c will protect the moving parts of the unit 40 from damage by shocks and overload. The displacement of the driving element and the winding and releasing of the spring 44c are a substantially constant factor, wherein each spring jump represents a certain displacement of the driving element 42. The time between spring jumps relates to the speed of the driving element. This makes the generator 43 as such ideally suitable to be used as (additional) signal producing element configured to produce input signals which may be used by a signal processor 45 to generate one or more output signals. As visualised, also this unit 40 comprises various other signal producing elements 46, 47, 48 connected to said signal processor 45. Furthermore, the unit also comprises a return spring 49 and a mechanical holding element 50 for temporary holding a bulge 51 making part of the driving element 42, which operate the same as discussed above in the description of figure 1.

[0043] Figure 4 shows a schematic view of another signal producing unit 60 according to the invention. The unit 60 shown in figure 4 is based upon a combination of the units 20, 40 shown in figures 2 en 3. The unit 60 also comprises an rotary annular driving element 61 rather mounted by a support structure 62. The driving element 61 encloses a generator 63 and a transmission connecting the driving element 61 and the generator 63. The transmission is formed by a set of gears and related accessories, and comprises more in particular a first gear 64 directly co-acting with a rotor 63a of the generator 63. Said first gear 64 comprises a (small diameter) pinion 64a, a (large diameter) gear wheel 64b, and a spiral torsion spring 64c (also referred to as a flat hairspring) positioned in between said pinion 64a and said gear wheel 64b. The pinion 64a and the gear wheel 64b are mutually rotatably mounted onto a central shaft 64d. The set of

gears further comprises two mechanical rectifiers 65, 66 which directly co-act with the toothed inner edge 61a of the driving element 61. Each rectifier comprises a small gear and a larger gear, wherein the small gears directly co-act with the driving element, and wherein the large gears merely rotate in case the related small gear is rotated in one predefined rotation. The large gears, either directly or indirectly, drive the large gear wheel 64b of the first gear 64. Rotation of the driving element 61 leads to rotation of the pinion 64a which causes the torsion spring 64c to wind. In case the spring tension of the torsion spring 64c exceeds a (substantially) predetermined threshold value, the torsion spring 64c will unwind itself quite quickly (in opposite direction) thereby - quickly - rotating the gear wheel 64b. Application of this spring system makes the unit 60 independent of the speed of rotation of the driving element 61. Moreover, the spring 64c will protect the moving parts of the unit 60 from damage by shocks and overload. The displacement of the driving element 61 and the winding and releasing of the spring 64c are directly related, as a result of which each spring jump represents a certain displacement of the driving element. The time between spring jumps relates to the speed of the driving element 61. Also the unit shown in figure 4, several signal producing elements 67a, 67b, 67c are provided, and - optionally - the generator 63 which may also act as signal producing element, which are connected to a signal processor 68 programmed to generate one or more driving element behaviour dependent output signals. Examples of which input signals may lead to which output signals have already been described above.

[0044] Figure 5 shows an alternative unit 80 according to the invention. The unit 80 shown is substantially identical to the unit 40 shown in figure 3. The single difference between the unit 40 shown in figure 3 and the unit 80 shown in figure 5, is related to a distinctive driving element 81. The driving element 81 comprises a basic structure 81a, a top portion of which is provided with a push button 81b, wherein a rear side the basis structure 81a is provided with a bulge 81c, and wherein a bottom portion 81d of said basic structure 81a co-acts with a return spring 82. The basic structure 81a is provided with two notches 81e, 81f configured to hold and/or clamp a tooth rack 81g by means of two compression or tension springs (coil springs) 81h, 81i. Each spring 81h, 81i is positioned in between and/or attached to a notch 81e, 81f and an outer end of said rack 81g, and is configured to hold the rack 81g in place. This leads to the situation that the rack 81g is displaceable to some extent with respect the basic structure 81a. This provides the rack 81g a certain inertia to move along with the displacement of the basic structure 81a, as a result of which the rack 81g may function as inertia damper, and thus as shock absorber. Moreover, application of the resiliently mountable rack 81g assures that sufficiently force will have to be applied to drive a generator co-acting with said rack 81g, which assures that sufficient electrical energy will be generated by said

generator.

[0045] Although in figures 1-5 driving elements are shown which are either linearly displaceable or rotatable, it is also conceivable to apply alternatively operating driving elements. An example of such an alternatively operating driving element 90 is shown in figure 6, wherein an initial, (substantially) linear displacement is converted into a rotary movement within the driving element 90 itself. To this end, the driving element 90 is mounted onto a support structure 91, wherein the driving element 90 comprises a central driving element segment 90a, and a substantially disc shaped peripheral driving element segment 90b partially enclosing the central driving element 90a. The central driving element segment 90a is linearly displaceable with respect to a central hole 90c provided in the peripheral driving element segment 90b. An outer surface of the central driving element segment 90a is provided with an outer thread 90d configured to co-act with an inner thread 90e applied to an inner surface of said central hole 90c. A coil spring 90f is provided in between an enlarged upper surface (head) 90g of the central driving element 90a and the peripheral driving element 90b to push the central driving element 90a in upward direction. In case a user or another power source, such as a machine, apparatus, or device, pushes the head 90g of the central driving element 90a linearly in downward direction, the co-action between the threads 90d, 90e causes the disc-like driving element segment 90a to rotate. A peripheral rim/edge of said disc-like driving element 90a may be used to drive a transmission and/or generator.

[0046] Figures 7-22 show different embodiments of signal producing elements, which may be used in the signal producing units shown in figures 1-5. Figures 7-22 are explained in more detail below.

[0047] Figure 7 shows a linearly displaceable driving element 100 which is provided with two protruding bulges 101a, 101b with mutually different sizes. As shown in figure 7, a first set 102a of electrical contact points and a second set 102b of electrical contact points are applied, wherein a contact point of each set 102a, 102b, facing toward a top position of the driving element 100 (as shown), is provided with a resilient, electrically conductive bridge, more in particular a first bridge 103a and a second bridge 103b. Each set 102a, 102b of contact points is connected to a signal processor 104. In an initial state (rest state) the first bridge 103a connects the opposite contact point of the first set 102a, which leads to the generation of an (electrical) input signal for a first period of time, which can be measured, detected, and/or initiated by the signal processor 104. It is imaginable that a user can feel the mechanical resistance during deformation of the bridge, which provides the user feedback about the magnitude of displacement of the driving element 100. In case the driving element is pushed in downward direction, the first bridge 103a will reopen and, subsequently, the second bridge 103b will be closed by the lower bulge 101b for a first period of time, and, preferably

simultaneously, the first bridge 103a will be closed by the upper bulge 101a for a second period of time (which may deviate from said first period of time), wherein at least one further input signal is produced. Based upon the input signals received by the processor 104, the processor 104 detects ('knows') to which position the driving element 100 has been pushed downwardly, and is programmed to produce a representative output signal related to the displacement of the driving element 100. Depending on the number, position and length of the signal producing elements 102a, 102b, and the produced input signals, information and commands can be generated related to e.g. the position, speed, direction and acceleration of the driving element. The signal producing elements 102a, 102b can also be used as retaining means to provide user feedback, or to make the system speed independent combined with a spring body.

[0048] Two alternative signal producing elements 110, 111 are shown in figure 8, wherein a first signal producing element 110 comprises a first set of contact points 110a, 110b, wherein one contact point 110a is provided with a resilient conductive first bridge 110c. A second signal producing element 111, likewise, comprises a second set of contact points 111a, 111b, wherein one contact point 111a is provided with a resilient conductive first bridge 111c. Both bridges 110c, 111c mutually extend in (more or less) the same direction, such that a axially rotatable driving wheel 112, which may be formed or make part of a gear, is configured to co-act with both bridges 110c, 111c, and more in particular to deform and close said bridges 110c, 111c. An outer edge 112a of said wheel 112 is provided with a first bulge 113, a second bulge 114, and a third bulge 115. The length between the heart (centre) of the first bulge 113 and heart of the second bulge 114 is indicated as L1, wherein the enclosed angle is indicated with α . The length between the heart of the second bulge 114 and heart of the third bulge 115 is indicated as L2, wherein the enclosed angle is indicated with β . The length between the heart of the second bulge 114 and the heart of the third bulge 115 is indicated as L3, wherein the enclosed angle is indicated with γ . The lengths L1, L2, and/or L3 may be equal or mutually different. The lengths L1, L2, and/or L3 are predefined. The width (size) of each bulge 113, 114, 115 mutually differs, though is also predefined in this example. The width of the first bulge 113 is smaller than the width of the second bulge 114, which is smaller than the width of the third bulge 115. Each bulge 113, 114, 115 is configured to co-act with each bridge 110c, 111c, dependent of the orientation of the wheel 112. During rotation of the wheel 112 in clockwise direction, at constant speed, starting from the orientation (position) as shown, the following successive actions take place:

- closing of the first bridge 110c by the first bulge 114, thereby producing a first input signal (i1) during a first period of time (t1) in and/or for a signal processor 116;

- reopening of the first bridge 110c,
- closing of the second bridge 111c by the first bulge 114 during said first period of time (t1), thereby producing a second input signal (i2),
- reopening of the second bridge 111c,
- closing of the first bridge 110c by the second bulge 113, thereby producing a first input signal (i1) during a second period of time (t2),
- reopening of the first bridge 110c,
- closing of the second bridge 111c by the second bulge 113, during said first period of time (t2), thereby producing a second input signal (i2),
- reopening of the second bridge 111c,
- closing of the first bridge 110c by the third bulge 115, thereby producing a first input signal (i1) during a third period of time (t3),
- reopening of the first bridge 110c,
- closing of the second bridge 111c by the third bulge 115 during said third period of time (t3), thereby producing a second input signal,
- reopening of the second bridge 111c,
- (et cetera)

[0049] By means of the input signals (i1, i2), and the durations thereof (t1, t2, t3), which may lead to aggregated input signals i1'(i1 x t1), i2'(i1 x t2), i3'(i1 x t3), i4'(i2 x t1), i5'(i2 x t2), and i6'(i2 x t3). At least a part of these (aggregated) input signals may be transformed into one or more output signals by the processor 116. The output signals are representative for the degree of rotation, and possibly the speed of rotation, of the wheel 112. Depending on the number, position and length of the signal producing elements 110, 111, and the produced signals, information and commands can be generated related to the position, speed, direction and acceleration of the driving element 112. The signal producing elements 110, 111 can also be used as retaining means to provide user feedback, or to make the system speed independent combined with a spring body.

[0050] Figure 9 shows an alternative embodiment of a part of the signal producing unit 120 according to the invention, which comes close to the embodiment shown in figure 8. The mere difference between the embodiment of figure 8 and the embodiment of figure 9 is the way of closing (connecting) electric contact points of a first set 121 of (resilient) conductive contact points 121a, 121b and second set 122 of (resilient) conductive contact points 122a, 122b. Here, in figure 9, both sets 121, 122 are stationary and connected to a support structure. None of the sets 121, 122 is provided with a resilient conductive bridge, as illustrated in some of the previous figures. Instead, a front surface of rotary wheel 123 is provided with three (moving) pads 124, 125, 126, acting as bridges, each with its own length, and mutually positioned such that angles α , β , γ are enclosed by the respective centres of said pads 124, 125, 126. Each of the angles α , β , γ may be 120°, though may also be distinctive from 120°. In figure 9, angle α is about 150°, angle β is

about 115° , and γ is about 95° . This orientation is comparable to the orientation as shown in figure 8. Each pad 124, 125, 126 forms a sliding, electrically conductive, sliding surface for (sliding) contact points 121a, 121b, 122a, 122b to engage, and by means of which pads 124, 125, 126, the contact points 121a, 121b, 122a, 122b can be connected, dependent on the orientation of the wheel 123, which may lead to substantially the same signals as comprehensively described above in the description of figure 8. Here, the stationary, (somewhat) resilient, conductive sliding contact points 121a, 121b, 122a, 122b directly engage, preferably with tension, onto (front surface of) the wheel 123 and may therefore directly engage onto the bridges 124, 125, 126. In an alternative embodiment, as shown in figure 10, alternative (resilient) conductive pads 124', 125', 126' applied onto an alternative wheel 123' may extend radially (or axially) with respect to said wheel 123', such that the pads 124', 125', 126' may contact alternative sets 121', 122' of contact points 121a', 121b', 122a', 122b positioned laterally (or, alternatively, axially and/or radially) with respect to said wheel 123'. Also this alternative embodiment is based upon sliding contacts.

[0051] The application of sliding contacts is not restricted to rotary wheels, and may also be applied in substantially linearly displaceable elements, such as a linearly displaceable driving element. Exemplary embodiments are shown in figures 11 and 12. In figure 11, a driving element 130 is shown, comprising a push button 130a at a top side, a toothed rack 130b at a front side, and two distant, conductive taps 130c, 130d at a rear side of the driving element 130. Two distant sets 131, 132 of distant contact points 131a, 131b, 132a, 132b, connected to a signal processor 133, are oriented such that the contact points 131a, 131a, 132a, 132b of a set 131, 132 can be connected during (vertical) displacement of the driving element, and may lead to various, distinctive input signals which may be transformed by the signal processor 133 into one or more output signals related to the detected movement of the driving element 130. Although the contact points 131a, 131b, 132a, 132b are not mounted by the driving element 130, it is conceivable that in an alternative embodiment of the driving element 130, the contact points are mounted by the driving element, and are thus displaceable, and that the connecting bridges or tabs are positioned stationary nearby said alternative driving element.

[0052] Figure 12 shows a part of another signal producing unit 140 according to the invention. Said unit 140 comprises two stationary, signal producing elements 141, 142. Each signal producing element 141, 142 comprises a coil 141a, 142a enclosing a (magnetic) core 141b, 142b at least partially. The coils 141a, 142a are electrically connected to a signal processor 143. A substantially linearly displaceable driving element 144, configured to drive a generator (not shown) for powering said processor 143, is positioned laterally with respect to said coils 141a, 142a. Said driving element 144 is provided

with two alternating oriented (bar) magnets 145a, 145b. By displacing the driving element 144, and hence the magnets 145a, 145b with respect to the coils 141a, 142a, an induced voltage (and consequently an induced current) is generated in each coil. According to Lenz's law, the current which is thereby generated in the coil must cause an effect which opposes the approaching or leaving magnetic field. Hence, displacing the driving element 144 in downward direction will induce a current in a direction which is opposite to the direction of the current which is induced when the driving element 144 is displaced in upward direction. The direction and magnitude of the induced current may be monitored by the signal processor 143. To this end, the signal processor 143 may be equipped with a voltmeter and/or ammeter. The detected induced current values can be used as input signal for the processor 143 to produce at least one related output signal to be used for other purposes. As shown in figure 12, one magnet 145a is oriented with a south pole towards the coils 141a, 142a, while the other magnet 145b is oriented with a north pole towards the coils 141a, 142a. An alternative orientation of the magnets 145a, 145b is and coils 141a, 142a (including cores 141b, 142b) also thinkable, as is shown for example in figure 13, wherein the same reference signs are applied. As a further alternative embodiment, shown in figure 14, the two coils 141a, 142a have been replaced by two hall sensors and/or reed relays 146a, 146b. The hall sensors and reed relays can be activated by the magnets in order to produce one or more input signals. An actuator, such as a magnet or bulge, may be considered to make part of a signal producing unit, though will often be considered as additional component which does not make part of a signal producing unit, since the signal producing unit is typically considered as electric or electronic component, connected to a signal processor.

