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(54) METHOD OF ENSURING CORRECT ELECTRONIC MODULE ATTACHMENT

(57) The present invention pertains to a device for monitoring a position of an electronic module and a corresponding electronic module, in particular for monitoring a proper functioning of medical gas cylinders and associated components. Accordingly, a device (10) for monitoring a position of an electronic module (22) for a gas cylinder (12) is suggested, comprising a body (24) configured to be coupled to the gas cylinder (12), a detection unit (16) for detecting a positional relationship between the gas cylinder (12) and the body (24), when the device (10) is coupled to the gas cylinder (12), and an evaluation unit (20) in communication with the detection unit (16) and configured to determine a position of the device (10) based on the detected positional relationship. The evaluation unit (20) is furthermore configured to output a signal based on a comparison of the determined position with a predefined position.

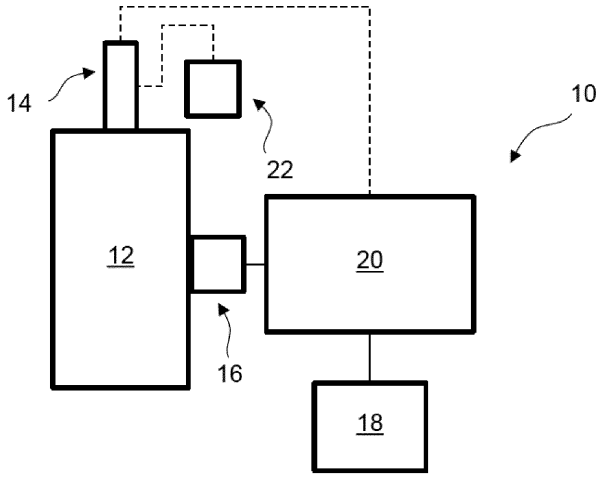

Fig. 1

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Description

Technical Field

[0001] The invention relates to a device for monitoring a position of an electronic module and a corresponding electronic module, in particular for monitoring a proper functioning of medical gas cylinders and associated components.

Technological Background

[0002] With the increasing demand of providing improved control of devices and applications, electronic control and digital features have become indispensable in many technical fields. In particular, such digitalization provides the advantage of facilitating evaluations and automatization of ongoing processes and providing feedback to a user with increasing detail. Furthermore, digital technologies facilitate the interconnectivity between devices and may provide an overview even when a large number of products are present within a same area and sharing a same network forming, e.g. an Internet of Things (IoT).

[0003] In particular in the medical field, digital technology has advanced patient care and therapeutic efficiency and has facilitated monitoring of medical applications and patient physiologic parameters. For example, in medical gas applications wherein a medical gas is administered to a patient, e.g. as an inhalable medicament in the treatment of respiratory disorders or to remedy deficiencies in newborns, smart valves, e.g. digitalized valves, have been developed for gas cylinders so as to track e.g. a current flow rate, a remaining pressure, and/or a content of the respective gas cylinder while at the same time providing a control function for said valve. Such valves not only facilitate the monitoring of a therapy of the patient, but also facilitate the application of the therapy itself and the management of such medical devices, thereby providing a significant support for medical personnel and hospital staff.

[0004] However, replacement or upgrading all of the available assets that do not provide such digital control functions is very laborious and not cost-effective, such that digital technologies have been developed including electronic modules, which may be coupled to non-digital devices or appliances to provide digital functions for said devices.

[0005] Such coupling or fixation however poses the risk of an improper attachment, which may be caused by various degrees of handling e.g. during filling, transportation, unloading, and/or installment of a gas cylinder. In such cases, the electronic module may not be properly attached or arranged, such that detections provided by a sensor may be invalid or unreliable and hence incorrect sensor readings may be reported. Furthermore, the electronic module may also be dislodged, such that no readings are available.

[0006] Accordingly, a need exists to ensure that such electronic modules are capable of providing the required function independent of a potential mishandling of the device to which it is coupled.

Summary of the invention

[0007] It is an object of the present invention to provide a device for monitoring a position of an electronic module for a gas cylinder which improves the above undesirable problems.

[0008] Accordingly, in a first aspect, a device for monitoring a position of an electronic module for a gas cylinder is suggested, which comprises a body configured to be coupled to the gas cylinder, a detection unit for detecting a positional relationship between the gas cylinder and the body, when the device is coupled to the gas cylinder, and an evaluation unit in communication with the detection unit and configured to determine a position of the device based on the detected positional relationship. The evaluation unit is furthermore configured to output a signal based on a comparison of the determined position with a predefined position.

[0009] The device may e.g. be coupled to the gas cylinder via a valve of the gas cylinder, a valve component, a valve guard, or a corresponding holder associated with the gas cylinder. Accordingly, a fixation means may be provided, which ensures that the device is secured to the gas cylinder. For example, such fixation means may be provided as a mechanical fixation means, e.g., in the form of one or more straps, clamps, hook and loop fasteners, screwing attachments, interlocking features, or by interference fit. Alternatively, such coupling may be provided e.g. by magnetic coupling. Hence, various means may be provided to either directly or indirectly couple the device to the gas cylinder.

[0010] In order to avoid redundancies and to improve the robustness of the device, the device may be formed as an integral part of the electronic module, wherein a body of the electronic module comprises the body of the device. Accordingly, in order to couple the device to the gas cylinder, fixations means as described in the above may alternatively or additionally be provided on the electronic module. Furthermore, the body of the device may either be a part of the body of the electronic module or may be provided as the body of the electronic module. Also, the evaluation unit may at least in part be provided by a control unit of the electronic module, e.g. via a corresponding interface. Hence, when providing the device as an integrated unit, corresponding features may be omitted or shared, thereby providing a more compact device and reducing the number of required components and/or connections.

[0011] To detect the positional relationship between the gas cylinder and the body of the device, the device may comprise e.g. a sensing element in the form of a sensor, which may be arranged between the body and e.g. the valve of the gas cylinder, when the device is

coupled to the gas cylinder. As the device may be directly or indirectly coupled to the electronic module, the monitoring of a position of the electronic module may hence be provided by such sensing element. The positional relationship may hence correspond to a detected contact between e.g. the device and the valve body of the gas cylinder or lack thereof. Alternatively, or in addition, the sensor may detect a corresponding distance between such components.

[0012] Such contact or distance may correspond to a particular position of the device, which may be accordingly determined by the evaluation unit. Within the evaluation unit, the determined position is then compared with a predefined position, which may correspond to a particular distance or contact intensity, which may e.g. be detected by a corresponding sensor output. Based on said comparison, the evaluation unit then outputs a signal, e.g., indicating a coupling status of the device. For example, a mechanical switch, lighting means, or indicator may be color coded and may indicate the status based on the visible color.

[0013] The detection unit and evaluation unit of the device coupled to the evaluation unit hence provide that not only a positional relationship between the device to the gas cylinder, but also a positional relationship between the electronic module and the gas cylinder may be determined, so as to provide a monitoring of the positioning of the electronic module. Thereby, a correct functioning of the electronic module may be ensured and the position of the device or electronic module may be accordingly adjusted, should the comparison performed by the evaluation unit reveal that the detected position deviates from the predefined position. Accordingly, the measurement and/or control function of the electronic module may be maintained and a dysfunction of the electronic module or erroneous measurements due to an incorrect positioning or arrangement may hence be prevented.

