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(54) **SYSTEM, COMPRISING AN ASSEMBLY AND A REMOTE SERVER**

(57) The present invention relates to a system comprising an assembly (5) and a remote server (10), wherein the assembly (5) comprises at least a first technical component and a second technical component, wherein the first and the second technical components preferably are gas cylinders (1), wherein there is provided a sensor (6) for determining a first measurement value, the sensor (6) being provided for the first technical component, the second technical component, or the assembly (5) as a whole, further comprising a transmission module (9) for sending the first measurement value to the remote server (10), wherein a first threshold value, a second threshold value, and a third threshold value are stored on the remote server (10), and wherein the remote server (10) is configured to issue an alarm when the measurement value exceeds at least one of the threshold values.

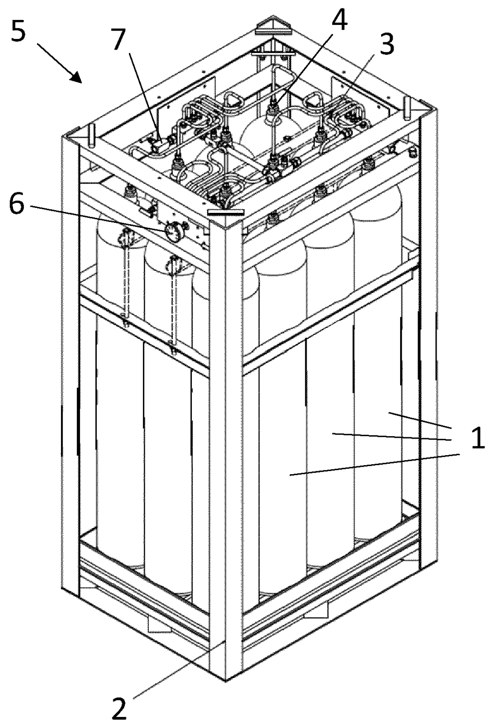

Fig. 1

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(52) Cooperative Patent Classification (CPC): (Cont.)
F17C 2250/0636; F17C 2260/024;
F17C 2260/042; F17C 2270/05

Description

[0001] The invention relates to a system comprising an assembly and a remote server, wherein the assembly comprises at least a first technical component and a second technical component, wherein the first and the second technical components preferably are gas cylinders.

[0002] In the state of the art, telemetry systems are known to surveil the state of individual gas cylinders, see for example US 5,953,682. This disclosure teaches to provide a collar for each gas cylinder of a plurality of gas cylinders. These collars act as individual storage devices and transmitters for data relating to the gas cylinder. For example, the collar can store data relating to an inventory status such as a serial number of the gas cylinder or shipping information.

[0003] Furthermore, US 5,953,682 also teaches to store measurement data of physical sensors on the collar, see for example figures 12 and 13 disclosed therein. It is taught to transmit the measurement data to a host computer, which is programmed to cause an alarm in the event that the process gas pressure varies outside of preselected limits, for example.

[0004] In reference to figure 1 of US 5,953,682, it can also be seen that a single host computer can be used to monitor a plurality of gas cylinders, each having its own collar. While this system is reliable for the purpose for which it was designed, i.e., the monitoring of individual gas cylinders, it has the drawback that each new gas cylinder in such a system must be equipped with a new collar and new sensors. In turn, each sensor is observed individually by the host computer. These systems are not flexible and deliver telemetry information only for the component they are installed on, e.g., the pressure value from a pressure sensor.

[0005] It is an object of the invention to provide a more flexible system for remotely monitoring a system comprising a plurality of technical components, especially gas cylinders.

[0006] This object is achieved by means of a system comprising an assembly and a remote server, wherein the assembly comprises at least a first technical component and a second technical component, wherein the first and the second technical components preferably are gas cylinders, wherein there is provided a sensor for determining a first measurement value, the sensor only being provided for (e.g., only attached to) the first technical component, the second technical component, or the assembly as a whole, further comprising a transmission module for sending the first measurement value to the remote server, wherein a first threshold value, a second threshold value, and a preferably also third threshold value are stored on the remote server, wherein the optional first threshold value corresponds to a tolerance range of the first technical component, the second threshold value corresponds to a tolerance range of the second technical component and the third threshold value corresponds to a tolerance range of the assembly as a whole, and wherein at least two of the threshold values are different from each other, and wherein the remote server is configured to receive the measurement value from the transmission module and to issue a warning message when the measurement value exceeds at least one of the threshold values.