[0053] Figure 15 shows a part of a signal producing units 150 comprises a rotary wheel 151 configured to drive a rotor of a generator. The wheel 151 is provided at or close to an outer rim with multiple magnets 152a, 152b, 152c which are positioned at predefined locations on the wheel 151, and wherein each magnet 152a, 152b, 152c has its own predefined orientation. Two core-coil assemblies 153a, 153b are positioned in the vicinity of the rotary wheel 151, such that during rotation of the wheel 151, and hence of the magnets 152a, 152b, 152c, a current can be induced in the assemblies 153a, 153b, which acts as input signal for a signal processor 154 connected to said assemblies 153a, 153b in order to generate at least one output signal which is representative for the wheel motion and hence for a driven driving element co-acting with said wheel. The wheel 151 may form integral part of the driving element. Also in this embodiment, the orientation of the magnets 152a, 152b, 152c can be changed, in particular switched (e.g. 90° or 180°), and/or at least one of the core-coil assemblies 153a, 153b may be replaced by a hall sensor and/or reed relay.

[0054] In figure 16, an alternative embodiment is

shown of a part of a signal producing unit 160 according to the invention, which looks quite similar to the embodiment shown in figure 7. More in particular, a linearly displaceable driving element 161 is shown which is provided with a first protruding bulge 162a, and a second protruding bulge 162b. The first bulge 162a is configured to mechanically co-act successively with two stationary piezo elements 163a, 163b, during downward movement of the driving element 161. The second bulge 162b is configured to mechanically co-act merely with one stationary piezo element 163a during downward movement of the driving element 161. In case a bulge 162a, 162b engages a piezo element 163a, 163b, the particular piezo element 163a, 163b is at least partially deformed, which leads to a piezoelectric effect, wherein a, preferably piezo element 163a, 163b dependent, voltage is generated, which can be detected and used by a signal processor 164 connected to said piezo elements 163a, 163b for further purposes. Commonly the generated voltage level is directly related to the magnitude of deformation of a piezo element 163a, 163b. As can be seen in figure 17, a magnet may also be used to realise a deformation of a piezo element. More in particular, instead of applying bulges 162a, 162b to a driving element 161, the driving element 165 shown in figure 17 is provided with two permanent magnets 166a, 166b, which is oriented such that they are able to attract iron cores 167a, 167b, each of which being attached to an outer end of a piezo element 168a, 168b. Displacing the driving element 165 with the magnets 166a, 166b along the cores 167a, 167b will attract the cores resulting in a deformation of the piezo element 168a, 168b to which the respective core 167a, 167b is attached, and hence to the generation of a voltage in the deformed piezo element which can be used by a processor 169 to generate one or more co-related output signals. Instead of applying a linearly displaceable driving element 161, 165, as shown in figure 16 and 17, also a rotary wheel, which may act as driving element, can be applied, as for example shown in figures 8 and 15.

[0055] Figures 18 shows a part of an alternative signal producing unit according to the invention. In figure 18, in particular an assembly of a rotary wheel 170 provided with bulges 171a, 171b, 171c (equal to the wheel shown in figure 8) and a leaf spring 172 is shown. The leaf spring 172 is designed such that a receiving space 172a is created, which is configured to accommodate a part of one bulge 171a in this example, though which may also be modified such that each of the bulges 171a, 171b, 171c may be accommodated at least partially. The leaf spring 172 acts as retaining element, in particular a holding force generating element or a holding torque generating element, which may impede passing of said bulge 171a along said leaf spring 172, which is observable by a user directly or indirectly rotating said wheel 170. This provides information to the user that a predefined orientation of the wheel 170 with respect to the leaf spring 172 has been reached. In an alternative embodiment, as shown in figure 19, a rotary wheel 173 is applied which has been

provided with multiple, mutually different recesses 174a, 174b, 174c at a circumferential edge 173a of the wheel 173. The recesses are also referred to as cut-away portions. A leaf spring 175 provided with a protruding bulge 175a is applied, which is oriented in such a way that said bulge 175a is configured to co-act with the bulges 174a, 174b, 174c during axial rotation of the wheel 173. Since the recesses have mutually different lengths (dimensions), distinctive touch based feedback can be provided to a user manually rotating said wheel, either directly or indirectly.

[0056] Figure 20 shows a schematic view of a preferred embodiment of an assembly of signal producing unit 180 according to the invention, acting as remote control, and distant light generating devices 181, 182 to be controlled by said unit 180. The unit 180 comprises a support structure 183, which may comprise and/or be formed by a printed circuit board or any other structure configured to support and/or carry components of the unit 180. The unit 180 also comprises an electrical generator 184 supported by said support structure 183, said generator 184 comprising a stator 184a and a rotor 184b. The rotor 184b is at least partially enclosed by said stator 184a. In this example, the stator 184a comprises a field winding which is arranged in the axial direction outside the radial projection of the rotor 184b, and claw-pole-like magnetoconductive sheets, preferably 12, 14, or 16 sheets, guided axially in the radial projection of the rotor. The generator 184 has a holding torque to assure sufficient starting force/torque and so sufficient speed of the rotor 184b of the generator 184, and hence sufficient output power to power the unit 180. The rotor 184b co-acts with a gear box (transmission) comprising multiple compound gears 185, 186. Each compound gear 185, 186 comprises a small diameter gear 185a, 186a (often referred to as pinion), and a large diameter gear 185b, 186b (often referred to as gear wheel) mounted on a common shaft 187, 188 (axle). Each shaft is supported by the support structure 183. The large diameter gear 185b of one gear 185 co-acts with the small diameter gear 186a of the other gear 186, wherein the large diameter gear 186b of the last mentioned gear 186 co-acts with the rotor 184b of the generator 184. The small diameter gear 185a of the compound gear 185 positioned at a distance from the generator 185 co-acts with a toothed profile 189a of a substantially linearly displaceable driving element 189. The displacement direction of the driving element 189 is indicated with arrow A. The driving element 189 is supported by the support structure 183. A return spring 190 is provided which co-acts with both the support structure 183 and an outer end (section) 189b of the driving element 190, and is configured to urge the driving element 189 to its initial position (as shown). An opposite outer end (top section) 189c of the driving element 189 is configured as push button for a user. Once the push button 189c is manually (or mechanically) pushed downwardly, the compound gears 185, 186 will be rotated causing an accelerated axial rotation of the rotor 184b (with respect

to the stator 184a), which generates electrical energy to be used to power at least a signal processor 191 (supported by the support structure 183) of the unit 180 as will be explained below. The driving element 189 is provided with a bulge (protrusion) 192, which is configured to co-act with and to move a leaf spring 193 during downward movement, which co-action can be felt by a user pushing the driving element 189 in downward direction, and which indicates to a user that a lowest position of the driving element 189 has been reached. The unit 180 comprises a set of electrical contact points 194a, 194b, wherein an upper contact point 194a, facing toward to the top section 189c of the driving element 189, is provided with an electrically conductive connecting bridge 194c. The bridge 194c is initially positioned as shown, and does not connect the contact points 194a, 194b. During downward displacement of the driving element 189, the driving element 189 will push (force) the bridge to connect both contact points 194a, 194b, which results in closing of at least a part of a signal processing circuit, and which can be detected by said signal processor 191 connected to said contact points 194a, 194b and also making part of said circuit. Aforementioned detection is considered as input signal, which is representative for the displacement of the driving element 189. The same applies to the generator 184, which also produces signals which are representative for the displacement of the driving element 189. At least one of these produced input signals serves as basis for the signal processor 191 to generate one or more output signals representing commands for controlling said external devices 181, 182, which are wirelessly emitted by means of a transmitter 195 connected to said processor 191, for example by using a Bluetooth and/or ZigBee protocol and/or by using WiFi, Infrared technology, or by means of other electromagnetic radiation. The transmitter 195 may be integrated with the processor 191. The emitted output signal(s) can be received directly by a light generating device 182, though may also be received by an intermediate device 196, which as transceiving hub, wherein the intermediate 196 device is configured to emit (forward) to the output signal(s) to a light generating device 181. The light generating devices 181, 182 comprises a receiver 181a, 182a configured to receive the output(s) based upon which the light generating devices 181, 182 are remotely controlled. Also environmental or other signals produced by one or more further signal producing elements (not shown) might be fed to the processor 191. This unit 180 as shown in figure 20 is capable to detect the position of the driving element and can be capable to detect the speed, acceleration and direction of the driving element. The signal processor 191 may also be equipped with a wireless receiver (not shown) to listen to and/or receive feedback from other devices/transmitters, which may be used for control and/or monitoring purposes.

[0057] Figure 21 shows a schematic view of another preferred embodiment of a signal producing unit 200 according to the invention. The unit 200 is predominantly

similar to the unit 180 shown in figure 20 with the most important difference that a rotary driving element 201 rather than a linearly displaceable driving element 189 is applied. The unit 200 is also predominantly similar to the unit 20 as shown in figure 2, with the most important difference that signal producing elements 202a, 202b are positioned at different location within the unit 200. The unit 200 comprises a carrier (not shown) acting as support structure and/or housing, onto which the driving element 201 is rotatably mounted, and onto which all other components of the unit 200 are also mounted, either directly or indirectly. The driving element 201 is ring-shaped (annular shaped) wherein an inner peripheral side 202 is provided with a profiled surface (toothed surface). Said driving element 201 is also referred to as a ring gear or toothed rim. The toothed surface 202 co-acts with a plurality of mutually co-acting (compound) gears 203, 204 configured to drive a axially rotatable rotor 205a of a generator 205 in an accelerated way, which in co-action with a surrounding stator 205b is configured to generate electrical energy. The generator 205 has a holding torque to assure sufficient starting force/torque, and therefore speed of the rotor 205a of the generator 205 and hence output power. The gear 203 directly engaging the driving element 201 may be provided with a slip clutch (not shown) to prevent damaging moving parts of the unit 200. A gear 204 directly co-acting with the generator 205 is provided with a protruding bulge 206 configured to co-act with a specifically shaped leaf spring 207, which acts as mechanical retaining (holding) element in line with figure 18 and the description thereof. The leaf spring 207 is provided to impede orientation-dependent rotation of the driving element 201, which can be observed/felt by a user during use of the unit 200, and which provides the user touch based feedback about the magnitude of rotation (degree of rotation). The unit 200 comprises a signal processor 208 to which three signal producing elements 209, 210, 211 are connected, together forming one or multiple signal processing circuits. One of the signal producing elements 211 is formed by the generator 205. The two other signal producing elements 209, 210 each comprises a set of contact points which co-act with a surface of the gear 204 directly engaging the generator 203, onto which surface one or more conductive strips, also referred to as one or more conductive pads, acting as conductive bridges, wherein a single conductive strip 225 is shown. Mutually connecting (short-circuiting) a set of sliding contact points by a passing conductive strip 225, during rotation of said gear 204, will be registered by the processor 208 (as input signal). The sine wave pattern generated by the generator 203 may also be registered by the processor 208, and also acts as input signal. At least a number of the input signals received by the processor 208 are transformed into one or more output signals which are representative for the displacement of the driving element 201. Instead of applying sliding contacts which are connectable by means of a moving bridge, as shown in figure 21, also an assembly of one or more

moving magnets 220 (applied onto a rotary gear 221) and co-acting hall sensors 222 and/or reed contacts (reed relays) can be used as visualized in figure 22. An stationary magnet 223 may be applied to realize a contactless magnetic holding torque element, which holding torque can be felt by a user during turning (rotating) of a driving element 224 co-acting with said gear 221. This holding torque (retaining force) can be use to assure sufficient rotor speed, and hence sufficient power output. The functionality of the embodiment shown in figure 22 is substantially identical to the functionality of the embodiment shown in figure 21.

[0058] Figure 23 shows a detailed view of a part of a signal producing unit according to the invention. More in particular, figure 23 shows a common driving gear 230 configured to drive two generators 231, 232. Each generator 231, 232 comprises a rotor and a stator 231a, 232a. Each rotor comprises a pinion 231b, 232b mounted onto an axially rotatable shaft 231c, 232c, wherein the rotor further comprises a multipole magnet 231d, 232d which is also mounted onto said shaft 231c, 232c. Due to the relative position of the multipole magnet 231d, 232d on a pinion shaft 231c, 232c, and the generator 231, 232 with respect to the common gear 230, during operation a phase shifted output is generated by said generators 231, 232. This is visualized by the two phase-shifted sine waves shown in the time-voltage chart of figure 25a.

[0059] Figure 24a shows a perspective view of a generator 240, comprising stationary multiple coils 241, 242 and multiple stators 245, 246, which are oriented in a phase-shifted manner. The phase-shift between said stators 245, 246, and consequently the phase-shift in coils 241, 242 is visualized in figure 24b by angle α . The stators 245, 246 and the coils 241, 242 are enclosed by a multipole magnet 243, 244 with multiple magnetic poles 243a. Due to the relative assembly position of the both stators 245, 246 in relation to the common magnet 243, 244 during operation a phase shifted output is generated by said generators. This is visualized by the two phase-shifted sine waves shown in the time-voltage chart of figure 25a. The sine-wave pattern generated by a generator comprising a single coil (instead of two phase-shifted coils) is shown in figure 25b. In the charts according to figures 25a and 25b, the frequency and voltage level are directly related to the speed of rotation of the rotor of the generator, while the total frequency in a period of time as well as the total amount of energy generated are indicative for the absolute or relative (actual) position of the rotor, and hence of a driving element driving the rotor. Furthermore, the order of sine waves of the phase-shifted output (shown in figure 25a) is indicative for the direction of rotation of the rotor, and often also for the displacement direction of a driving element driving said rotor.

[0060] It will be apparent that the invention is not limited to the exemplary embodiments shown and described here, but that within the scope of the appended claims numerous variants are possible which will be self-evident

to the skilled person in this field. It is possible here to envisage that different inventive concepts and/or technical measures of the above described embodiment variants can be wholly or partially combined without departing from the inventive concept described in the appended claims.

[0061] The verb "comprise" and conjugations thereof used in this patent publication are understood to mean not only "comprise", but are also understood to mean the phrases "contain", "substantially consist of", "formed by" and conjugations thereof.