[0014] In order to provide a more versatile device for monitoring a coupling status or position of the electronic module, the device is preferably adapted for use with a variety of gas cylinders, valves, and/or electronic modules. Accordingly, in order to differentiate between the various types of components, the predefined position is preferably stored in the evaluation unit and may be based on a type of gas cylinder, a type of valve, and/or a type of electronic module. Such data may be provided in the form of a database or memory storing the data in the form of one or more lists, wherein each type may be matched to a particular input value of the detection unit, e.g. a normalized sensor output value. The evaluation unit may accordingly comprise a processing means, e.g. a microprocessor, capable of processing the inputted information or data, and comprising an implemented logic, e.g. in the form of a chip, so as to provide a corresponding output signal.

[0015] Although a variety of detection units may be implemented in the device, the detection unit is preferably configured as a strain sensor comprising a first part configured to be secured to the gas cylinder or a valve of the gas cylinder, when the device is coupled to the gas cylinder, and a second part being secured to the body, wherein the evaluation unit is configured to determine the position based on the received strain measurement.

[0016] For example, the fixation means of the device may provide an attachment of the device to a valve body of the gas cylinder causing the strain sensor to be secured to the valve body. Such attachment may e.g. be provided by a securing element, which is secured to the valve body and is connected to the body of the device by means of a connecting element. In such case, the strain sensor may e.g. be arranged on the connecting element so as to be mechanically coupled to the device end and the valve body end of the connecting element, such that a positional deviation between the device and the valve body may be detected by a corresponding change in the strain measurement outputted by the strain sensor. By the same token, the strain sensor may be arranged at the body of the device, such that the strain sensor is arranged between the valve body and the device and is accordingly compressed upon attachment of the device to the gas cylinder or valve body. In such case, a lower strain measurement or lack thereof may indicate a loosening or separation of the device.

[0017] Furthermore, the output of the strain sensor may correspond to a force being applied to the valve body or electronic module, which may result in a shift of the position of the device and may be comprised in the outputted signal of the evaluation unit. Accordingly, the evaluation unit may be configured to not only determine a deviation of the strain sensor, but also to correlate or match a particular distance to the measured sensor value in order to determine a distance between the device and e.g. the valve body. Said distance may then be compared with a predefined distance corresponding to the predefined position, which is preferably dependent on the type of gas cylinder, a type of valve, and/or a type of electronic module. The comparison between the determined position and the predefined position may hence be adapted by corresponding settings in the evaluation unit.

[0018] By the same token, the detection unit may also be configured as a Hall effect sensor comprising a first part comprising a magnetic element and configured to be secured to the gas cylinder or a valve of the gas cylinder, when the device is coupled to the gas cylinder, and a second part comprising an electric circuitry and being secured to the body, wherein the evaluation unit is configured to determine the position based on a measured voltage. In this case, the magnetic element influences the electric circuitry, such that when the first part and second part are at a predefined distance from each other, a corresponding current may be detected by the evaluation unit. When the first part and second part are separated or are spaced apart at a distance that deviates from the predefined distance, a deviating current is detected, which may be outputted by a corresponding signal of the evaluation unit.

[0019] Furthermore, a change in the detected current may also be provided by a change in orientation of the first part and/or second part as this results in a change of the magnetic field relative to the electric circuitry. Accordingly, the outputted signal of the evaluation unit may also be based on a change in the orientation or alignment of the device or electronic module.

[0020] The magnetic element may also be provided in the electronic module, e.g. in the form of a solenoid control element or valve, such that the first part may alternatively be an integrated part of the electronic module and is not comprised in the device itself. The evaluation unit may hence automatically detect a change in the current in the electric circuitry upon coupling the device to e.g. the valve body of the gas cylinder due to the presence of at least one magnetic element in the valve body, wherein the predefined position may be based on a particular current corresponding to the type of gas cylinder, a type of valve, and/or a type of electronic module.

[0021] Alternatively, or in addition, the detection unit may comprise an acoustic transmitter for outputting an input acoustic signal toward the gas cylinder and/or the valve of the gas cylinder and a receiver for receiving a reflected acoustic signal, wherein the evaluation unit is configured to determine the position based on a determined difference between the input acoustic signal and the reflected acoustic signal. For example, the position may be determined based on a detected difference in the amplitude, phase, and/or frequency between the input acoustic signal and the reflected signal, wherein said difference may be dependent on e.g. the type of gas cylinder, a type of valve, and/or a type of electronic module. Preferably, the acoustic signal is an ultrasound signal. For example, the detection unit may comprise the transmitter and the receiver adjacently to each other, e.g. on a part that is at a predefined position from a particular part of the valve body, wherein said part of the valve body comprises a particular shape corresponding to a predefined reflective surface for a type of valve. Alternatively, the detection unit may comprise a separate reflection surface, which is preferably at an adjustable distance from the transmitter and receiver and which is secured to e.g. the valve body of the gas cylinder upon coupling of the device to the gas cylinder.

[0022] The input acoustic signal or sine wave may hence be injected across a junction between the electronic module and a main valve of the gas cylinder, wherein a difference between the input acoustic signal and the reflected acoustic signal may indicate an incorrect attachment of the main device to the main body. However, instead of determining the position based on an input acoustic signal and a reflected acoustic signal, the evaluation unit may also comprise a transmitter and receiver as separated elements, wherein e.g. the transmitter is coupled to the valve body of the gas cylinder and the receiver is coupled to the electronic module. Accordingly, instead of detecting a reflected acoustic signal, the detection unit detects the input acoustic signal, wherein the evaluation unit determines the position of the device or electronic module based on e.g. a measured temporal difference and/or acoustic signal strength.

[0023] Preferably, the detection unit and the evaluation unit are configured to determine the position in relation to a reference point of the gas cylinder and/or valve of the gas cylinder in at least one direction, wherein the detection unit is preferably configured to perform a measurement of a distance between the position and the reference point. Such reference point may correspond to a predefined position of the electronic module, when the device and electronic module are correctly coupled to the gas cylinder, e.g. to the valve body of the gas cylinder. Instead of merely determining a positional relationship, the distance to such reference point may provide a certain tolerance level wherein the electronic module may properly function and may furthermore provide that a particular arrangement, i.e. a manner of securing the device and electronic module to the valve body, is monitored.

[0024] For example, a reference point may be dependent on the type of valve, wherein a predefined distance to a reference point may correspond to a correct fitting of the electronic module and device to the valve body. This may furthermore be ensured by providing a tactile feedback, e.g. by providing a coupling of the device and electronic module to the valve body via a snap-fit arrangement and/or by providing an acoustic feedback using a clicking and/or latching mechanism.

[0025] Furthermore, the detection unit and the evaluation unit may be configured to determine the position in relation to a reference point of the gas cylinder and/or valve of the gas cylinder in at least two directions and are configured to determine an orientation of the device in relation to the gas cylinder and/or valve of the gas cylinder. Accordingly, the evaluation unit may determine the position to be within a particular plane and/or may determine a particular alignment of the device or electronic module, such that the device ensures that the electronic module is not only properly secured to the valve body, but is also arranged at the correct position and may provide measurement and/or control functions according to a predefined orientation.

[0026] To further increase the validity of the detected positional relationship and the determined position of the device, the device may furthermore comprise a temperature sensor for measuring an ambient temperature of the gas cylinder, which is in communication with the evaluation unit and wherein the evaluation unit determines the position based on the received temperature measurement.

[0027] Such temperature sensor may already be present in the electronic module and may be coupled to the evaluation unit by a communication interface or may be provided separately on the device, preferably providing said measurements also to the electronic module via a corresponding communication interface. By providing ambient temperature measurements to the evaluation unit, said measurements may be factored into the detect-

ed positional relationships, which may different at varying temperatures. For example, when using an acoustic signal to determine the position, said acoustic signal may be deterred and/or may have a different propagation speed due to the different ambient temperature. By providing the ambient temperature measurement to the evaluation unit, the detected positional relationship and the determined position may hence be corrected.