[0007] The present invention has the advantage of monitoring data also for parts and components in an assembly which are themselves not equipped with sensors and thus enables an indirect monitoring. This is possible because the different technical components share a common world location and/or common environmental parameters, for example, making it possible to extend the measurement value of one sensor to other technical components. The invention therefore strongly facilitates the finding of substructures of the assembly that are responsible for failure, wear and disfunctions of the whole assembly. It is a strong tool for preemptive maintenance and functional safety of complex assemblies and their components.

[0008] In other words, the invention enables the extension of measurement values from one technical component to other technical components or to the assembly of technical components as a whole. Therefore, the invention surpasses the classical understanding that the measurement data of a sensor should only be used for the technical component it is mounted on. The invention, however, teaches to take the measurement values of one sensor of a certain technical component or of the assembly as a whole and determine if this measurement value exceeds the threshold values of other technical components or of the assembly as a whole.

[0009] The sensor could in principle measure any physical measurement value relevant to one or more technical components, preferably relevant to all technical components of the assembly, and relevant to the assembly as a whole. This could for example be an ambient temperature, which could be measured only by a sensor of one of the technical components, or a temperature or mass flow of a fluid running through a tubing connecting two or more technical components, especially gas cylinders. It is especially preferred, however, if the sensor is a shock sensor, e.g., an accelerometer, and the first threshold value corresponds to a maximum permissible shock value of the first technical component, the second threshold value corresponds to a maximum permissible shock value of the second technical component, the third threshold value corresponds to a maximum permissible shock value of the assembly as a whole, for example of the carrier frame.

[0010] It is especially preferred if said sensor is the only sensor of its type present in said assembly, i.e., the sensor is the only sensor of the assembly configured to output a predetermined physical measurement value such as a temperature, shock, pressure, mass flow, or the like. The invention is thus capable of extending the measurement value of only one sensor to all technical components and to the assembly as a whole, even if the sensor is only present on one of the technical components or on the carrier frame of the assembly, for example. Alternatively, it is at preferred if at least some of the technical components are not equipped with a sensor of the type of which the measurement value was obtained, but the threshold comparison is still performed for this technical component.

[0011] For example, only one gas cylinder could be equipped with a collar as taught in US 5,953,682, which could act as the sensor described above. Even if other gas cylinders of the assembly are not equipped with such a collar, it is possible to extend the measurement data on the collar of this gas cylinder onto other gas cylinders as well, even if they are of another type, or even onto the assembly as a whole. The collar could also be used as the transmission module of the present invention, for example.

[0012] In a preferred embodiment, the assembly comprises a carrier frame for mounting the technical components together, and the third threshold value corresponds to a tolerance range of the carrier frame. The carrier frame connects all technical components and therefore represents the assembly as a whole. For example, even if a shock would not lead to a failure of the technical components but of the carrier frame, the assembly as a whole would be compromised and possibly require maintenance.

[0013] Further preferably, the alarm is only issued for the technical component or for the assembly, respectively, of which the threshold value is exceeded by the measurement value. This makes it easier for the operator to determine which one of the technical components might require maintenance or if the assembly as a whole might be prone to failure. In other words, the alarm can comprise an indication of the cause of failure.

[0014] Furthermore, it is preferred if the transmission module is configured to transmit a unique identifier of the assembly and preferably also a list of unique identifiers of the technical components of the assembly to the remote server. Additionally or alternatively, the transmission module might be configured to transmit a type of the assembly and preferably also a list of types of the technical components of the assembly to the remote server. This has the advantage that only types and/or identifiers need to be transmitted from the transmission module to the remote server, but not the actual tolerance range itself. The remote server can in turn store a database, in which a mapping of types and/or identifiers with tolerance ranges is stored. For example, in this database it could be specified that the unique identifier X specifies a gas cylinder of type Y, which has a shock tolerance range of A and a temperature tolerance range B. Such mappings could be stored for multiple unique identifiers and/or types. In an initialization step, the transmission module could send a specification of the assembly to the remote server, e.g., stating the ID of the assembly and that it comprises five gas cylinders of type Y and four gas cylinders of type Z. When the transmission module then receives a measurement value from a sensor which is only provided for one of the gas cylinders, it can forward this measurement value together with only the ID of the assembly to the remote server, for example, where the remote server can retrieve, by means of the ID of the assembly, all tolerance ranges for all technical components of the assembly and tolerance ranges of the assembly itself. The measurement value could also be sent together with a unique identifier of the sensor, if the remote server has the information to which assembly this sensor belongs to.