Claims

1. Autonomous, low-power signal producing unit (1), in particular a sensor and control unit, comprising:

- a support structure;
- at least one electrical generator (3) supported by said support structure (2), said generator comprising a stator (3a) and a rotor (3b);
- at least one driving element (8) configured to drive said generator (3), wherein the relative orientation of the driving element (8) with respect to the support structure (2) can be changed by an external power source, such as human power, in order to drive said generator (3), and;
- at least one signal processing circuit powered by said generator, said circuit comprising:

- at least one signal producing element (14, 15), wherein this at least one signal producing element (14, 15) is configured to produce at least one distinctive input signal related to the displacement of the same driving element (8) with respect to the support structure (2), and
- preferably at least one signal processor (10), connected to at least one of said signal producing elements (14, 15), configured to receive the input signals produced by said at least one signal producing element (14, 15) and to transform at least one input signal into at least one output signal representative for the displacement of the driving element (8) with respect to the support structure (2),

characterized in that at least one rotary component of the signal producing unit (1) forms at least a part of at least one signal producing element (14, 15), such that this signal producing element is configured to produce a signal, the characteristics of which signal being dependent on the movement speed, the acceleration, the movement direction, the position, and/or the incremental position of the driving element (8) with respect to the support structure (2), wherein

- said rotary component is chosen from the group consisting of: a rotary driving element (21), a rotor (3b, 26a) of a generator (3, 26), and a transmission element (4,41a,41b) positioned in between the driving element (8,42) and a rotor (3b, 26a) of a generator (3, 26).
2. Signal producing unit (1) according to claim 1, wherein the signal producing unit comprises a plurality of signal producing elements (14, 15), wherein at least a part of at least a first signal producing element (14) is formed by a first rotary component, and wherein at least a part of at least a second signal producing element (15) is formed by a second rotary component, wherein said each of the first rotary component and second rotary component is chosen from the group consisting of: a rotary driving element (21), a rotor (3b, 26a) of a generator (3, 26), and a transmission element (4,41a,41b) positioned in between the driving element (8,42) and a rotor (3b, 26a) of a generator (3, 26).
 3. Signal producing unit (1) according to claim 1 or 2, wherein at least one generator (3) embodies at least a part of a plurality of signal producing elements (14,15), wherein said generator is a multiphase alternator configured to generate alternating currents of multiple different phases.
 4. Signal producing unit (1) according to one of the foregoing claims, wherein the unit comprises retaining means (25, 28) for generating orientation-selective holding torque and/or holding force in rendering at least one moving element self-holding, wherein the retaining means (25,28) comprises at least one first retaining element (25) and at least one complementary second retaining (28) element configured to co-act with said at least one first retaining element, wherein at least one moving component is provided with said at least one first retaining element, and at least one other component is provided with said at least one second retaining element, wherein at least one retaining element comprises at least one magnet and at least one complementary retaining element comprises at least one magnet and/or at least one magnetisable element configured to magnetically co-act with said at least one magnet. wherein at least one rotor (3b) of at least one generator (3) forms at least first retaining element and a stator (3a) of said generator (3) forms at least one second retaining element.
 5. Signal producing unit (1) according to one foregoing claims, wherein at least one signal producing element (14, 15) comprises at least one electromechanical switch, and wherein switch components are preferably positioned at predefined locations in the unit.
 6. Signal producing unit (1) according to claim 5, wherein at least one electromagnetic switch comprises at least one magnet and at least one switch, in particular a reed relay or piezo element, to be activated by said magnet.
 7. Signal producing unit (1) according to claim 5, wherein at least one electromagnetic switch comprises at least one magnet and at least one sensor, in particular a Hall sensor, configured to be activated by said magnet.
 8. Signal producing unit (1) according to one of the foregoing claims, wherein at least one signal producing element (14,15) is formed by at least one generator, wherein said generator is an alternator configured to generate an alternating current.
 9. Signal producing unit (1) according to one of the foregoing claims, wherein at least one generator (3) embodies multiple signal producing elements, wherein said generator (3) is preferably a multiphase alternator configured to generate alternating currents of multiple different phases.
 10. Signal producing unit (1) according to one of the foregoing claims, wherein at least one signal producing element (14,15) is configured to produce at least one input signal which is representative for the movement speed and/or acceleration of the driving element.
 11. Signal producing unit (1) according to one of the foregoing claims, wherein the signal processor (10) is configured to receive the input signals produced by the signal producing elements (14,15) and to transform multiple input signals into at least one output signal representative for the displacement of the driving element (8) with respect to the support structure (2).
 12. Signal producing unit (1) according to one of the foregoing claims, wherein the signal producing unit is configured as control, preferably remote control, wherein the signal processor (10) is configured to transform at least one input signal into at least one output signal representing at least one command to control a device (181,182), preferably an external device.
 13. Method for operating a low-power signal producing unit (1), in particular a sensor and control unit, according to one of claims 1-12, comprising the steps of:
 - A) displacing at least one driving element (8) with respect to the support structure (2) by means of an external power source, such as hu-

man power and/or mechanical power,
 B) generating electrical energy in the generator (3) co-acting with the driving element (8) during displacement of the driving element,
 C) powering a signal processing circuit by the electrical energy generated by the generator (3) according to step B), which allows:

C1) the production of at least one input signal by at least one signal producing element (14,15), said input signal being related to the movement speed and/or acceleration and/or movement direction and/or the position and/or the incremental position of the same driving element (8) with respect to the support structure (2), and
 C2) preferably, the transformation of at least one produced input signal into at least one output signal by a signal processor (10), wherein the output signal is representative for the displacement of the driving element (8) with respect to the support structure (2).

Patentansprüche

1. Autonome Kleinleistungs-Signalerzeugungseinheit (1), insbesondere Sensor- und Steuereinheit, die umfasst:

- eine Tragkonstruktion;
- wenigstens einen von der Tragkonstruktion (2) getragenen elektrischen Generator (3), wobei der Generator einen Stator (3a) und einen Rotor (3b) umfasst;
- wenigstens ein Antriebselement (8), das ausgelegt ist, den Generator (3) anzutreiben, wobei die relative Orientierung des Antriebselements (8) in Bezug auf die Tragkonstruktion (2) mittels einer externen Leistungsquelle, wie etwa Muskelkraft, geändert werden kann, um den Generator (3) anzutreiben, und;
- wenigstens eine vom Generator gespeiste Signalverarbeitungsschaltung, wobei die Schaltung umfasst:

- wenigstens ein Signalerzeugungselement (14, 15), wobei dieses wenigstens eine Signalerzeugungselement (14, 15) ausgelegt ist, wenigstens ein spezifisches Eingangssignal, das mit der Verschiebung desselben Antriebselements (8) in Bezug auf die Tragkonstruktion (2) zusammenhängt, zu erzeugen, und
- vorzugsweise wenigstens einen mit wenigstens einem der Signalerzeugungselemente (14, 15) verbundenen Signalprozessor (10), der ausgelegt ist, die vom wenigstens

tens einen Signalerzeugungselement (14, 15) erzeugten Eingangssignale zu empfangen und wenigstens ein Eingangssignal in wenigstens ein für die Verschiebung des Antriebselements (8) in Bezug auf die Tragkonstruktion (2) repräsentatives Ausgangssignal umzuwandeln,

dadurch gekennzeichnet, dass wenigstens eine Drehkomponente der Signalerzeugungseinheit (1) wenigstens einen Teil wenigstens eines Signalerzeugungselements (14, 15) ausbildet, so dass dieses Signalerzeugungselement ausgelegt ist, ein Signal zu erzeugen, wobei die Charakteristiken des Signals von der Bewegungsgeschwindigkeit, der Beschleunigung, der Bewegungsrichtung, der Position und/oder der inkrementellen Position des Antriebselements (8) in Bezug auf die Tragkonstruktion (2) abhängen, wobei die Drehkomponente ausgewählt ist aus der Gruppe bestehend aus: einem Drehantriebselement (21), einem Rotor (3b, 26a) eines Generators (3, 26), und einem zwischen dem Antriebselement (8, 42) und einem Rotor (3b, 26a) eines Generators (3, 26) positionierten Übertragungselement (4, 41a, 41b).

2. Signalerzeugungseinheit (1) gemäß Anspruch 1, wobei die Signalerzeugungseinheit eine Mehrzahl Signalerzeugungselemente (14, 15) umfasst, wobei wenigstens ein Teil wenigstens eines ersten Signalerzeugungselements (14) von einer ersten Drehkomponente ausgebildet wird, und wobei wenigstens ein Teil wenigstens eines zweiten Signalerzeugungselements (15) von einer zweiten Drehkomponente ausgebildet wird, wobei die erste Drehkomponente und zweite Drehkomponente jeweils ausgewählt sind aus der Gruppe bestehend aus: einem Drehantriebselement (21), einem Rotor (3b, 26a) eines Generators (3, 26), und einem zwischen dem Antriebselement (8, 42) und einem Rotor (3b, 26a) eines Generators (3, 26) positionierten Übertragungselement (4, 41a, 41b).

3. Signalerzeugungseinheit (1) gemäß Anspruch 1 oder 2, wobei wenigstens ein Generator (3) wenigstens einen Teil einer Mehrzahl Signalerzeugungselemente (14, 15) verkörpert, wobei der Generator ein Mehrphasenwechselstromgenerator ist, der zum Erzeugen von Wechselströmen mehrerer verschiedener Phasen ausgelegt ist.

4. Signalerzeugungseinheit (1) gemäß einem der vorstehenden Ansprüche, wobei die Einheit Haltemittel (25, 28) zum Erzeugen eines orientierungsselektiven Haltemoments und/oder einer orientierungsselektiven Haltekraft umfasst, um mindestens ein sich bewegendes Element selbsthaltend zu machen, wobei das Haltemittel (25, 28) wenigstens ein erstes

- Halteelement (25) und wenigstens ein komplementäres zweites Halteelement (28), das ausgelegt ist, mit dem wenigstens einen ersten Halteelement zusammenzuwirken, umfasst, wobei wenigstens eine sich bewegende Komponente mit dem wenigstens einen ersten Halteelement versehen ist, und wenigstens eine weitere Komponente mit dem wenigstens einen zweiten Halteelement versehen ist, wobei wenigstens ein Halteelement wenigstens einen Magneten umfasst und wenigstens ein komplementäres Halteelement wenigstens einen Magneten und/oder wenigstens ein magnetisierbares Element, das ausgelegt ist, mit dem wenigstens einen Magneten magnetisch zusammenzuwirken, umfasst, wobei wenigstens ein Rotor (3b) wenigstens eines Generators (3) wenigstens ein erstes Halteelement ausbildet, und ein Stator (3a) des Generators (3) wenigstens ein zweites Halteelement ausbildet.
5. Signalerzeugungseinheit (1) gemäß einem der vorstehenden Ansprüche, wobei wenigstens ein Signalerzeugungselement (14, 15) wenigstens einen elektromechanischen Schalter umfasst, und wobei Schalterkomponenten vorzugsweise an vorbestimmten Stellen in der Einheit positioniert sind.
6. Signalerzeugungseinheit (1) gemäß Anspruch 5, wobei wenigstens ein elektromagnetischer Schalter wenigstens einen Magneten und wenigstens einen vom Magneten zu aktivierenden Schalter, insbesondere ein Reed-Relais oder ein Piezoelement, umfasst.
7. Signalerzeugungseinheit (1) gemäß Anspruch 5, wobei wenigstens ein elektromagnetischer Schalter wenigstens einen Magneten und wenigstens einen Sensor, insbesondere einen Hallsensor, der ausgelegt ist, vom Magneten aktiviert zu werden, umfasst.
8. Signalerzeugungseinheit (1) gemäß einem der vorstehenden Ansprüche, wobei wenigstens ein Signalerzeugungselement (14, 15) von wenigstens einem Generator ausgebildet wird, wobei der Generator ein Wechselstromgenerator ist, der ausgelegt ist, einen Wechselstrom zu erzeugen.
9. Signalerzeugungseinheit (1) gemäß einem der vorstehenden Ansprüche, wobei wenigstens ein Generator (3) mehrere Signalerzeugungselemente verkörpert, wobei der Generator (3) vorzugsweise ein Mehrphasenwechselstromgenerator ist, der zum Erzeugen von Wechselströmen mehrerer verschiedener Phasen ausgelegt ist.
10. Signalerzeugungseinheit (1) gemäß einem der vorstehenden Ansprüche, wobei wenigstens ein Signalerzeugungselement (14, 15) ausgelegt ist, wenigstens ein Eingangssignal zu erzeugen, das für die Bewegungsgeschwindigkeit und/oder Beschleunigung des Antriebselements repräsentativ ist.
11. Signalerzeugungseinheit (1) gemäß einem der vorstehenden Ansprüche, wobei der Signalprozessor (10) ausgelegt ist, die von den Signalerzeugungselementen (14, 15) erzeugten Eingangssignale zu empfangen und mehrere Eingangssignale in wenigstens ein für die Verschiebung des Antriebselements (8) in Bezug auf die Tragkonstruktion (2) repräsentatives Ausgangssignal umzuwandeln.
12. Signalerzeugungseinheit (1) gemäß einem der vorstehenden Ansprüche, wobei die Signalerzeugungseinheit als Steuerung, vorzugsweise Fernsteuerung, ausgelegt ist, wobei der Signalprozessor (10) ausgelegt ist, wenigstens ein Eingangssignal in wenigstens ein wenigstens einen Befehl zum Steuern eines Geräts (181, 182), vorzugsweise eines externen Geräts, repräsentierendes Ausgangssignal umzuwandeln.
13. Verfahren zum Betreiben einer Kleinleistungs-Signalerzeugungseinheit (1), insbesondere eines Sensors und einer Steuereinheit, gemäß einem der Ansprüche 1-12, umfassend die Schritte:
- A) Verschieben wenigstens eines Antriebselements (8) in Bezug auf die Tragkonstruktion (2) mittels einer externen Leistungsquelle, wie etwa Muskelkraft und/oder mechanischer Leistung,
- B) Erzeugen elektrischer Energie im mit dem Antriebselement (8) zusammenwirkenden Generator (3) während des Verschiebens des Antriebselements,
- C) Speisen einer Signalverarbeitungsschaltung durch die vom Generator (3) gemäß Schritt B) erzeugte elektrische Energie, wodurch ermöglicht wird:
- C1) die Erzeugung wenigstens eines Eingangssignals durch wenigstens ein Signalerzeugungselement (14, 15), wobei das Eingangssignal mit der Bewegungsgeschwindigkeit und/oder Beschleunigung und/oder Bewegungsrichtung und/oder Position und/oder inkrementellen Position desselben Antriebselements (8) in Bezug auf die Tragkonstruktion (2) zusammenhängt, und
- C2) vorzugsweise, die Umwandlung wenigstens eines erzeugten Eingangssignals in wenigstens ein Ausgangssignal durch einen Signalprozessor (10), wobei das Ausgangssignal für die Verschiebung des Antriebselements (8) in Bezug auf die Tragkonstruktion (2) repräsentativ ist.

Revendications

1. Unité de production de signaux basse puissance autonome (1), en particulier unité de capteur et de commande, comprenant:

- une structure porteuse;
- au moins un générateur électrique (3) porté par ladite structure porteuse (2), ledit générateur comprenant un stator (3a) et un rotor (3b);
- au moins un élément d'entraînement (8) configuré pour entraîner ledit générateur (3), l'orientation relative de l'élément d'entraînement (8) par rapport à la structure porteuse (2) pouvant être modifiée par une source d'énergie externe, comme la force musculaire humaine, afin d'entraîner ledit générateur (3), et
- au moins un circuit de traitement de signaux alimenté par ledit générateur, ledit circuit comprenant:

- au moins un élément de production de signaux (14, 15), cet au moins un élément de production de signaux (14, 15) étant configuré pour produire au moins un signal d'entrée distinctif lié au déplacement du même élément d'entraînement (8) par rapport à la structure porteuse (2), et
- de préférence au moins un processeur de signaux (10), connecté à au moins l'un desdits éléments de production de signaux (14, 15), configuré pour recevoir les signaux d'entrée produits par ledit au moins un élément de production de signaux (14, 15) et pour transformer au moins un signal d'entrée en au moins un signal de sortie représentant le déplacement de l'élément d'entraînement (8) par rapport à la structure porteuse (2),

caractérisée en ce qu'au moins un composant rotatif de l'unité de production de signaux (1) constitue au moins une partie d'au moins un élément de production de signaux (14, 15), de sorte que cet élément de production de signaux est configuré pour produire un signal, les caractéristiques dudit signal étant dépendantes de la vitesse de mouvement, de l'accélération, de la direction de mouvement, de la position et/ou de la position incrémentielle de l'élément d'entraînement (8) par rapport à la structure porteuse (2), dans laquelle ledit composant rotatif est choisi dans le groupe composé : d'un élément d'entraînement rotatif (21), d'un rotor (3b, 26a) d'un générateur (3, 26) et d'un élément de transmission (4, 41a, 41b) positionné entre l'élément d'entraînement (8, 42) et un rotor (3b, 26a) d'un générateur (3, 26).