[0028] Although the outputted signal may be provided by e.g. a mechanical switch or indicator, the signal corresponding to the comparison between the determined and predefined position is preferably outputted by a visual and/or acoustic indicator, which may correspond to a particular comparison value or difference between said positions. For example, the evaluation unit may include a display or a lighting means, e.g. one or more LEDs, wherein e.g. an essentially matching position may correspond to a first color and a difference between said positions may correspond to a second color or to an outputting of the signal at a different interval. Accordingly, a user may easily monitor a positioning and hence a correct functioning of the electronic module.

[0029] Preferably, the evaluation unit is configured to output an alarm signal, when a deviation of the determined position from the predefined position exceeds a threshold stored in the evaluation unit, wherein the device preferably comprises a buzzer for outputting an acoustic alarm and/or at least one LED or lighting means for providing a visual alarm.

[0030] For example, if the detection unit is configured as a strain sensor, a force measured between the electronic module and the valve or gas cylinder body may fall below a certain threshold, indicating that a clamping force securing the device or electronic module to the respective component of the gas cylinder may be insufficient to correctly hold the electronic module in place or in the appropriate position. The evaluation unit may then provide an alert or alarm that the electronic module may not work as intended and measurements or control functions may be invalid or not reliable.

[0031] Accordingly, the device facilitates that an incorrect use of the electronic module, e.g. due to erroneous sensor data received by a microprocessor or controller of the electronic module, may be prevented, i.e. by alerting the user through an audible and/or visible alarm. This furthermore provides an early detection of failure, such that an early return of the faulty device to may be effected for repair or replacement.

[0032] As gas cylinders may be used and stored at various locations in e.g. a medical facility or hospital monitoring, a visual inspection to provide a monitoring of each of the respective corresponding electronic modules may not always be possible or may be too laborious as the distance between said gas cylinders and/or the number of gas cylinders increase. Accordingly, the device preferably comprises a wireless communication module in communication with the evaluation unit, wherein the wireless communication module is configured to transmit the output signal to a remote device, preferably a remote monitor and/or monitoring system, preferably via Bluetooth, Bluetooth Low Energy, Zigbee, RFID, and/or WLAN or similar communication standards to facilitate a nearby or remote communication.

[0033] Such communication module may also be provided by the electronic module, which may share the communication functions e.g. via a corresponding interface. Preferably, the device comprises the communication module, such that the communication may be provided independently and does not require further connections with the electronic module that may be prone to dislodging or disconnection.

[0034] By transmitting the output signal to a remote device, it is possible to locate and track a respective gas cylinder and it is ensured that an application of the gaseous mixture is correctly monitored by a corresponding electronic module via the monitoring of the positioning of the device and the corresponding output signal via the wireless communication module. This furthermore allows a tracking of active and inactive gas cylinders, wherein the device may furthermore be positioned or located based on the received signal strengths of the transmitted output signals, e.g. by means of triangulation by corresponding nodes or access points at a server end or at the remote device.

[0035] In a medical setting, this may furthermore ensure that medical personnel is alerted, when a determined position of the device deviates from a predefined position, which may indicate a lack of a control function provided by the coupled electronic module and hence potentially poses a risk for a corresponding patient. By providing an alert, e.g. via wireless broadcasting, the medical personnel may be immediately directed to the respective gas cylinder to avoid further usage. Such alert may not only be provided by the respective device, but may also be provided by the remote device or monitoring system, e.g. after verification, such that a particular user may be alerted or so as to increase the range of said alert to more remote locations.

[0036] The output signal may furthermore comprise a maintenance request and/or may prompt a user to verify the positioning of the device, when a remote device is coupled to the device. This hence not only provides an alert, but also ensures that incorrect usage of the electronic module is detected at an early stage and effects an early return of the faulty device for repair or replacement. By providing an on-demand maintenance and preferably directing of maintenance personnel to the respective device, the functionality of the electronic modules is improved and the availability of functional electronic modules is increased. Thereby, an improved fleet management and better stock management may be provided at the respective facility.

[0037] For ease of implementation and to ensure that the device may be used at remote locations and may be functional during transportation, the device is preferably configured as a stand-alone unit comprising an electrical

energy storage medium and/or comprising an electrical coupling. For example, the device may be powered by a battery, such as half an AA, an AA or an AAA standard battery, which provides a sufficient longevity to maintain the device between one to five years in standby or low activity mode. Such battery power has the advantage that no further implementations are required other than a correct coupling of the device to the gas cylinder and that the device may be used with a gas cylinder at an arbitrary location. Alternatively, or in addition, the device may be provided with an electric coupling device, such that the device may be charged or powered by an external electrical energy source. Furthermore, the device may be electrically coupled to a powered integrated valve or the electronic module by means of a corresponding interface.

[0038] According to a further aspect of the invention, an electronic module for monitoring a status of the gas cylinder and/or a status of the valve of the gas cylinder is suggested, which comprises the device for monitoring a position of the electronic module as described in the above.

[0039] For example, the device may be coupled to electronic module via an attachment or fixation means, such as a screwing attachment, or alternatively via an electromagnetic coupling. Preferably, the device is integrated in the electronic module, e.g. embedded or otherwise securely fixed to the electronic module. Accordingly, the device may be provided as a releasable module, which is secured to the electronic module, e.g., for retrofitting purposes of existing electronic modules, or may be formed as an integral part.

[0040] Such electronic module may e.g. provide a measurement of a flow rate and/or a pressure of the gaseous mixture that is applied or administered to a patient and may evaluate said measurements to provide feedback of a performed therapy. Furthermore, such electronic modules may determine a status of the gaseous mixture provided in the gas cylinder, so as to increase the safety of the patient being treated with the gaseous mixture. In addition, the electronic module may comprise a controller, which may provide a corresponding control function for the valve, such that the electronic module may provide a digital control of analogous or manual valves which have not been updated by smart valves or integrated valves.

[0041] Preferably, the electronic module is configured to monitor an activation status of the valve, preferably a flow rate of the valve, and/or to monitor a status of a gaseous mixture contained in the gas cylinder.

[0042] Such activation status may be provided indirectly by providing a temperature sensor that is coupled to the valve body of the valve of the gas cylinder and by providing an ambient temperature sensor. The activation of the valve may then be determined based on a measured temperature difference between the valve body and the ambient temperature, in particular by evaluating a temperature change over a predefined period of time. For example, a temperature drop of the valve body may result from a Joule-Thomson effect, when the gaseous mixture is released from the gas cylinder and is accordingly expanded. By the same token, an ambient temperature measurement may indicate the presence of a liquid phase of a gaseous component in the gaseous mixture, which may result from the high pressure within the gas cylinder and due to storage at lower temperatures, e.g. below 0°C or -6°C.

[0043] By providing the device as a component of the electronic module, the correct functioning of the electronic module may be monitored based on the determined position.

[0044] Although the detection unit and evaluation unit have been described in view of an electronic module for a gas cylinder, the device may alternatively also be used in any application where a sensor or device should be mounted to another solid object such as a pipeline, a truck tank, a bulk liquid tank or the like, wherein an incorrect attachment of a device could lead to incorrect or inaccurate sensor data.