[0015] It is therefore also preferred if the remote server comprises a database, which lists one or more tolerance ranges for types and/or unique identifications of technical components and/or assemblies. Thereby, technical components of the assembly can be quickly replaced, and this change only has to be indicated by means of changing a type or identification of the technical component.

[0016] The inventive system works especially is cases with mixed types of technical components, i.e., when the assembly further comprises a third technical component, which is of a different type than the first and second technical component, wherein a fourth threshold value is stored on the remote server, wherein the fourth threshold value corresponds to a tolerance range of the third technical component. For example, sensors could only be provided for one type of technical components, but the measurement values of this sensor can also be used for performing a threshold comparison with the other type of technical components. For example, the first and second technical components can be gas cylinders and the third technical component can be a tubing between the gas cylinders. The sensor could for example be a mass flow sensor which is only provided on one or more of the gas cylinders. The measurement value, here a measured mass flow, can be used for a threshold comparison whether the mass flow exceeds the tolerance range of one or more of the gas cylinders but also whether the mass flow exceeds the tolerance range of the tubing even though the tubing is not equipped with a mass flow sensor.

[0017] Furthermore, the remote server could be configured to send a control signal to a controllable entity, preferably a valve, of the assembly or of one of the technical components when issuing an alarm. Thereby, the system can automatically perform adequate actions after an event detection of a measurement value exceeding a threshold.

[0018] Further details and advantages of the system according to the invention will become more apparent in the following description and the accompanying drawings.

Figure 1 shows an assembly according to the invention, which comprises a plurality of gas cylinders on a carrier frame.

Figure 2 shows a block diagram detailing the components of an assembly according to the invention.

Figure 3 shows a schematic diagram of an interaction between the assembly and a remote server according to the invention.

[0019] Figure 1 shows a plurality of gas cylinders 1, i.e., twelve gas cylinders 1. The gas cylinders 1 are located in the vicinity of each other and coupled together by various means. For example, the gas cylinders 1 are located on a carrier frame 2 such that the gas cylinders 1 are coupled together in a physical sense, e.g., for transportation. Additionally or alternatively, the gas cylinders 1 can be coupled together by means of a tubing 3 as shown in figure 1, such that the fluids of the gas cylinders 1 are connected. Of course, valves 4 could be arranged between the gas cylinders 1 and the tubing 3 or within the tubing 3 to control the withdrawal of fluids, for example.

[0020] Together, the components shown in figure 1 form an assembly 5 as they share certain physical properties, such as location, temperature, or gas properties. However, the invention is not restricted to an assembly 5 of gas cylinders 1 but could also be extended to an assembly of other technical components such as components of cars or airplanes. For the sake of simplicity, the following description is explained by means of gas cylinders but could equally be extended to other assemblies of technical components under the limitations set forth below.

[0021] The present invention relates to observing the physical properties of the individual gas cylinders 1 but also of the assembly 5 as a whole. To this end, at least one sensor 6 is provided for one of the gas cylinders 1 (in general for a first technical component), or for the assembly 5 as a whole. If the sensor 6 is provided for the technical component, it can be mounted thereon, for example. If the sensor 6 is provided for the assembly 5 as a whole, it is usually not in direct contact with any of the technical components but could be mounted on the carrier frame 2, for example.

[0022] In one embodiment, the sensor 6 could be a shock sensor (e.g., an accelerometer) arranged directly on one of the gas cylinders 1 to measure a shock amplitude in g. It is a finding of the present invention that this shock amplitude is not only representative for the gas cylinder 1 the sensor is located on, but also for all other gas cylinders 1 of the assembly 5 and for the assembly 5 as a whole as well. This knowledge can be used to determine if the measured shock amplitude is relevant for the gas cylinder 1 for which it as measured, or if the measured shock amplitude is relevant for a different gas cylinder 1 because it might have a lower tolerance range than the gas cylinder 1 for which the shock value was initially measured. Furthermore, it can be determined if the measured shock amplitude is relevant for the assembly 5 as a whole, for example because the carrier frame 2 on which the gas cylinders 1 are placed has a lower tolerance range than the gas cylinder 1 for which the shock value was initially measured.