2. Unité de production de signaux (1) selon la revendication 1, dans laquelle l'unité de production de signaux comprend une pluralité d'éléments de production de signaux (14, 15), dans laquelle au moins une partie d'au moins un premier élément de production de signaux (14) est formée par un premier composant rotatif, et dans laquelle au moins une partie d'au moins un deuxième élément de production de signaux (15) est formée par un deuxième composant rotatif, dans laquelle chaque dit composant du premier composant rotatif et du deuxième composant rotatif est choisi dans le groupe composé : d'un élément d'entraînement rotatif (21), d'un rotor (3b, 26a) d'un générateur (3, 26) et d'un élément de transmission (4, 41a, 41b) positionné entre l'élément d'entraînement (8, 42) et un rotor (3b, 26a) d'un générateur (3, 26).

3. Unité de production de signaux (1) selon la revendication 1 ou 2, dans laquelle au moins un générateur (3) comprend au moins une partie d'une pluralité d'éléments de production de signaux (14, 15), dans laquelle ledit générateur est un alternateur à phases multiples configuré pour générer des courants alternatifs de plusieurs phases différentes.

4. Unité de production de signaux (1) selon l'une quelconque des revendications précédentes, dans laquelle l'unité comprend des moyens de retenue (25, 28) pour générer un couple de maintien et/ou une force de maintien sélectif/sélective en orientation en rendant au moins un élément mobile à maintien automatique, dans laquelle les moyens de retenue (25, 28) comprennent au moins un premier élément de retenue (25) et au moins un deuxième élément de retenue (28) complémentaire, configuré pour coopérer avec ledit au moins un premier élément de retenue, dans laquelle au moins un composant mobile est muni dudit au moins un premier élément de retenue, et au moins un autre composant est muni dudit au moins un deuxième élément de retenue, dans laquelle au moins un élément de retenue comprend au moins un aimant et au moins un élément de retenue complémentaire comprend au moins un aimant et/ou au moins un élément magnétisable configuré pour coopérer de manière magnétique avec ledit au moins un aimant,

dans laquelle au moins un rotor (3b) d'au moins un générateur (3) constitue au moins un premier élément de retenue et un stator (3a) dudit générateur (3) constitue au moins un deuxième élément de retenue.

5. Unité de production de signaux (1) selon l'une quelconque des revendications précédentes, dans laquelle au moins un élément de production de signaux (14, 15) comprend au moins un commutateur électromécanique, et dans laquelle des composants

de commutateur sont de préférence positionnés à des emplacements prédéfinis dans l'unité.

6. Unité de production de signaux (1) selon la revendication 5, dans laquelle au moins un commutateur électromagnétique comprend au moins un aimant et au moins un commutateur, en particulier un relais à lames souples ou un élément piézoélectrique, à activer par ledit aimant. 5
7. Unité de production de signaux (1) selon la revendication 5, dans laquelle au moins un commutateur électromagnétique comprend au moins un aimant et au moins un capteur, en particulier un capteur à effet Hall, configuré pour être activé par ledit aimant. 10
8. Unité de production de signaux (1) selon l'une quelconque des revendications précédentes, dans laquelle au moins un élément de production de signaux (14, 15) est formé par au moins un générateur, ledit générateur étant un alternateur configuré pour générer un courant alternatif. 15
9. Unité de production de signaux (1) selon l'une quelconque des revendications précédentes, dans laquelle au moins un générateur (3) comprend plusieurs éléments de production de signaux, ledit générateur (3) étant de préférence un alternateur à phases multiples configuré pour générer des courants alternatifs de plusieurs phases différentes. 20
10. Unité de production de signaux (1) selon l'une quelconque des revendications précédentes, dans laquelle au moins un élément de production de signaux (14, 15) est configuré pour produire au moins un signal d'entrée qui représente la vitesse de mouvement et/ou l'accélération de l'élément d'entraînement. 25
11. Unité de production de signaux (1) selon l'une quelconque des revendications précédentes, le processeur de signaux (10) étant configuré pour recevoir les signaux d'entrée produits par les éléments de production de signaux (14, 15) et pour transformer plusieurs signaux d'entrée en au moins un signal de sortie représentant le déplacement de l'élément d'entraînement (8) par rapport à la structure porteuse (2). 30
12. Unité de production de signaux (1) selon l'une quelconque des revendications précédentes, dans laquelle l'unité de production de signaux est configurée comme une commande, de préférence une télécommande, dans laquelle le processeur de signaux (10) est configuré pour transformer au moins un signal d'entrée en au moins un signal de sortie représentant au moins une commande pour commander un dispositif (181, 182), de préférence un 35

dispositif externe.

13. Procédé d'exploitation d'une unité de production de signaux basse puissance (1), en particulier une unité de capteur et de commande, selon l'une quelconque des revendications 1 à 12, comprenant les étapes consistant à: 40

A) déplacer au moins un élément d'entraînement (8) par rapport à la structure porteuse (2) au moyen d'une source d'énergie externe, telle de que la force musculaire humaine et/ou de la force mécanique,

B) générer de l'énergie électrique dans le générateur (3) coopérant avec l'élément d'entraînement (8) pendant le déplacement de l'élément d'entraînement,

C) alimenter un circuit de traitement de signaux par l'énergie électrique générée par le générateur (3) selon l'étape B), ce qui permet:

C1) la production d'au moins un signal d'entrée par au moins un élément de production de signaux (14, 15), ledit signal d'entrée étant lié à la vitesse de mouvement et/ou à l'accélération et/ou à la direction de mouvement et/ou à la position et/ou à la position incrémentielle du même élément d'entraînement (8) par rapport à la structure porteuse (2), et

C2) de préférence, la transformation d'au moins un signal d'entrée produit en au moins un signal de sortie par un processeur de signaux (10), le signal de sortie représentant le déplacement de l'élément d'entraînement (8) par rapport à la structure porteuse (2). 45