Brief description of the drawings

[0045] The present disclosure will be more readily appreciated by reference to the following detailed description when being considered in connection with the accompanying drawings in which:

Figure 1 is a schematic view of a device for monitoring a position of an electronic module for a gas cylinder coupled to a gas cylinder;

Figure 2 is another schematic view of a device being coupled to an electronic module;

Figure 3 is another schematic view of the device according to Figure 2 with a multi-part body;

Figure 4 is a schematic view of the device according to Figure 3 with an acoustic detection unit;

Figure 5 is a schematic view of the device according to Figure 3 with a Hall effect detection unit; and

Figure 6 is a schematic view of the device according to Figure 3 with wireless communication fu nctional ity.

Detailed description of preferred embodiments

[0046] In the following, the invention will be explained in more detail with reference to the accompanying figures. In the Figures, like elements are denoted by identical reference numerals and repeated description thereof may be omitted in order to avoid redundancies.

[0047] In Figure 1 a device 10 for monitoring a position of an electronic module 22 for a gas cylinder 12 is sche-

matically depicted. The device 10 is attached to the gas cylinder 12 via a detection unit 16 and is secured to the gas cylinder 12 with e.g. one or more straps or other attachment means, such that the device 10 may be associated with a particular gas cylinder 12. As indicated by the dashed line, the device 10 is not required to be in direct contact with the valve 14 of the gas cylinder 12. For example, the device 10 may also be coupled to the valve 14 by arranging the device 10 at an outer wall or holder or rack of the gas cylinder 12 and adjacent to the valve 14, or by arranging the device 10 at a valve guard of the valve 14. By the same token, the electronic module 22 is not required to be directly attached to the valve 14, but may also be coupled to the valve 14 by attaching the electronic module 22 to a valve body or valve guard of the valve 14 by corresponding attachment means, as indicated by the dashed line.

[0048] The device 10 and the electronic module 22 are arranged to be in proximity or in contact with each other, such that the device 10 is coupled to the electronic module 22. The detection unit 16 may hence determine a positional relationship between the device 10 and the gas cylinder 12 which simultaneously provides a measure for the positional relationship between the electronic module 22 and the gas cylinder 12. For example, the detection unit 16 may be configured as a strain sensor or pressure sensor, which outputs a sensor value based on compressive or tensile forces acting upon the strain sensor. Said value is then communicated to an evaluation unit 20, which is coupled to the detection unit 16.

[0049] The evaluation unit 20 accordingly comprises a processing means, e.g. a microprocessor, capable of processing the inputted sensor value, and comprises an implemented logic in the form of a chip, so as to provide a corresponding output signal. The evaluation unit 20 may comprise a database or data storage, e.g., in the form of one or more lists, so as to determine a positional relationship between the device 10 and the gas cylinder 12 based on the inputted sensor value. For example, the inputted sensor values may be normalized and subsequently be matched to a value or value range stored in the evaluation unit 20 corresponding to a particular distance, such that the evaluation unit 20 may determine a distance between the device 10 and the gas cylinder 12 to indicate a corresponding position of the device 10 and hence of the electronic module 22 based on the detected positional relationship.

[0050] The detection unit 16 may be configured to provide the sensor readings or values periodically or continuously, e.g. by an implemented timer or clock. Furthermore, the data storage in the evaluation unit 20 may provide different lists for particular types of electronic modules 22 or types of valves 14, such that the detected positional relationship may be specific for a type of electronic module 22 and/or a type of valve 14, thereby providing a more versatile device 10 and increasing the validity of the determined position. For example, electronic modules 22 may be shaped differently, such that a coupling or attachment to a respective electronic module 22 may result in a different detected positional relationship by the detection unit 16 due to e.g. a different separation or spacing of the detection unit 16, which is predefined by the shape of the electronic module 22. Such type specific data may be selected e.g. via a dial or switch provided on the evaluation unit 20 or at a corresponding interface of the device 10.

[0051] Accordingly, the evaluation unit 20 compares the determined position with a predefined position, wherein the predefined position optionally comprises a tolerance range and/or is specific for a type of valve 14 or electronic module 22. Based on said comparison, the evaluation unit, then outputs a signal, which may be provided to a user by means of an indicator 18. The indicator 18 may e.g. be provided in the form of a mechanical switch and/or color coding indicating whether the device 10 and hence the electronic module 22 is at a predefined position. Such indication may be automatically provided, by providing a corresponding attachment, e.g., in the form of a poka yoke or snap-fit attachment, such that the indication may only be visible, when the device 10 is properly coupled.

[0052] Optionally, the indicator 18 may be configured in the form of a display which is in communication with the evaluation unit 20 to receive an output signal corresponding to a matching of the determined position and a predefined position. The display may hence present a text message or graphical icon indicating whether the electronic module 22 is correctly attached to the gas cylinder 12 or valve 14, so as to indicate a validity of measurements and control functions provided by the electronic module 22. However, alternatively, or in addition, the indicator 18 may also provide an indication of the correct attachment of the electronic module 22 by means of a light or LED and/or acoustic signal, such as an alarm via a buzzer.

[0053] A more direct coupling of the device 10 to the gas cylinder 12 is depicted in the embodiment according to Figure 2, wherein the device 10 is attached to the electronic module 22, which is secured to a valve body of the valve 14. Such direct coupling to the electronic module 22 has the advantage that a movement of the electronic module 22 relative to the valve 14 is directly detected by the detection unit 16, which is arranged at a junction between the device 10 and the valve 14 or valve body. For example, the device 10 may be brought into a snap-fit arrangement with the electronic module 22, such that the device 10 is releasably attached while at the same time being secured to the electronic module 22. For this purpose, the device 10 and the electronic module 22 may e.g. comprise matching grooves, keys, recesses, and/or protrusions made of a resilient material. By the same token, the device 10 may also be sandwiched between the electronic module 22 and the valve 14, such that the electronic module 22 is coupled to the valve 14 via the device 10.

[0054] A body of the device 10 may be formed by the

respective components of the device 10, but may also be provided as a separate component, which may optionally have multiple parts, as schematically depicted in the embodiment according to Figure 3. Accordingly, a body 24 of the device 10 may comprise a first part 26, which is secured to the valve 14 of the gas cylinder 12 and is connected to a second part 28, which connects the first part 26 to the evaluation unit 20 and the detection unit 16 at an opposing end of the valve 14. However, other arrangements of the second part 28 are possible, such that the second part 28 is not required to be in contact with the evaluation unit 20 or detection unit 16. For example, the second part 28 may also be coupled to a main part or core of the device 10, essentially forming the body 24, wherein the first part 26 is configured as an attachment arm.

[0055] The first part 26 and second part 28 may furthermore be integrated with the detection unit 16, e.g. forming integral parts of an implemented strain sensor. For example, the detection unit 16 may be positioned so as to be at the junction between the valve 14 and the device 10, wherein the first part 26 and the second part 28 are essentially formed as clamping jaws biasing the device 10 to, warts the valve 14 or valve body thereof. Due to said biasing force, the detection unit 16, e.g. the strain sensor, is compressed by the valve 14 and the device 10 in the coupled state of the device 10. Accordingly, the evaluation unit 20 may receive sensor measurements from the detection unit 16 indicating that the device 10 has been attached to the valve 14, as indicated by the dashed line.

[0056] The electronic module 22 is coupled to the valve 14 via a corresponding attachment to the device 10. The device 10 according to the embodiment of Figure 3 is hence sandwiched between the electronic module 22 and the valve 14. However, the device 10 may also be coupled to the valve 14 by attachment to the electronic module 22, as described in the above in view of Figure 2. In such arrangement, the first part 26 and, optionally, the second part 28, may also be formed as parts of the electronic module 22, such that the electronic module 22 comprises a gripping arms or clamping jaws securing the electronic module 22 to the valve 14.