[0023] From the previous example it can be seen that a sensor 6 provided for one of the gas cylinders 1 (or technical components in general) can be used to surveil the status of other gas cylinders 1 or of the assembly 5 as a whole. Conversely, the sensor 6 could also be provided on the carrier frame 2, for example, and the measurement value could be used to surveil the individual gas cylinders 1. In this variant, a sensor 6 provided for the assembly 5 as a whole can be used to surveil the status of the gas cylinders 1 (or technical components in general).

[0024] Figure 2 shows how an assembly 5 of the present invention can be structured. One assembly 5 could comprise two or more gas cylinders 1 and a tubing 3 connecting said gas cylinders 1. Each gas cylinder 1 could comprise one or more sensors 6 and one or more valves 4. The tubing 3 could comprise one or more fittings 7, which could be controlled in the same way as the valves 4. Referring again to the general wording, the gas cylinders 1 and the tubing 3 are regarded as the technical components, which each may comprise one or more sensors 6 and optionally also one or more controllable entities (valves 4, fittings 7, ...).

[0025] Furthermore, figure 2 shows that the assembly 5 can also comprise a sensor 6 provided for the assembly 5 as a whole ("Sensor 5" in figure 2). For example, this sensor 6 could be a GPS sensor. A GPS based tolerance range for a gas cylinder 1 could for example be a predefined location because certain types of gas cylinders 1 can contain hazardous fluids, which may not be allowed to move outside of a restricted area (predefined location). As shown, the sensor 6 could be connected to the assembly via an optional data logger 8, which could also log data of all other sensors 6.

[0026] Furthermore, the assembly 5 comprises a transmission module 9 for communication with a remote server 10 (figure 3). The transmission module 9 is in particular configured for forwarding measurement values from the sensors 6 to the remote server 10 and optionally also for receiving control data from the remote server 10 to control the valves 4 or fittings 7.

[0027] As can further be seen from figure 2, the assembly 5 can be assigned an ID, for example a unique identification for all assemblies 5 in the system, and a type, for example to indicate that the assembly 5 is a plurality of coupled gas cylinders 1.

[0028] Furthermore, also the gas cylinders 1 can be assigned an ID, i.e., a unique identifier, and a type. The type can indicate the build of the gas cylinder 1, for example, such that tolerance ranges of the gas cylinder 1 can be inferred from the type of the gas cylinder 1. For example, in the remote server 10 there can be provided a database 13 in which the type and one or more tolerance ranges relating to various physical properties of the gas cylinder 1 can be stored. The same mappings can be applied to the tubing 3, for example, which can also have a type and an ID. In general, all technical components can be assigned a type and an ID.

[0029] Furthermore, also the sensors 6, controllable entities, and the data logger 8 can be assigned an ID and a type. Furthermore, in addition to the ID and the type, further data could be assigned to the assembly 5, the technical components, the sensors 6, controllable entities, and the data logger 8. For example, the further data could be one or more tolerance ranges for various other physical properties, a date of the last maintenance, or the like.

[0030] To track said information (ID, type, and further data), the data logger 8 could store this information for the assembly 5, for the technical components, for the sensors 6, for the controllable entities and for itself. Furthermore, the data logger 8 could store the relationship of said elements similar to a structure shown in figure 2, e.g., which sensor 6 and which controllable entity is connected to which technical component and which technical component is part of the assembly 5. The data logger 8 could thus be a data base, optionally with its own computer. While figure 2 shows the relationship between these elements, it is to be understood that the sensors 6 and controllable entities could be directly connected to the data logger 8, for example, such that the data logger 8 could directly record data from the sensors 6 or forward said data via the transmission module 9.

[0031] Referring now to figure 3, it can be seen that the transmission module 9 forwards at least one measurement value from at least one of the sensors 6 to the remote server 10. To this end, the remote server 10 can comprise a transceiver 11. The transmission module 9 and the transceiver 11 can communicate according to one or more communication standards known in the art, for example via a cellular network. To enable communication between the transmission module 9 and the transceiver 11, there could also be provided at least one proxy, for example a reader. In one embodiment, the transmission module 9 could be a RFID tag and the reader could be an RFID reader for reading information from the transmission module 9. The reader could then forward the information to the transceiver 11 via a cellular network, for example.