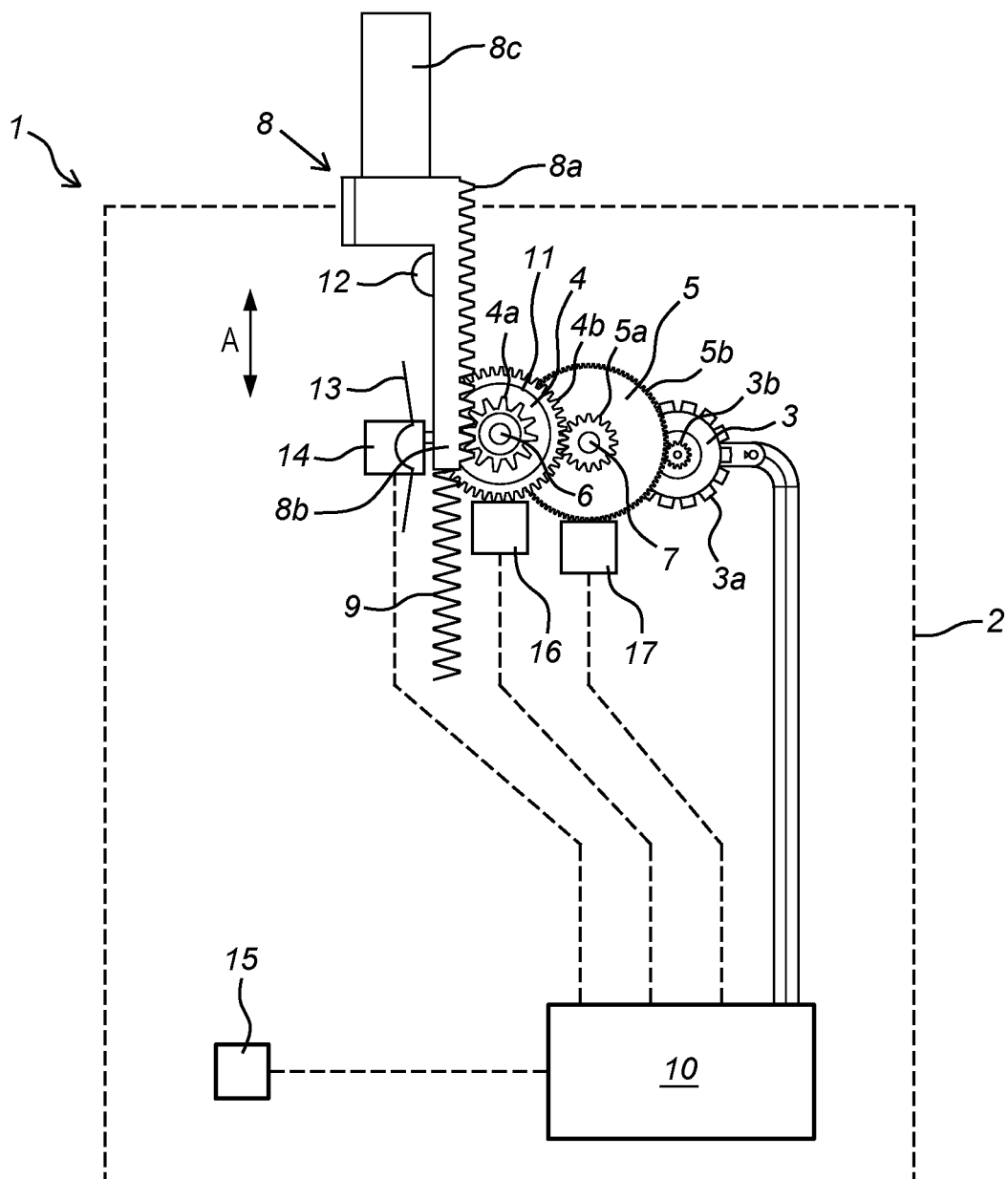


Fig. 1

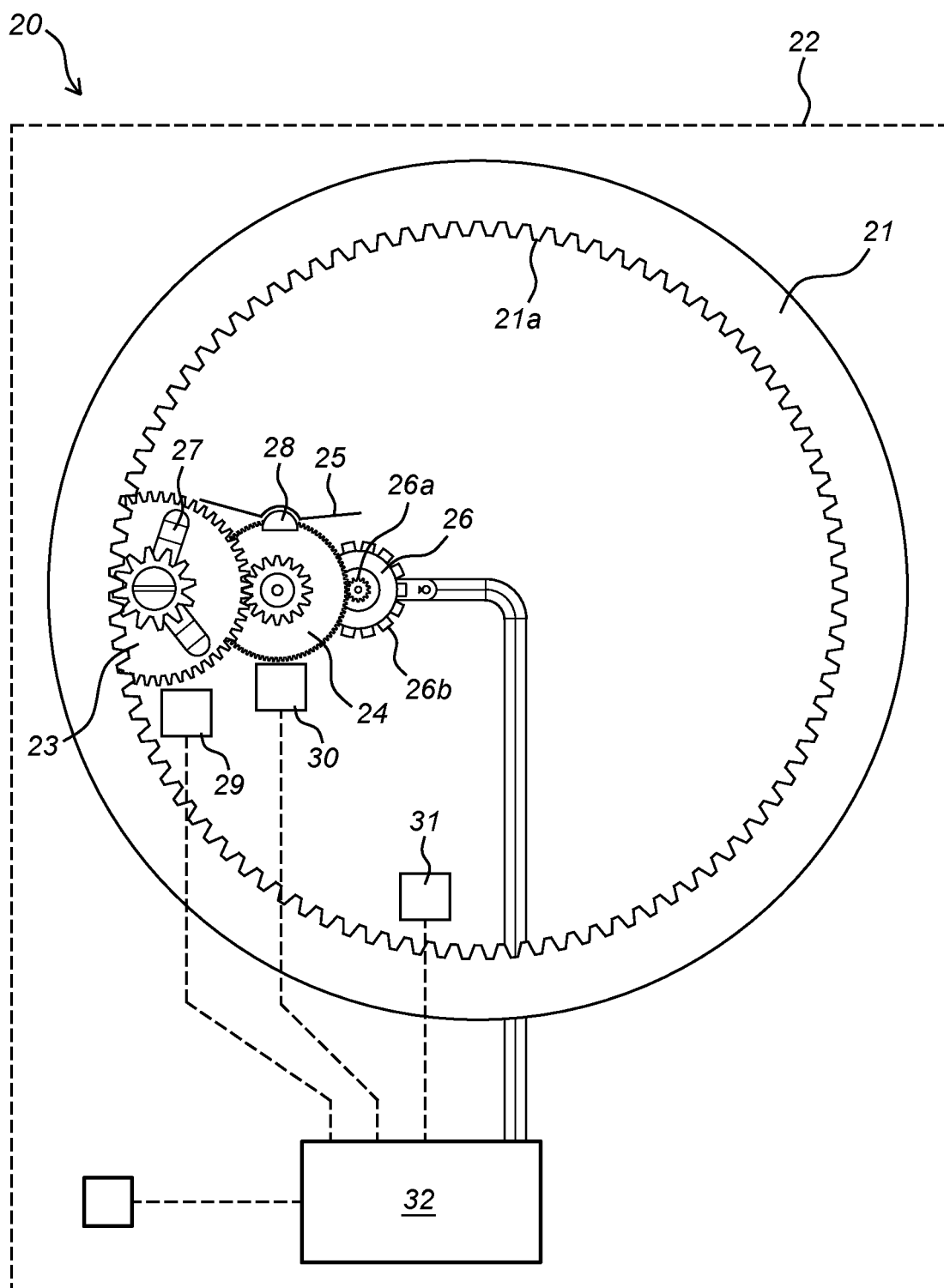


Fig. 2

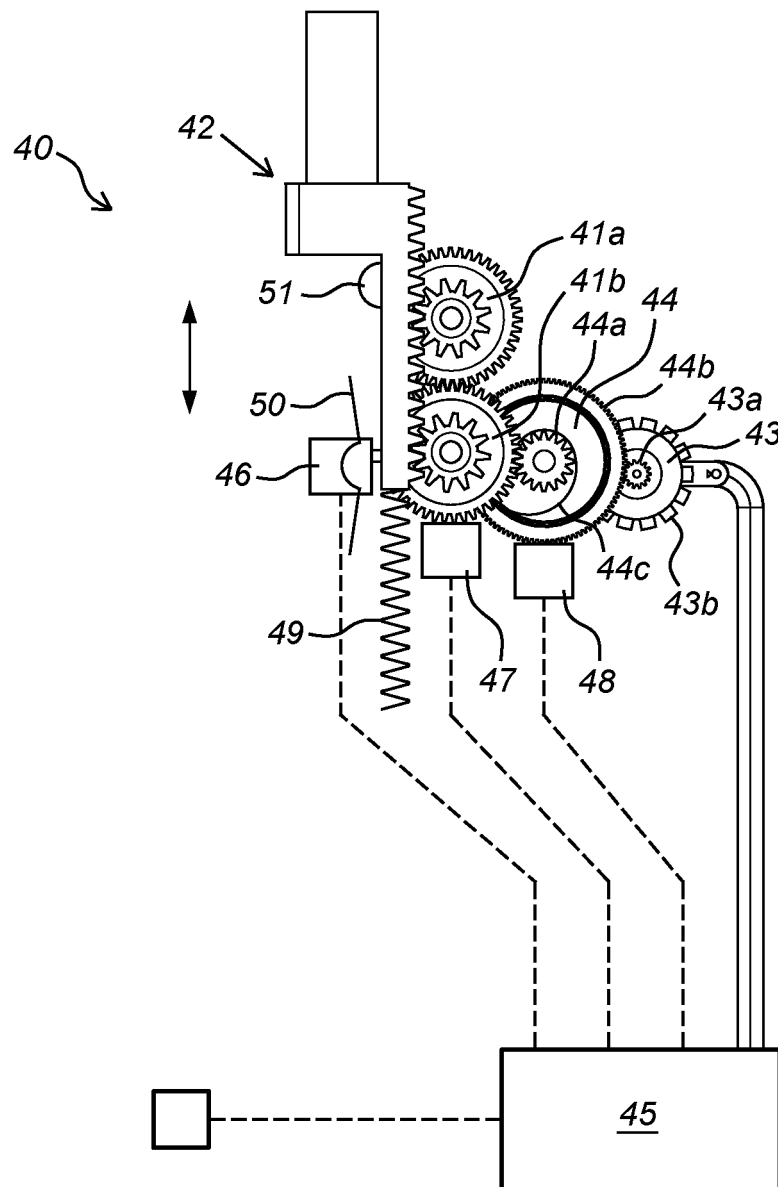


Fig. 3

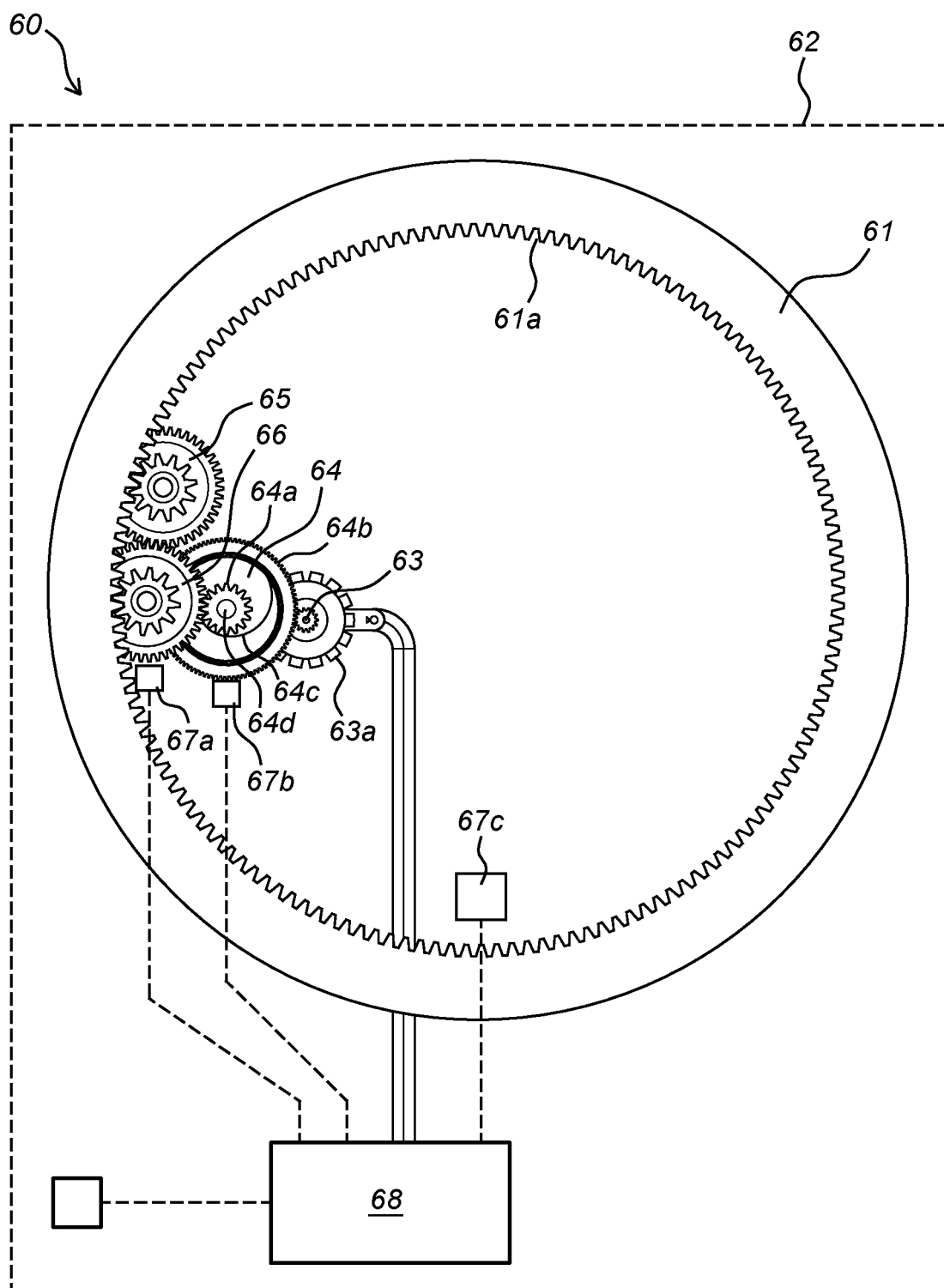


Fig. 4

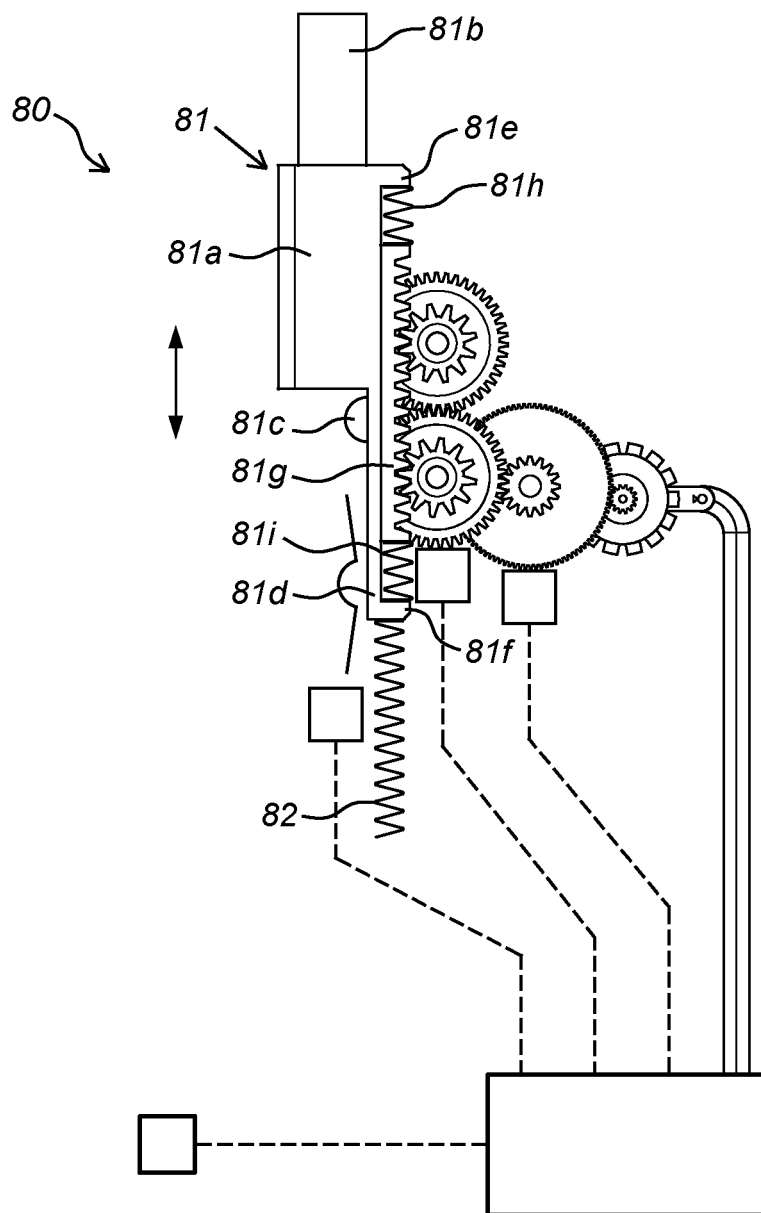


Fig. 5

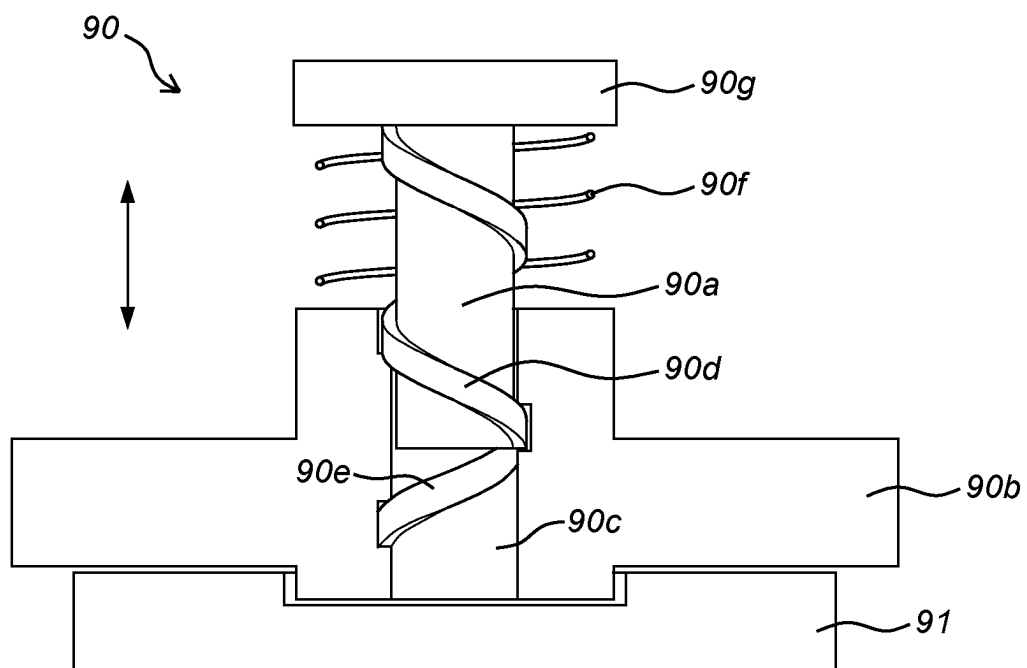


Fig. 6