[0057] The embodiment according to Figure 4 essentially corresponds to the embodiments of Figures 2 and 3, wherein the detection unit 16 is configured as an acoustic detection unit. The detection unit 16 comprises an acoustic transmitter 30 for outputting an input acoustic signal 34 toward the valve 14 of the gas cylinder 12 and a receiver 32 for receiving a reflected acoustic signal 36. The evaluation unit 20 is configured to determine the position based on a determined difference between the input acoustic signal 34 and the reflected acoustic signal 36, for example, by detecting a difference in the amplitude, phase, and/or frequency between the input acoustic signal 34 and the reflected signal 36. In order to increase the sensitivity of the measurement and to avoid any disturbances for a user, the acoustic signal is preferably an ultrasound signal. Furthermore, the transmitter 30 and the receiver 32 are arranged adjacently to each so as to maximize the signal strength while minimizing the required intensity and avoiding any undesirable acoustic manipulation. However, other arrangements are possible, such that the transmitter 30 and the receiver 32 may also be space apart from each other or arranged at different components of the device 10.

[0058] Although not shown in the schematic depiction of the embodiment according to Figure 4, the detection unit 16 is preferably aligned with and at a predefined position from a particular part of the valve body of the valve 14 in the coupled state of the device 10. Such part of the valve body may comprise a particular shape corresponding to a predefined reflective surface for a type of valve 14. This allows that the evaluation unit 20 may compare the determined position with a predefined position specific for a type of valve 14, such that the device 10 may be used with valves 14 and corresponding electronic modules 22 of different shapes and sizes. Such reflective surface may also be provided separately as a part of the detection unit 16, wherein said part may be secured to e.g. the valve body of the gas cylinder 12 upon coupling of the device 10 to the gas cylinder 12 or valve 14.

[0059] Accordingly, the detection unit 16 and the evaluation unit 20 may be configured to determine the position in relation to a reference point of the valve 14 of the gas cylinder 12 in at least one direction and may perform a measurement of a distance between the determined position and the reference point. For example, a reflective surface of the valve 14 may have a particular curvature in different regions, wherein a particular curvature is in line with the input acoustic signal 34 so as to provide an expected reflective acoustic signal 36, when the device 10 and the electronic module 22 are correctly coupled to the gas cylinder 12 via the valve 14 or valve body of thereof. Instead of merely determining a positional relationship, the distance to such reference point may provide a certain tolerance level wherein the electronic module 22 may properly function and may furthermore provide that a particular arrangement, i.e. a manner of securing the device and electronic module to the valve body, is monitored, e.g. by providing that a predefined distance to a reference point corresponds to a correct fitting of the electronic module 22 and device 10.

[0060] As described in the above, the evaluation unit 20 may determine the position of the device 10 and electronic module 22 based on e.g. a measured temporal difference and/or difference in acoustic signal strength between the input acoustic signal 34 and the reflected acoustic signal 36. Thereby, the evaluation unit 20 indicates whether the device 10 and hence the electronic model 22 are correctly attached to the valve 14, which may be indicated by the indicator 18 based on the outputted signal from the evaluation unit 20.

[0061] By the same token, the detection of a positional relationship between the device 10 and the gas cylinder 12, or between the device 10 and a valve body of the

valve 14 of the gas cylinder 12, may also be provided by a detection unit 16 configured as a Hall Effect detection unit 16, as depicted in the embodiment according to Figure 5. Accordingly, the device 10 comprises a magnetic element 38 as a part of the electronic module 22 and which is hence coupled to the gas cylinder 12 and valve 14, when the device is coupled to or associated with the gas cylinder 12. Such magnetic element 38 may be provided e.g. in the form of a solenoid control element, such that the first part may be an integrated part of the electronic module 22.

[0062] Alternatively, the magnetic element 38 may be formed as a first part of the detection unit 16 that is configured to be secured to the gas cylinder 12 or a valve 14 of the gas cylinder 12, when the device 10 is coupled to the gas cylinder 12.

[0063] The device 10 furthermore comprises a second part comprising an electric circuitry 40, which is secured to or is configured as a part of the evaluation unit 20. Alternatively, the second part may be secured to a body of the device 10, wherein the electric circuitry 40 in communication with the evaluation unit 20. In either case, the evaluation unit 20 is configured to determine the position based on a measured voltage, wherein the magnetic element 38 influences the electric circuitry 40, such that when the first part and second part are at a predefined distance from each other, a corresponding current may be detected by the evaluation unit 20. When the first part and second part are separated or are spaced apart at a distance that deviates from the predefined distance, a deviating current is detected. The evaluation unit 20 may hence automatically detect a change in the current in the electric circuitry 40 upon coupling of the device 10 to e.g. the valve body of the gas cylinder 12 due to the presence of at least one magnetic element 38 in the electronic module 22 or in a control function of an integrated valve body. Such detected current change may be outputted by a corresponding signal of the evaluation unit 20 and may be indicated by the indicator 18. Accordingly, an alert or alarm may be provided to a user, such that a potential failure or erroneous function of the electronic module 22 may be remedied.

[0064] Furthermore, a change in the detected current may also be provided by a change in orientation of the first part and/or second part as this results in a change of the magnetic field relative to the electric circuitry 40. Accordingly, the outputted signal of the evaluation unit 20 may also be based on a change in the orientation or alignment of the device 10 or coupled electronic module 22.

[0065] In the embodiment according to Figure 6 a schematic view of a device 10 according to Figure 3 is provided with wireless communication functionality. To implement such communication, the device 10 comprises a wireless communication module 42, which is in communication with the evaluation unit 20 and is configured to transmit the output signal based on the position comparison to a remote device 44, e.g. via Bluetooth or Low Energy Bluetooth. This ensures that a user or medical personnel that is not in direct vicinity of the gas cylinder 12 may monitor the correct attachment and functionality of the electronic module 22 and may be alerted, if e.g. a comparison of the determined position and a predefined position exceeds a predefined threshold. To be able to transmit such information the wireless communication module 42 may require a coupling with the remote device 44, e.g. by providing an identifier or by requiring an initial physical proximity to the device 10, e.g. via NFC or RFID, to ensure that the transmitted information is only receivable by an authorized remote device 44.

[0066] The wireless communication module 42 may furthermore be in communication with a remote device 44 configured as a central monitoring unit or remote central computer system. The transmitter of the wireless communication module 42 may hence transmit the signal corresponding to the determined position to the remote device 44 to alert the operator of the remote device 44, if the determined status poses a risk for a user. In addition, the transmitter may be capable of transmitting data, which in addition to the determined position and depending on the configuration of the evaluation unit 20 may include e.g. the gas cylinder 12 details, an activity or data of the electronic module 22, and/or the remaining volume left in the gas cylinder 12 to the remote device 44 to make the operator of the remote device 44 aware if the cylinder needs changing. Accordingly, such wireless communication module 42 may provide additional functionalities to the electronic module 22 by a corresponding connective coupling provided by means of e.g. an interface or communication bus.

[0067] The remote device 44 or plurality of remote devices 44 may be positioned e.g. in a ward, surgery, filling station, and/or storage station and may be either stationary or configured as a mobile and/or handheld device. Furthermore, to facilitate the communication between the device 10 and the remote device 44, the communication may be provided via one or more hubs, wherein the hubs can then communicate with e.g. the central computer using wireless transmission protocols more suitable for longer distances, such as Wi-Fi or WLAN. The provision of the wireless communication module 42 hence facilitates localization or positioning of the device 10 and the associated gas cylinder 12, as well as the corresponding electronic module 22, which may be advantageous when a plurality of gas cylinders 12 and electronic modules 22 are simultaneously used at remote locations and may provide a monitoring of the respective available gas cylinders 12 at various locations. Furthermore, such communication may be implemented in telemedicine approaches, so as to provides an improved level of safety for a patient, i.e. by providing a warning or alerting system to medical personnel in case of an incorrect positioning of the device 10.