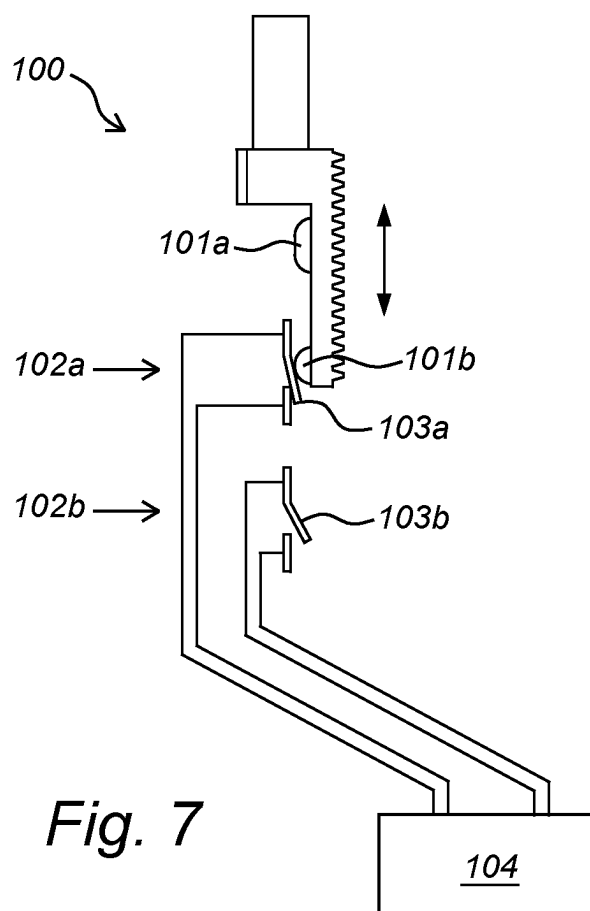


Fig. 7

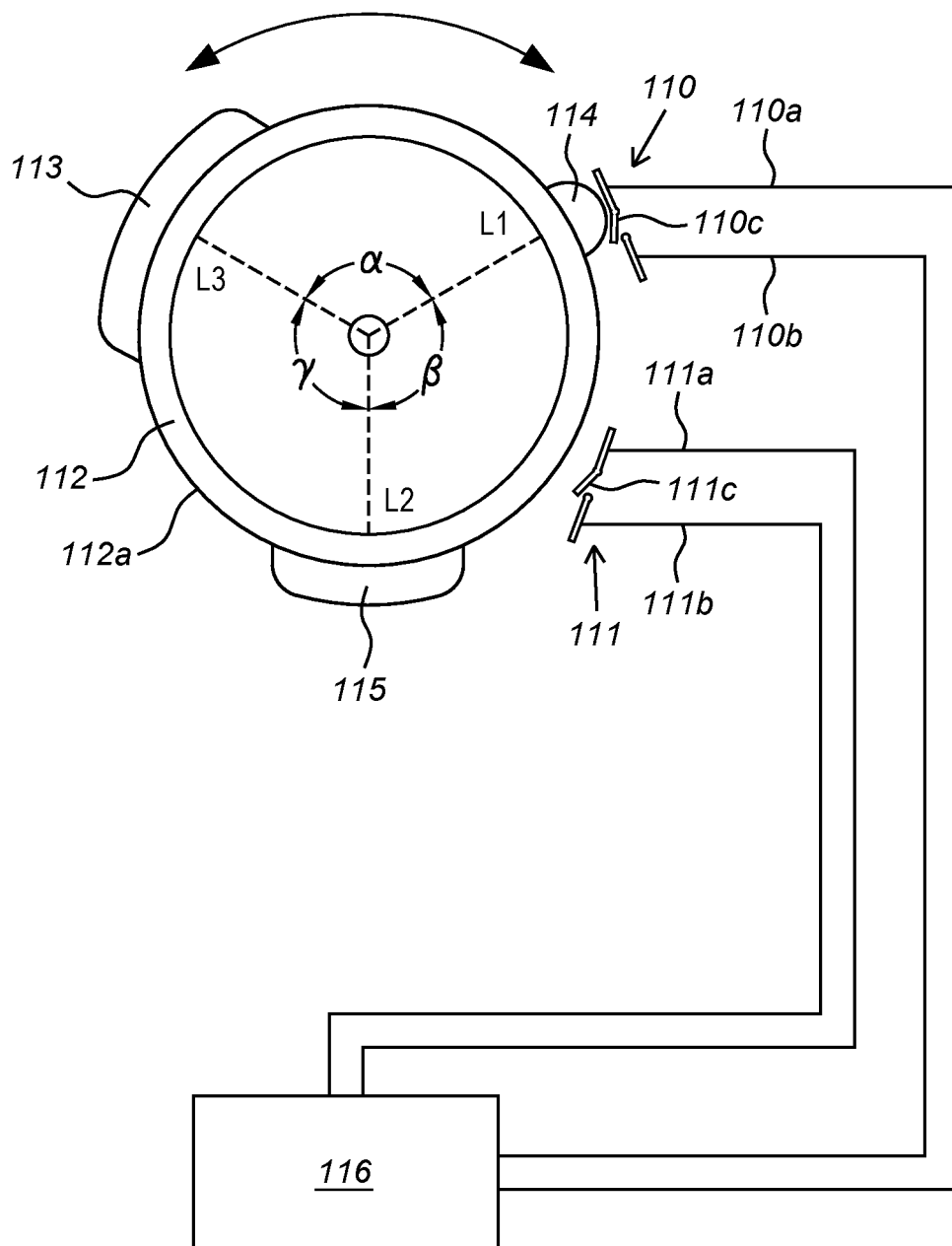


Fig. 8

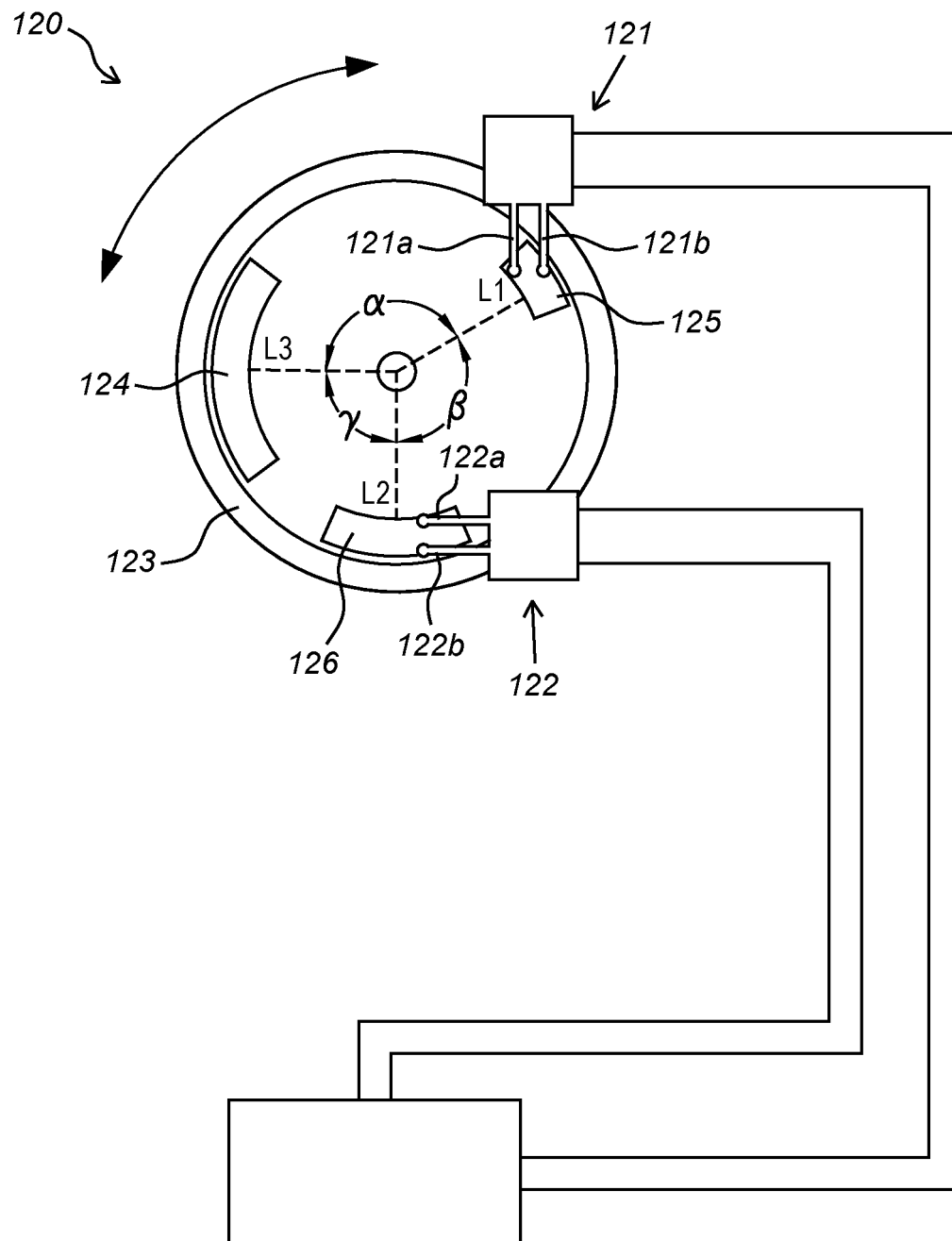


Fig. 9

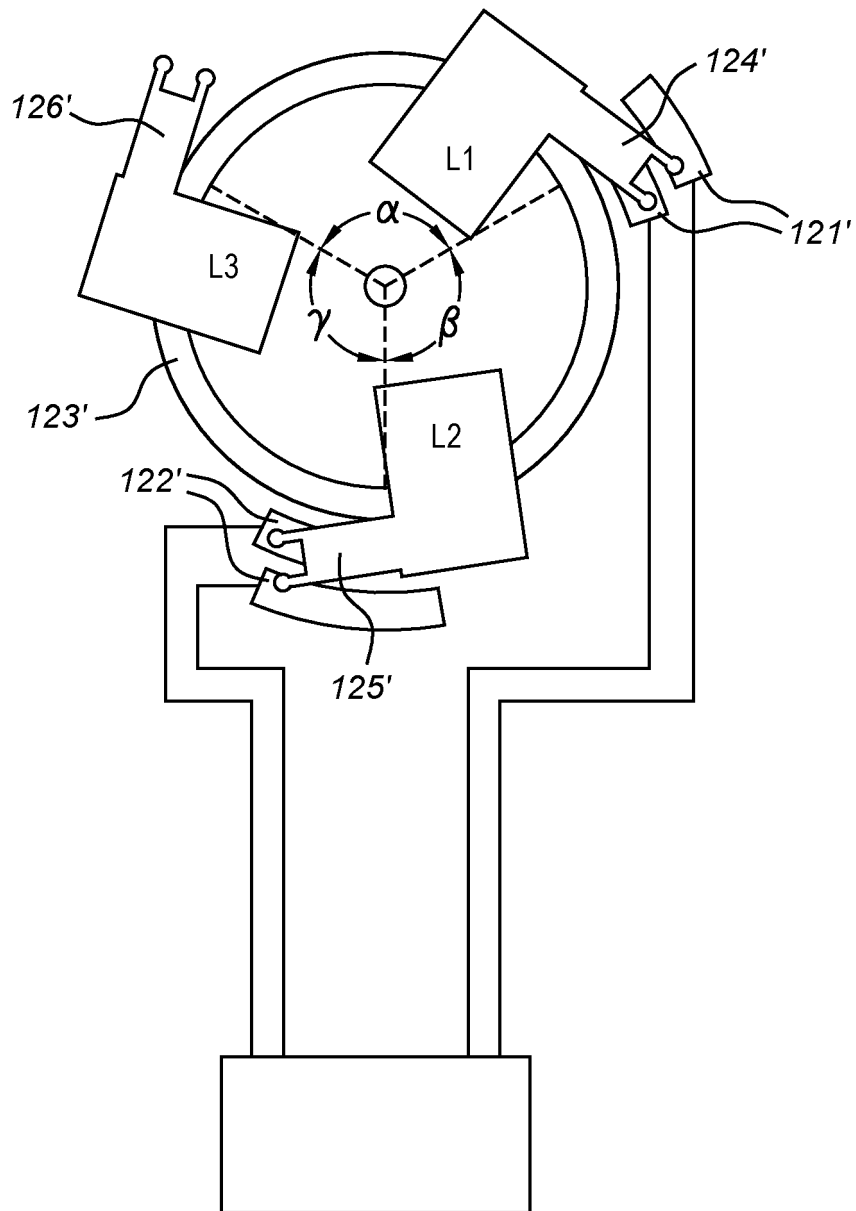


Fig. 10

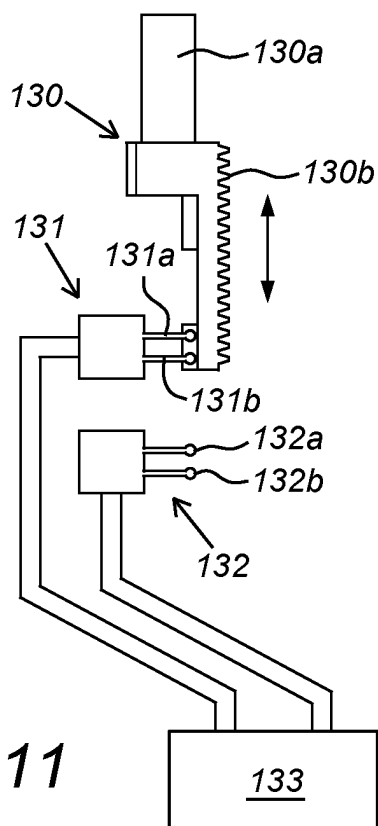


Fig. 11

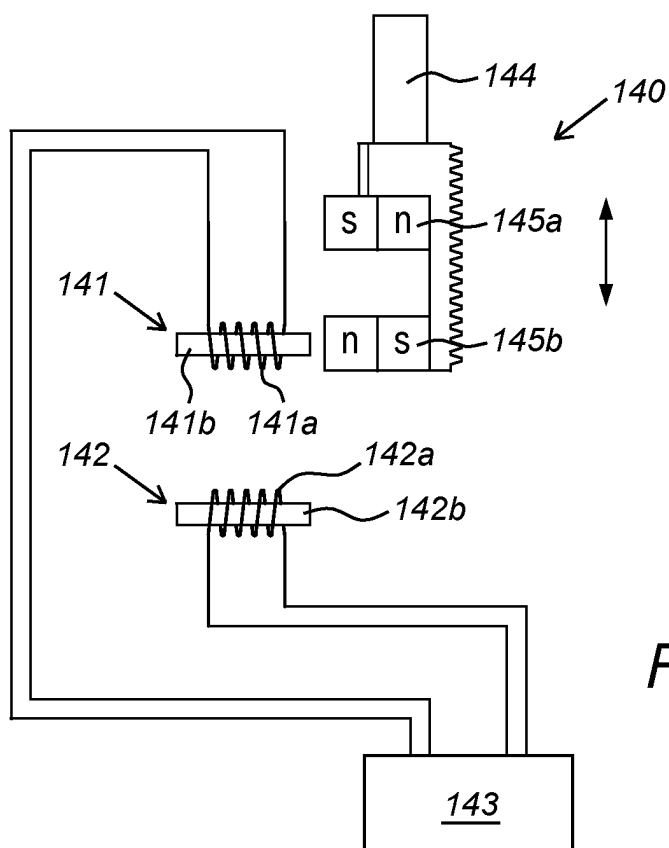


Fig. 12

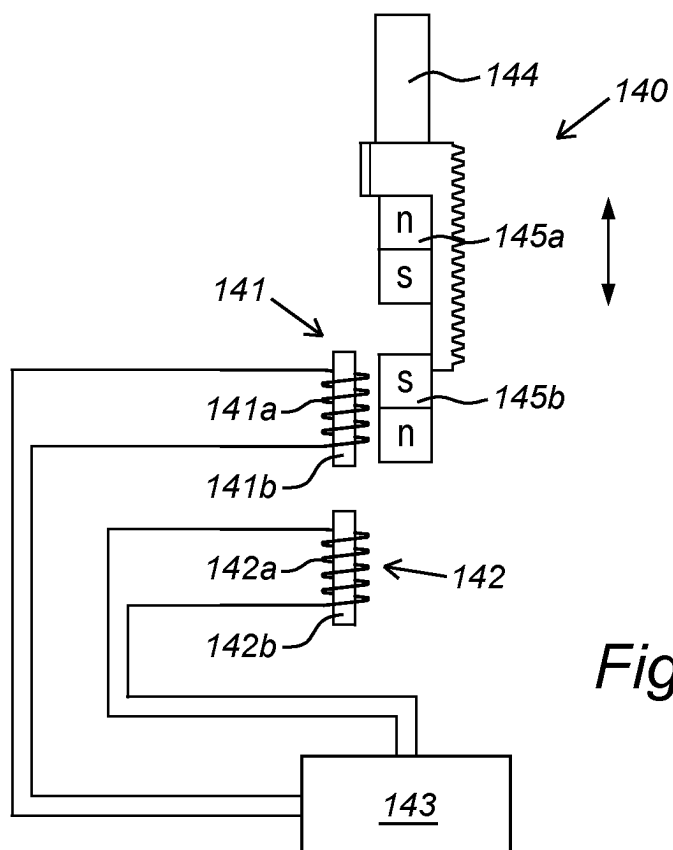


Fig. 13

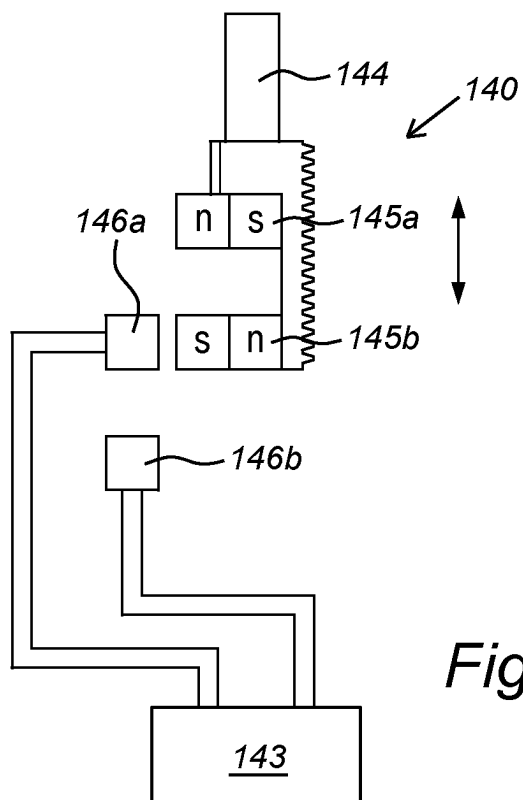


Fig. 14

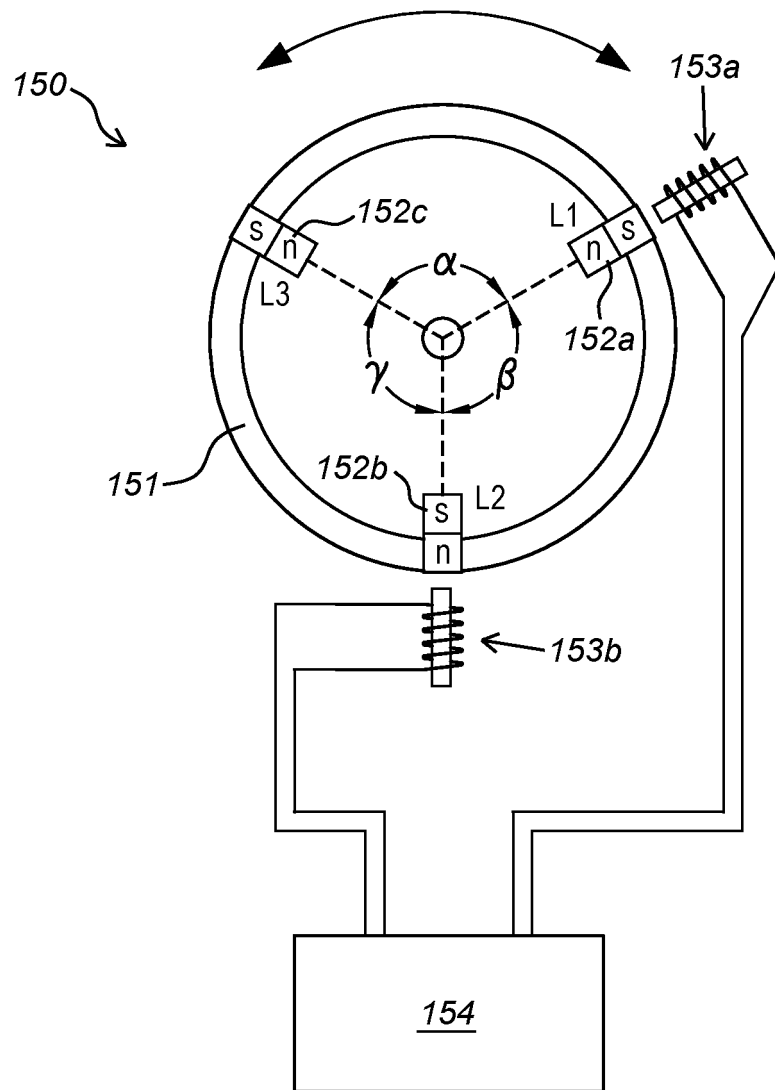
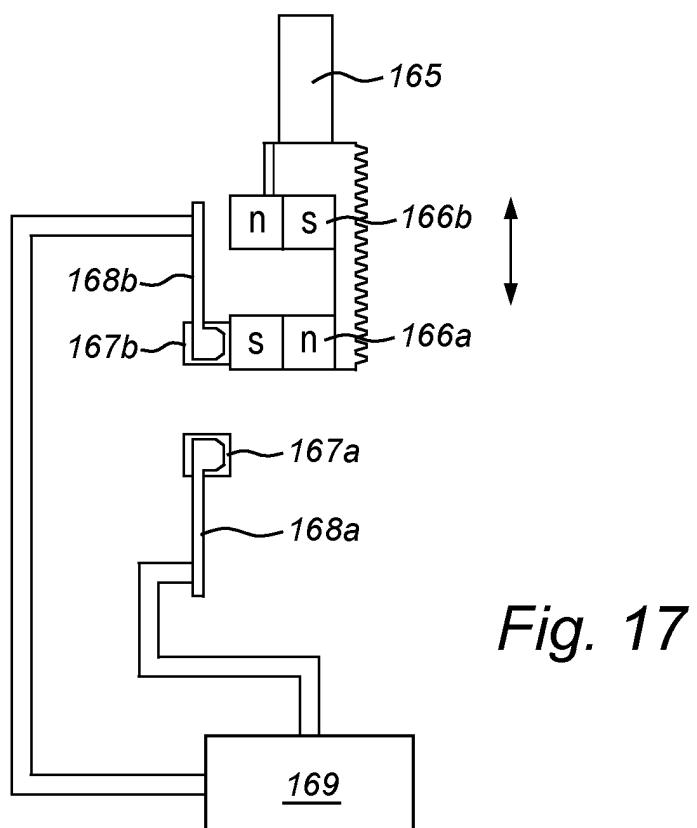
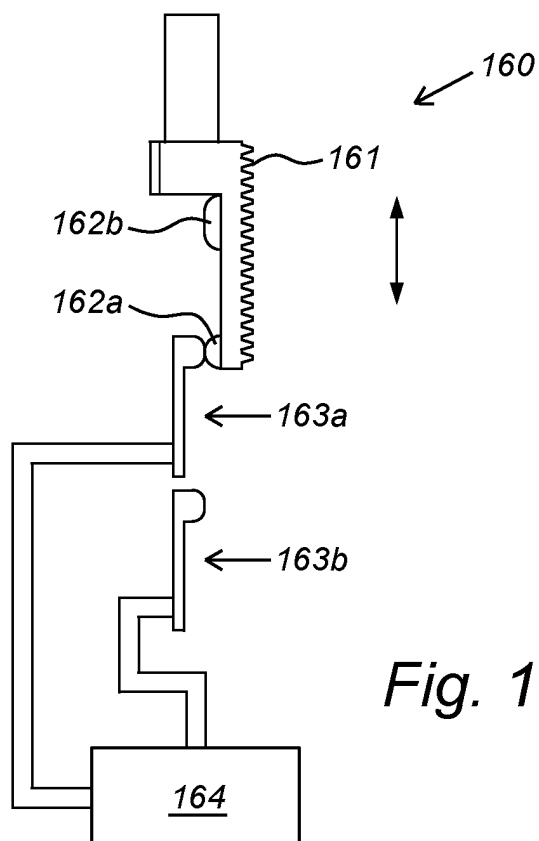
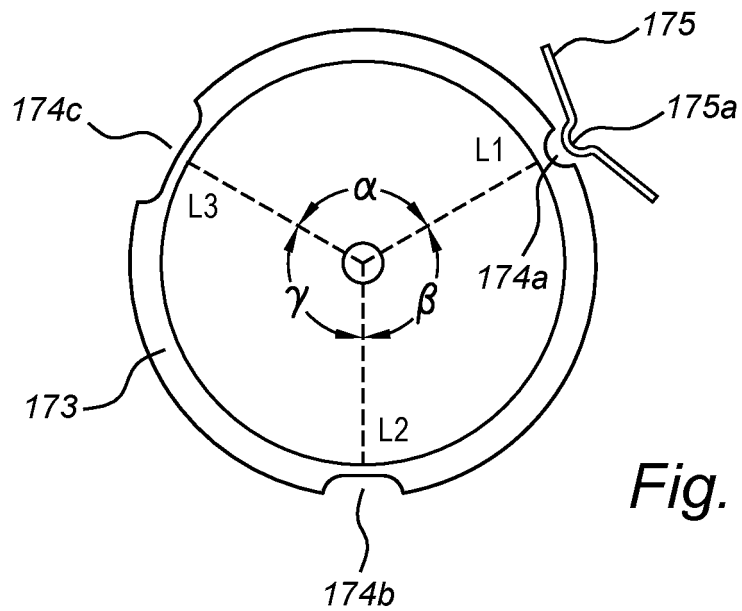
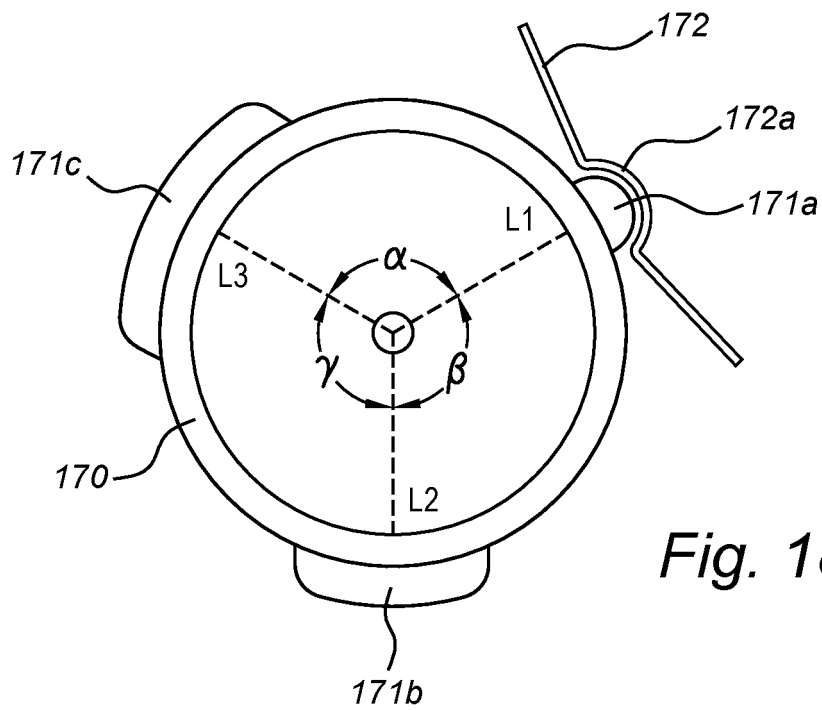