[0068] By the same token, the remote device 44 may be configured to not only receive the information from the wireless communication module 42, but to also trans-

mit input data for the evaluation unit 20, e.g. by comprising a transceiver, including control commands for the valve 14. Thereby, a medical professional or operator may ensure that a gaseous mixture is safely administered to a patient. Furthermore, such input data may replace or support a data storage provided in the evaluation unit 20.

[0069] The wireless communication module 42 furthermore replaces the indicator 18, such that the device 10 may have a more compact design and improved energy management. The evaluation unit 20 may e.g. periodically update the determined position and may provide such update via the outputted signal to the remote device 44. Therefore, a continuous indication is avoided. Furthermore, such update may also be provided upon a particular request from the remote device 44, such that the outputted signal is provided by means of on-demand retrieval. To provide a further level of security, such retrieval may require an identifier, such that e.g. only medical personnel is capable to perform the status reading. In addition, an indicator may optionally be provided.

[0070] It will be obvious for a person skilled in the art that these embodiments and items only depict examples of a plurality of possibilities. Hence, the embodiments shown here should not be understood to form a limitation of these features and configurations. Any possible combination and configuration of the described features can be chosen according to the scope of the invention.

List of reference numerals

[0071]

10	Device
12	Gas cylinder
14	Valve
16	Detection unit
18	Indicator
20	Evaluation unit
22	Electronic module
24	Body
26	First part
28	Second part
30	Transmitter
32	Receiver
34	Input acoustic signal
36	Reflective acoustic signal
38	Magnetic element
40	Electric circuitry
42	Wireless connection module
44	Remote device

Claims

1. Device (10) for monitoring a position of an electronic module (22) for a gas cylinder (12), comprising:

a body (24) configured to be coupled to the gas cylinder (12),

a detection unit (16) for detecting a positional relationship between the gas cylinder (12) and the body (24), when the device (10) is coupled to the gas cylinder (12), and

an evaluation unit (20) in communication with the detection unit (16) and configured to determine a position of the device (10) based on the detected positional relationship and to output a signal based on a comparison of the determined position with a predefined position.

2. Device (10) according to claim 1, wherein the device (10) is formed as an integral part of the electronic module (22) and wherein a body of the electronic module comprises the body (24) of the device (10).

3. Device (10) according to claim 1 or 2, wherein the predefined position is stored in the evaluation unit (20) and is based on a type of gas cylinder, a type of valve, and/or a type of electronic module.

4. Device (10) according to any of the preceding claims, wherein the detection unit (16) is configured as a strain sensor comprising a first part (26) configured to be secured to the gas cylinder (12) or a valve (14) of the gas cylinder (12), when the device (10) is coupled to the gas cylinder (12), and a second part (28) being secured to the body (24), wherein the evaluation unit (20) is configured to determine the position based on the received strain measurement.

5. Device (10) according to any of the preceding claims, wherein the detection unit (16) is configured as a Hall effect sensor comprising a first part (26) comprising a magnetic element (38) and configured to be secured to the gas cylinder (12) or a valve (14) of the gas cylinder (12), when the device (10) is coupled to the gas cylinder (12), and a second part (28) comprising an electric circuitry (40) and being secured to the body (24), wherein the evaluation unit (20) is configured to determine the position based on a measured voltage.

6. Device (10) according to any of the preceding claims, wherein the detection unit (16) comprises an acoustic transmitter (30) for outputting an input acoustic signal (34) toward the gas cylinder (12) and/or the valve (14) of the gas cylinder (12) and a receiver (32) for receiving a reflected acoustic signal (36), wherein the evaluation unit (20) is configured to determine the position based on a determined difference between the input acoustic signal (34) and the reflected acoustic signal (36), preferably based on a detected difference in the amplitude, phase, and/or frequency between the input acoustic signal (34) and the reflected signal (36), wherein the acoustic signal is

preferably an ultrasound signal.

7. Device (10) according to any of the preceding claims, wherein the detection unit (16) and the evaluation unit (20) are configured to determine the position in relation to a reference point of the gas cylinder (12) and/or valve (14) of the gas cylinder (12) in at least one direction, wherein the detection unit (16) is preferably configured to perform a measurement of a distance between the position and the reference point.

8. Device (10) according to claim 7, wherein the detection unit (16) and the evaluation unit (20) are configured to determine the position in relation to a reference point of the gas cylinder (12) and/or valve (14) of the gas cylinder (12) in at least two directions and are configured to determine an orientation of the device (10) in relation to the gas cylinder (12) and/or valve (14) of the gas cylinder (12).

9. Device according to any of the preceding claims, further comprising a temperature sensor for measuring an ambient temperature of the gas cylinder and being in communication with the evaluation unit, wherein the evaluation unit determines the position based on the received temperature measurement.

10. Device (10) according to any of the preceding claims, wherein the evaluation unit (20) is configured to output an alarm signal, when a deviation of the determined position from the predefined position exceeds a threshold stored in the evaluation unit (20), the device (10) preferably comprising a buzzer for outputting an acoustic alarm and/or at least one LED or lighting means for providing a visual alarm.

11. Device (10) according to any of the preceding claims, further comprising a wireless communication module (42) in communication with the evaluation unit (20), wherein the wireless communication module (42) is configured to transmit the output signal to a remote device (44), preferably a remote monitor and/or monitoring system, preferably via Bluetooth, Bluetooth Low Energy, Zigbee, RFID, and/or WLAN.

12. Device according to claim 11, wherein the output signal comprises a maintenance request and/or prompts a user to verify the positioning of the device, when a remote device is coupled to the device.

13. Device according to any of the preceding claims, configured as a stand-alone unit comprising an electrical energy storage medium and/or comprising an electrical coupling.

14. Electronic module (22) for monitoring a status of the gas cylinder (12) and/or a status of the valve (14) of the gas cylinder (12) comprising a device (10) according to any of the preceding claims.

15. Electronic module (22) according to claim 14, configured to monitor an activation status of the valve (14), preferably a flow rate of the valve (14), and/or to monitor a status of a gaseous mixture contained in the gas cylinder (12).