Fig. 15





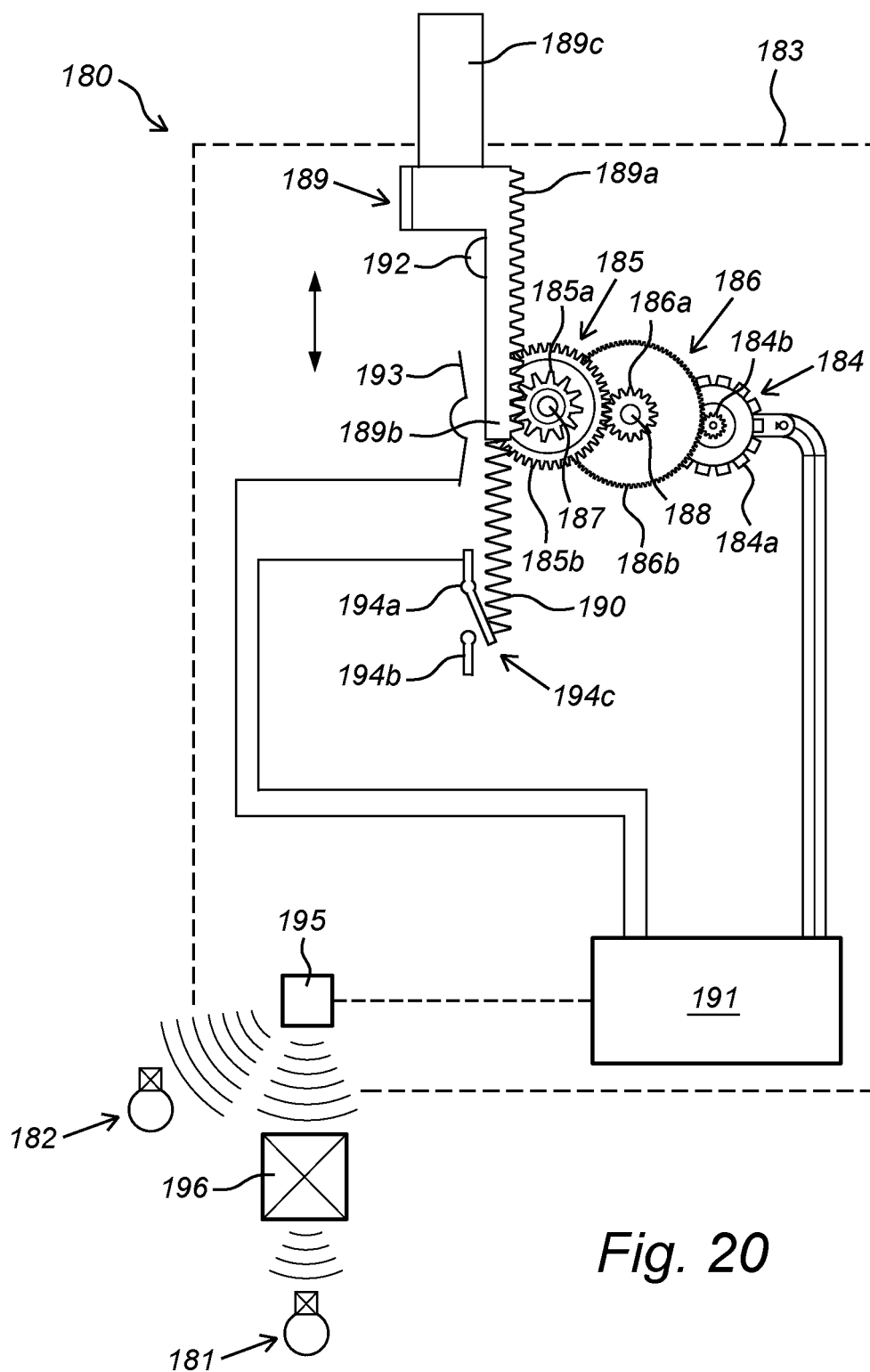


Fig. 20

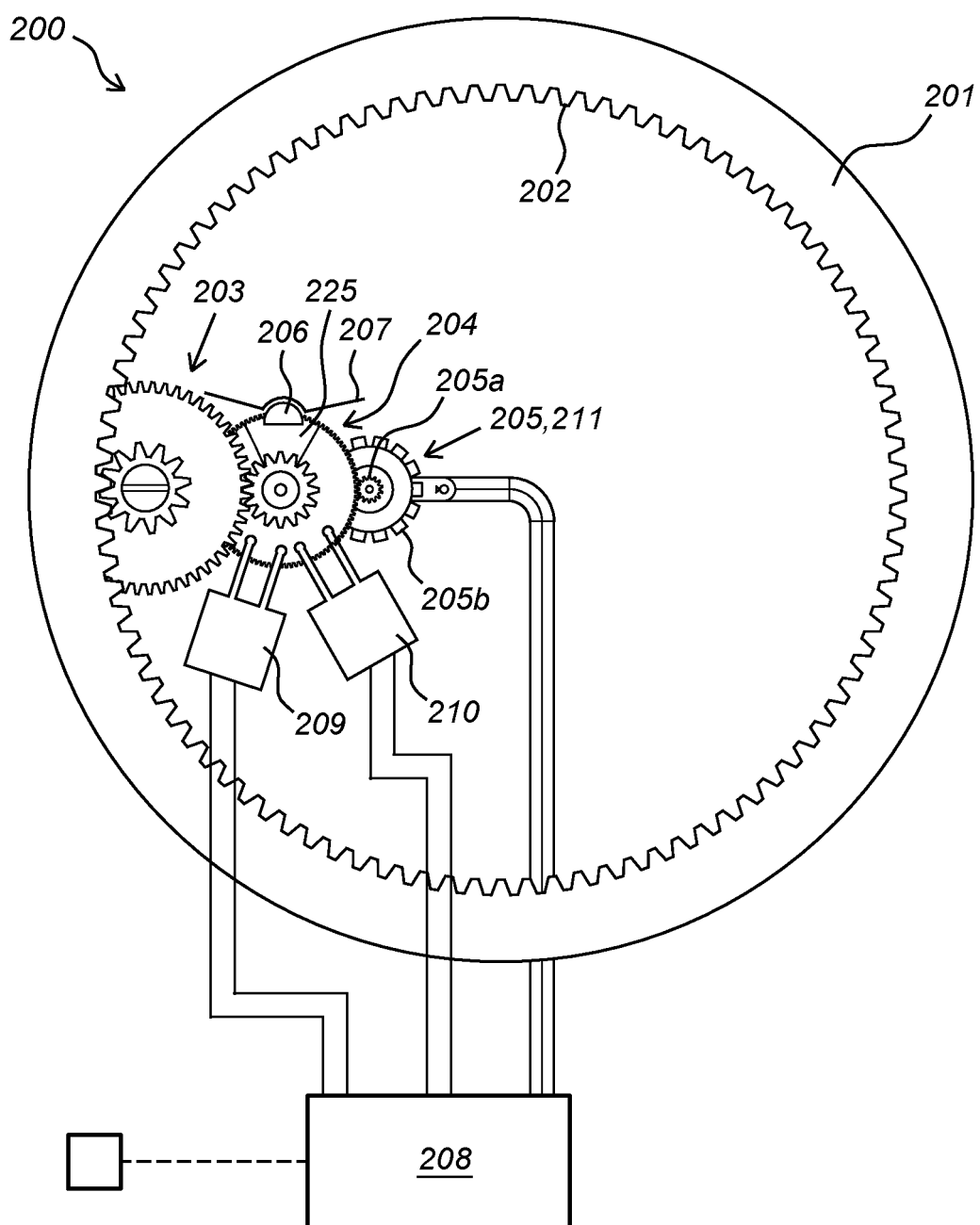


Fig. 21

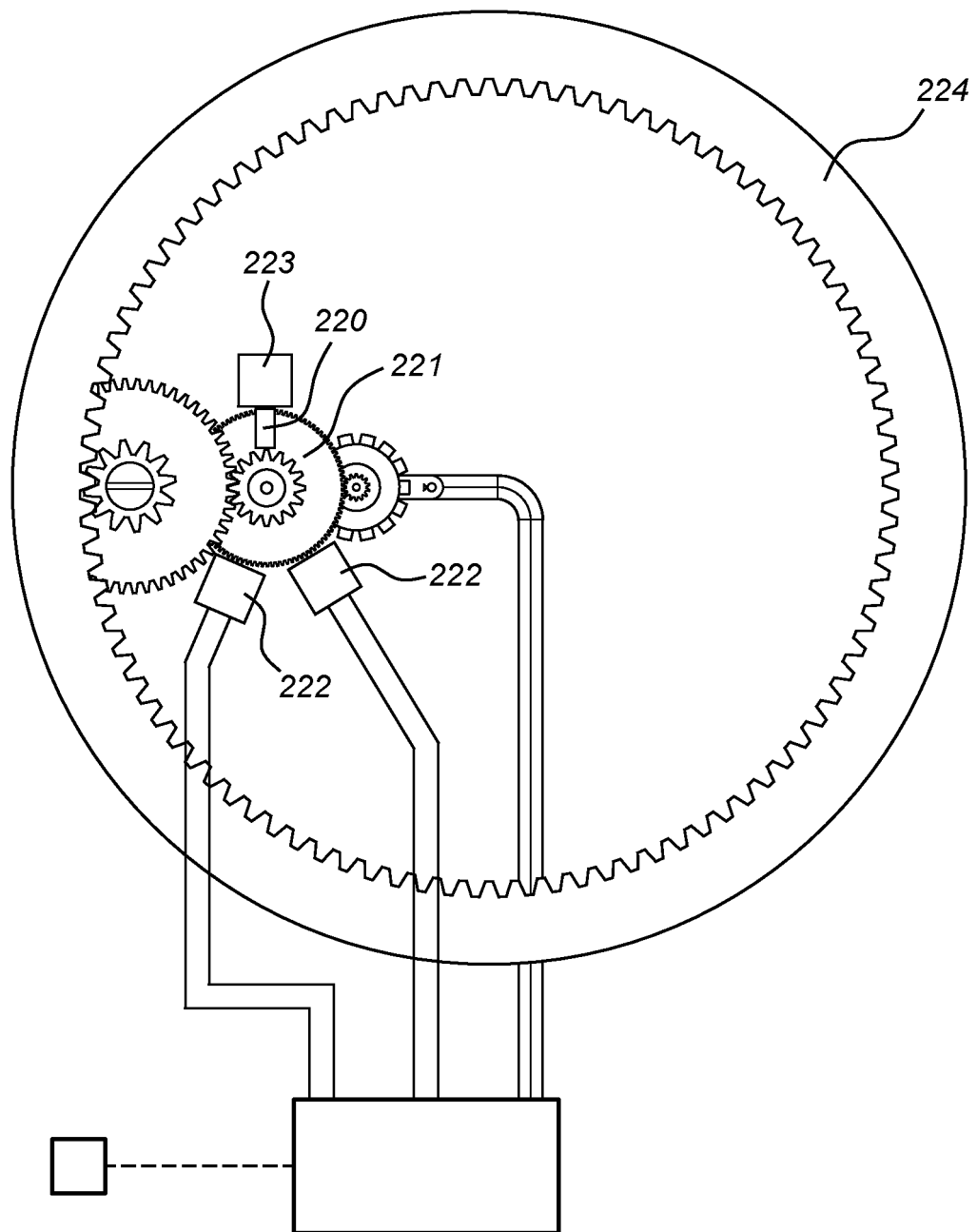


Fig. 22

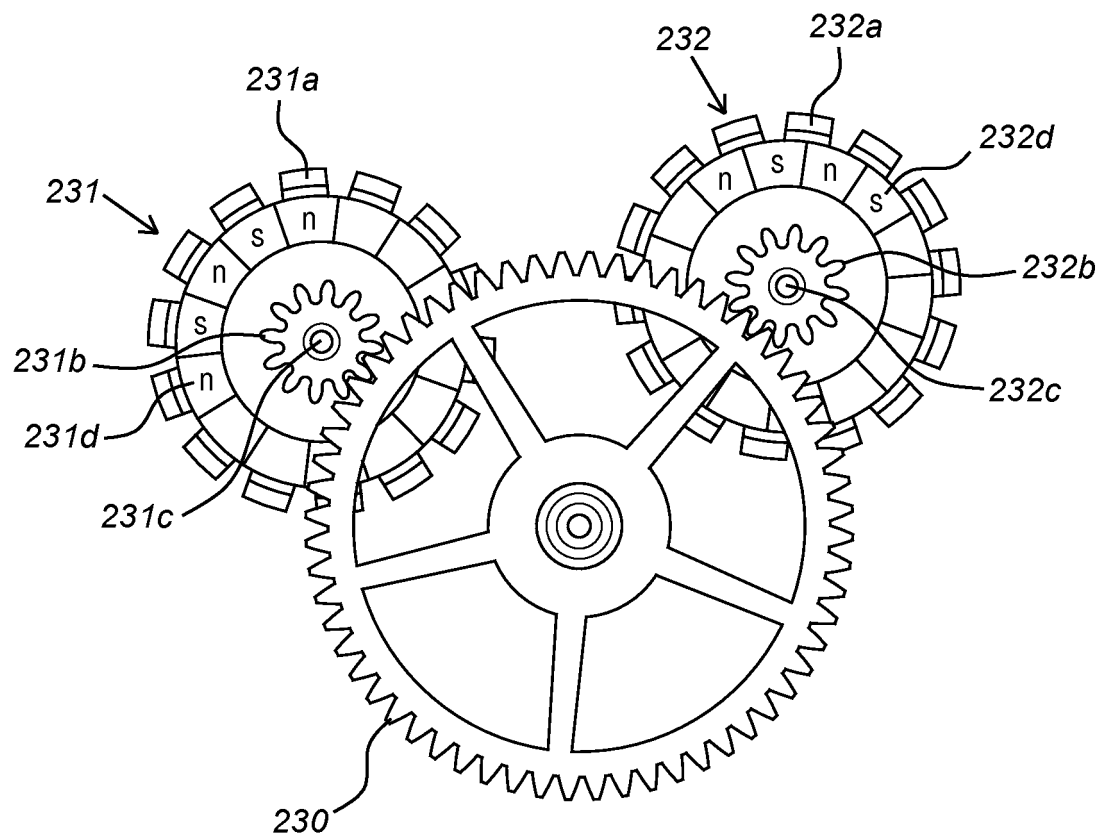


Fig. 23

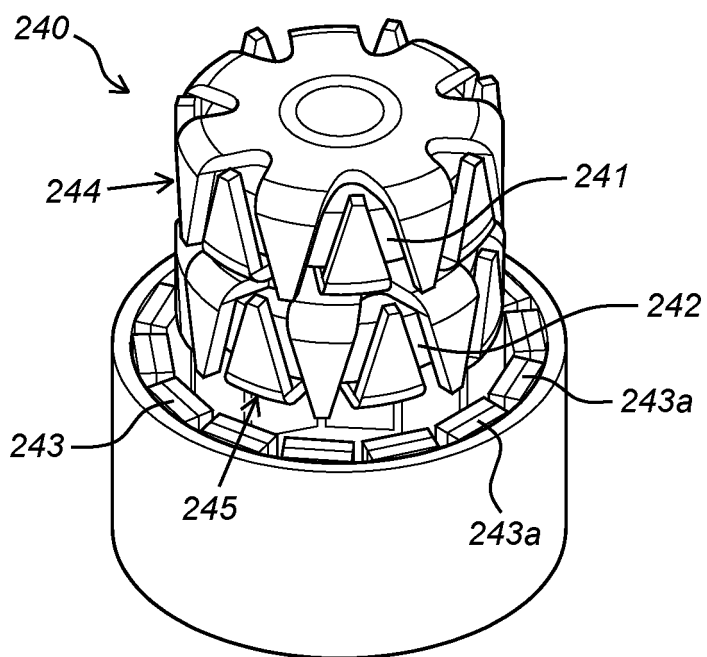


Fig. 24a

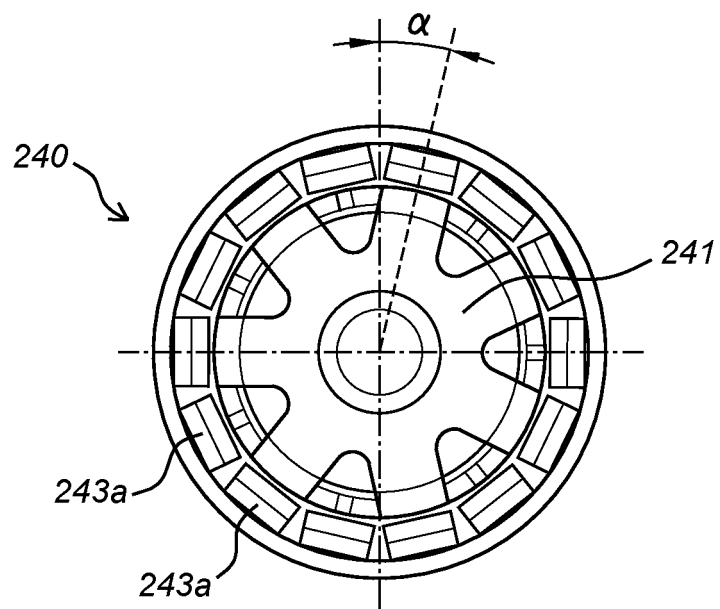


Fig. 24b

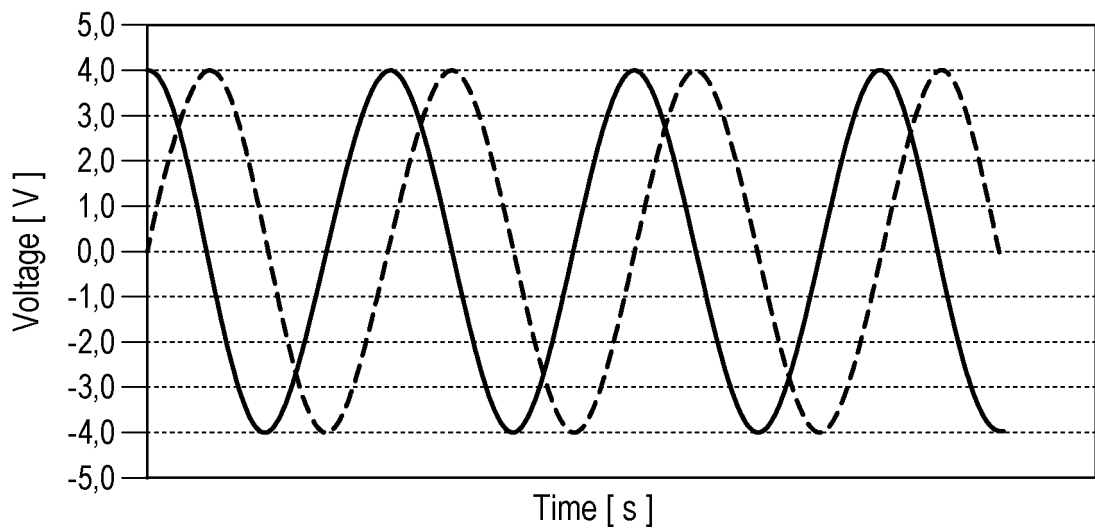
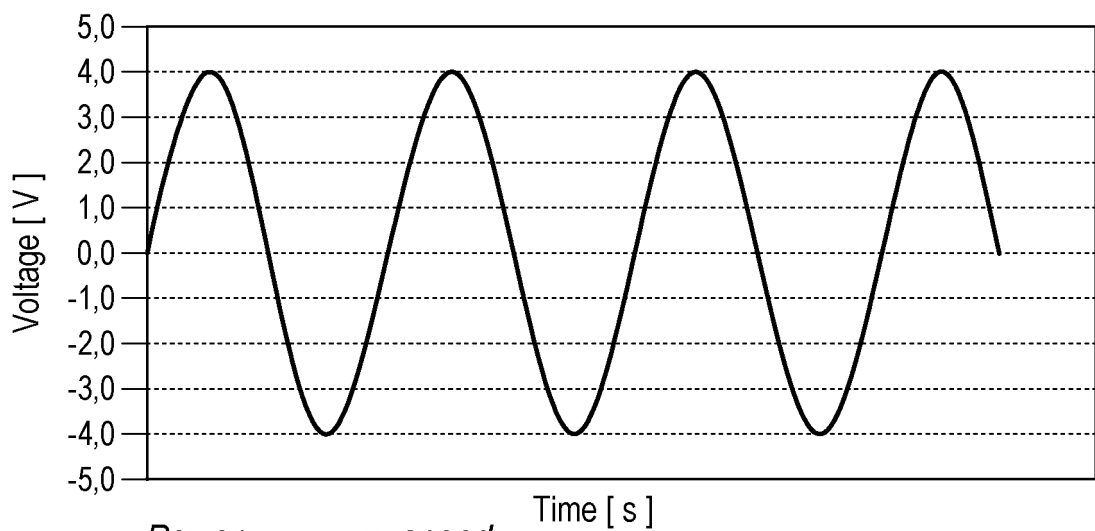


Fig. 25a



Power = *speed*
Frequency = *speed*
Voltage = *speed*
 Σ *Frequency* = *position*
Energy = *position*
Phase shift = *rotational direction*

Fig. 25b

REFERENCES CITED IN THE DESCRIPTION

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