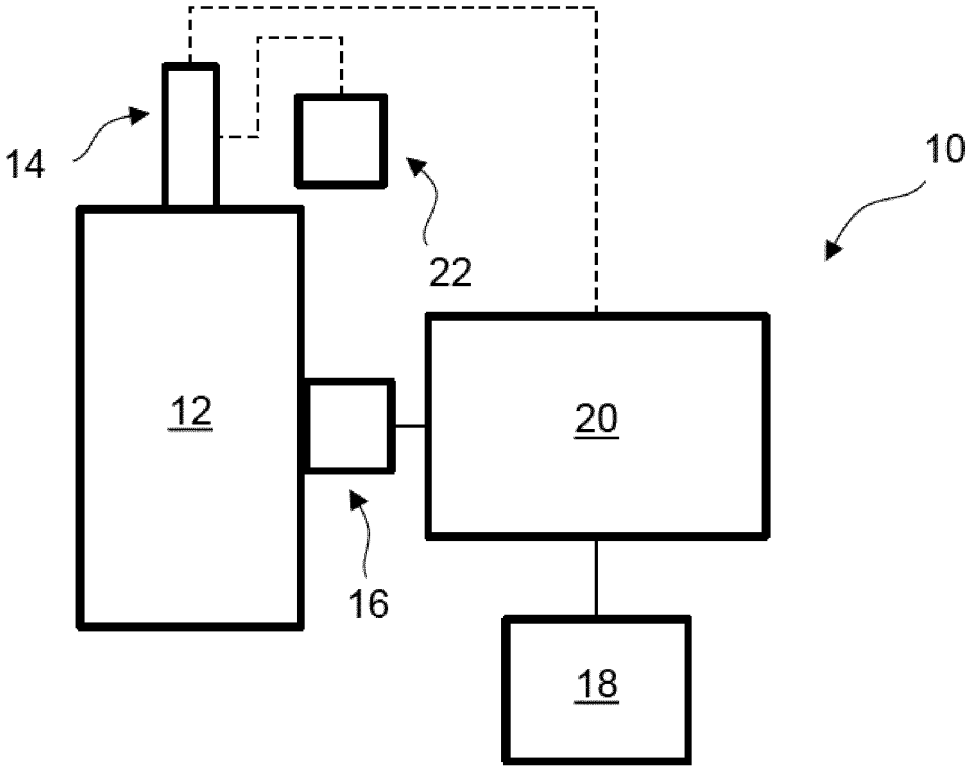

Fig. 1

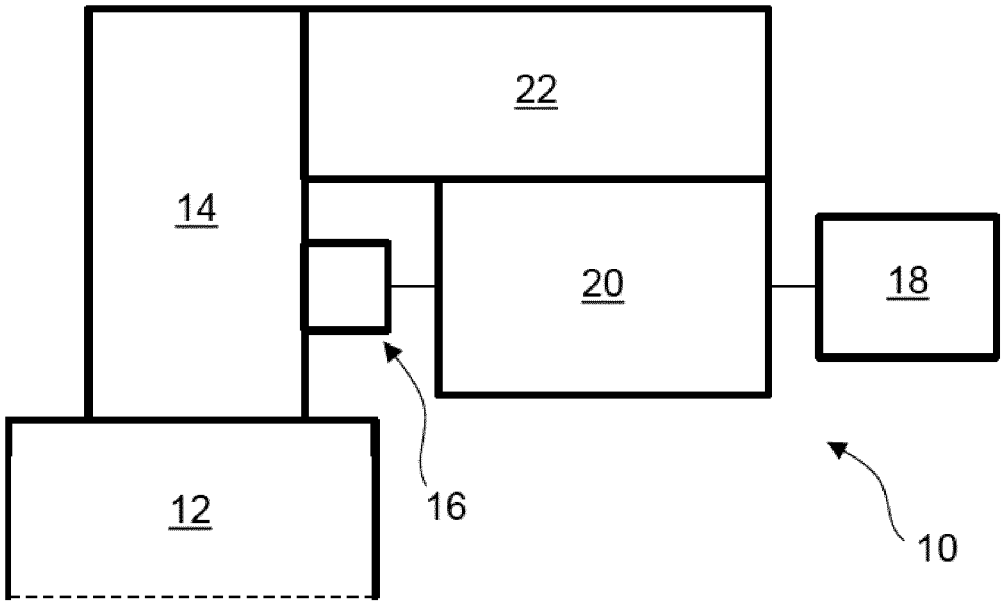

Fig. 2

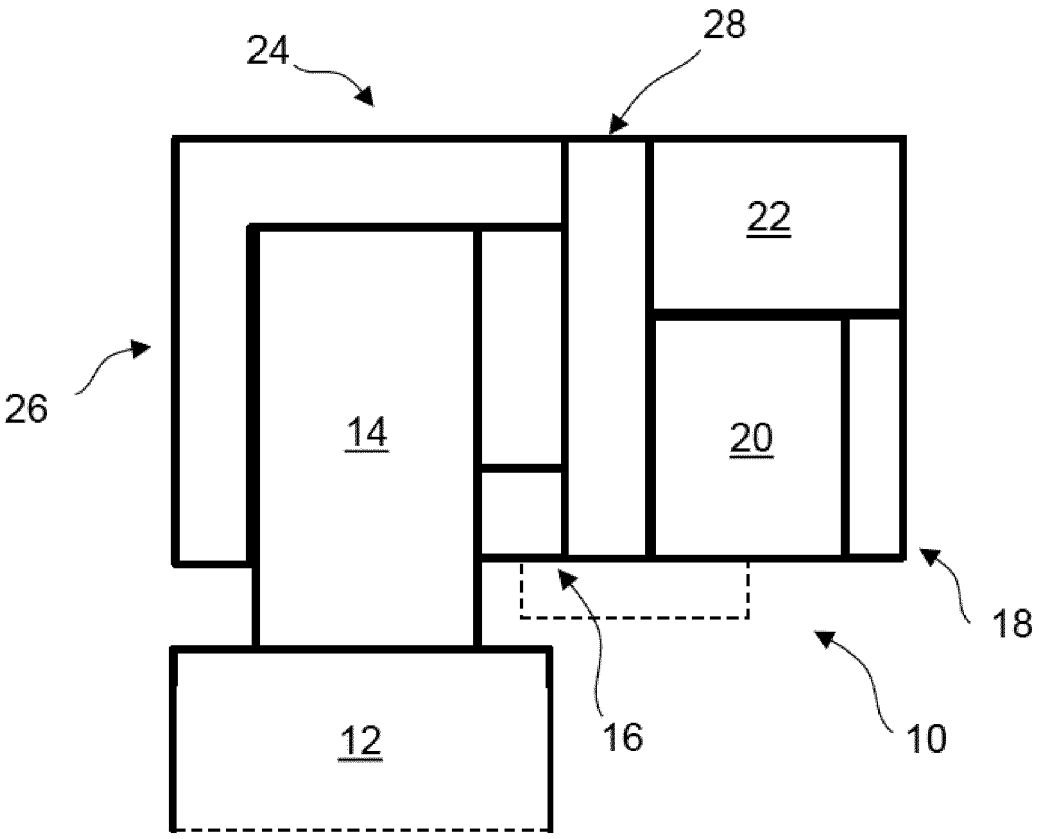

Fig. 3

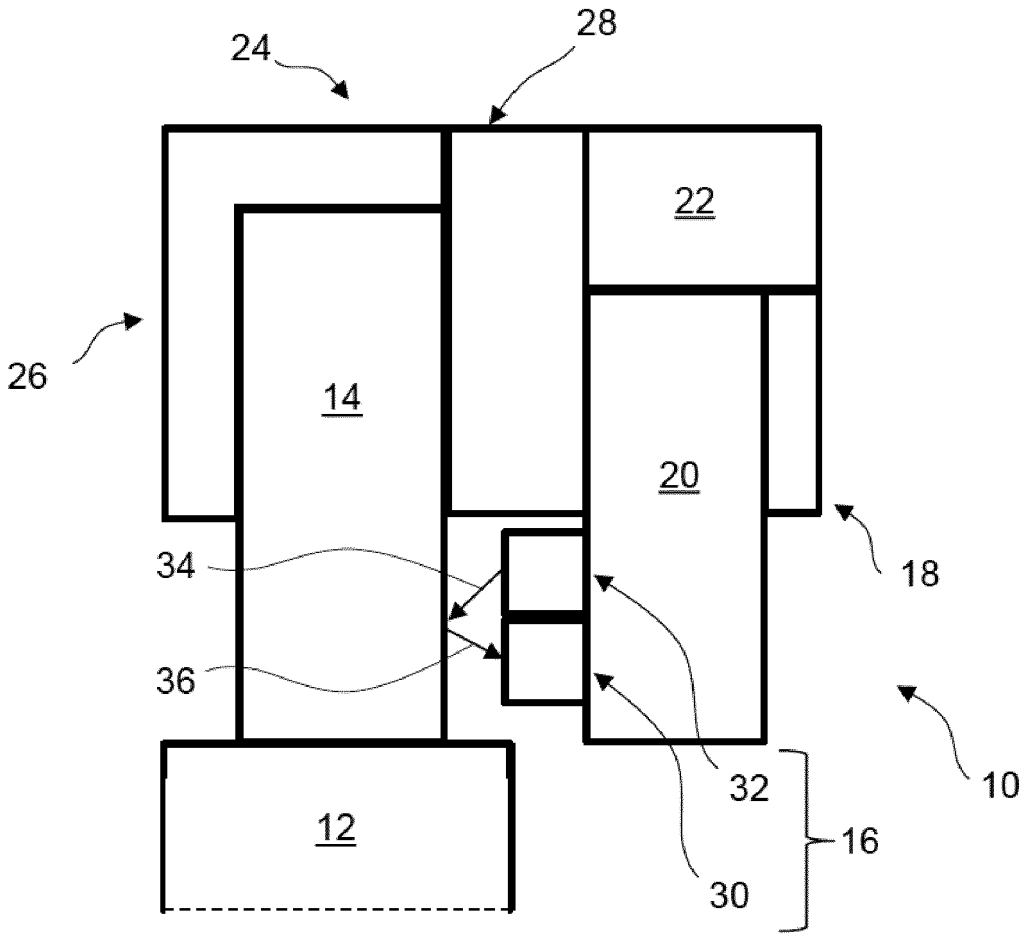

Fig. 4

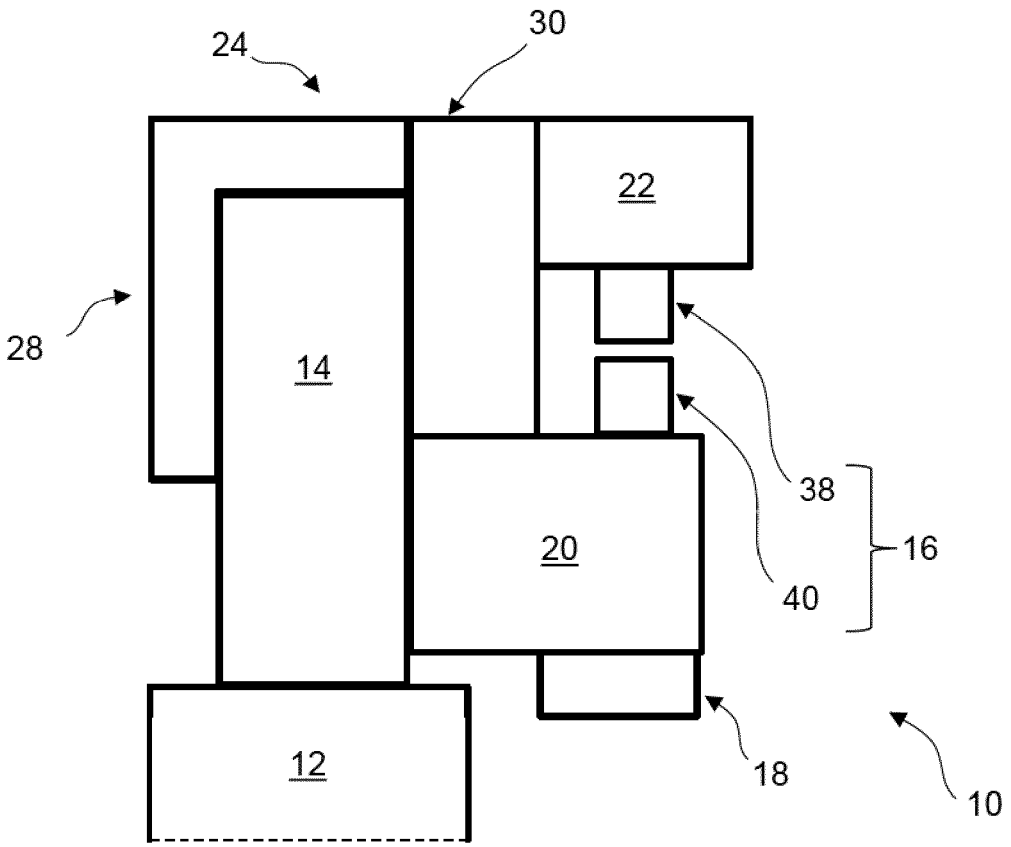

Fig. 5

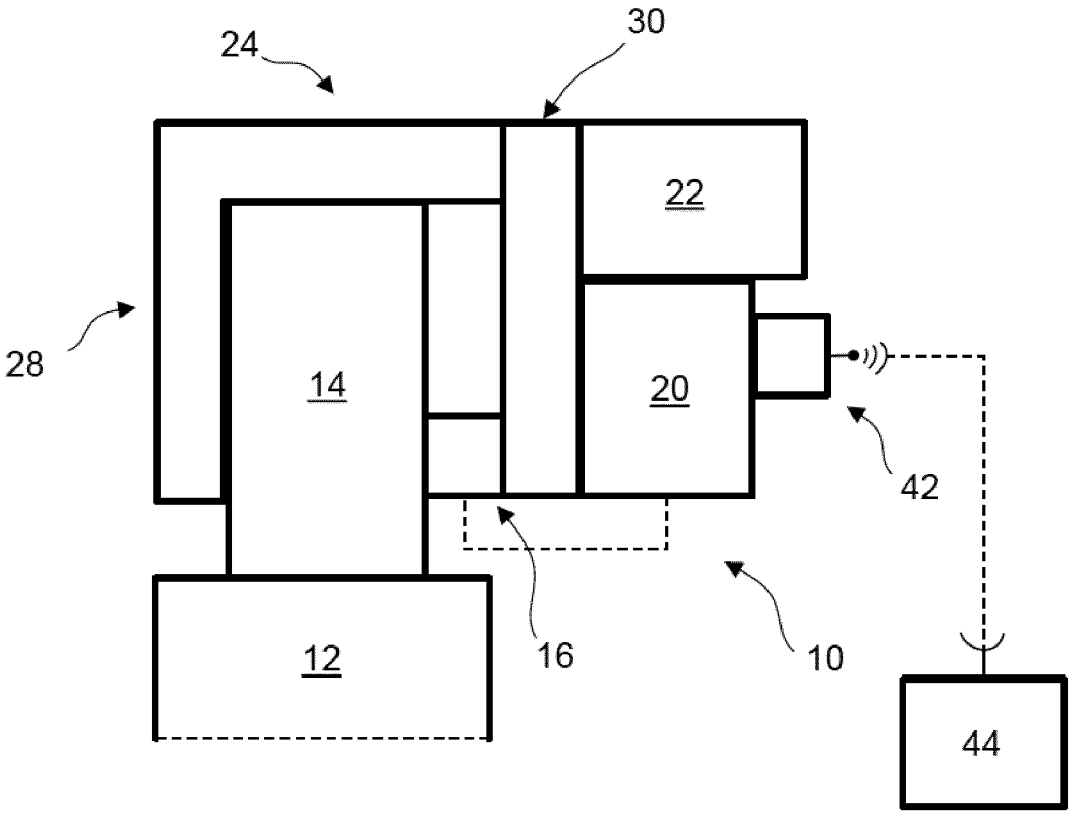

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 19 02 0362

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F17C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	18 December 2019	Papagiannis, Michail

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