[0032] To process the measurement value received from the transmission module 9, the remote server 10 can comprise a processor 12 connected to the transceiver 11. Furthermore, figure 3 shows that the database 13 can be connected to the processor 12. However, this is optional as the data stored in the database 13 could be transmitted directly from the transmission module 9 to the transceiver 11. In such a case, the data specified in the following is at least stored temporarily on the remote server 10.

[0033] The data stored in the database 13 (or more generally on the remote server 10) comprises a first threshold value, a second threshold value, and a third threshold value. The first threshold value corresponds to a tolerance range of the first technical component, the second threshold value corresponds to a tolerance range of the second technical component and the third threshold value corresponds to a tolerance range of the assembly 5 as a whole. In other words, the data stored on the remote server 10 indicates physical properties of the technical components and of the assembly.

[0034] For example, a first gas cylinder 1 might be of a first type, and breakage of such a first type of gas cylinder 1 could occur at a shock amplitude of 3g according to the specifications of the manufacturer. A second gas cylinder 1 might be of a second type, which is different from the first type, and breakage of such a second type of gas cylinder 1 could occur at a shock amplitude of 2.8g according to the specifications of the manufacturer. The assembly 5 as a whole might in turn be designed for a completely different maximum shock value, for example because the carrier frame 2 of the assembly 5 could exhibit a maximum shock amplitude of 1.5g.

[0035] However, the measurement value received by the transceiver 11 of the remote server 10 originally stems from sensor 1 of one of the gas cylinders 1 (in general of one of the technical components) such that in classical theory, the measurement value of the sensor 6 located on the first gas cylinder 1 would only be used to determine if this measurement value lies within the tolerance range of the first gas cylinder 1. According to the invention, however, an enhanced threshold value check is performed and it is checked whether the measurement value lies within the tolerance range of all (or at least two) technical components of the assembly 5 and/or within the tolerance range of the assembly 5 as a whole.

[0036] To this end, the processor 12 performs a threshold value check if the received measurement value exceed any of the stored or received threshold values available and relating to the measurement value. To expand on this, for a certain technical component there could be stored multiple threshold values, e.g., a first threshold value indicating a tolerance range for a shock value and a second threshold value indicating a tolerance range for a temperature value. If the received measurement value is a shock value, the threshold comparison is only performed for the threshold values relating to a tolerance range for shock. Similarly, the transceiver 11 could receive a measurement value of a different sensor 6, for example a temperature sensor, such that the other threshold value would be taken for the threshold comparison.

[0037] Referring back to the example of a first gas cylinder 1 with a shock amplitude of 3g, a second gas cylinder 1 with a shock amplitude of 2.8g and a carrier frame 2 with a maximum shock amplitude of 1.5g, the remote server 10 performs three threshold value comparisons, even if only one measurement value of one sensor 6 of one of the gas cylinders 1 is received. In general, the threshold comparison for the threshold value of the assembly 5 as a whole could be optional. For example, the remote server 10 could receive the information that the sensor 6 of the first gas cylinder 1 measured a shock amplitude of 2g. The threshold comparisons would determine that this measurement value is no concern for the first gas cylinder 1 and the second gas cylinder 1, but the measurement value lies outside of the tolerance range of the carrier frame 2. In such a situation, the processor 12 (or in general the remote server 10) would issue an alarm.

[0038] To issue an alarm, the remote server could locally display an alarm message on a monitor 14 or play an alarm sound. Additionally or alternatively, an alarm could be sent to an operator's phone or to a different computer. Furthermore, an alarm could be sent back to the transmission module 9 such that an alarm message or an alarm sound could be output directly on or near the assembly 5.

[0039] As is indicated in figure 2, there can be more than one assembly 5. The second assembly 5 could have the same or a similar structure as the assembly 5 specified above. The second assembly 5 could forward the measurement value of one of its sensors 6 to the same remote server 10 as the first assembly 5. In such a case, corresponding threshold values of the technical components of this assembly 5 and threshold values of the assembly 5 as a whole can be stored on the remote server 10. To discern between the two assemblies 5, the aforementioned unique identifiers of the assemblies 5 and/or of the technical components can be used.

Claims

1. System comprising an assembly (5) and a remote server (10), wherein the assembly (5) comprises at least a first technical component and a second technical component, wherein the first and the second technical components preferably are gas cylinders (1), wherein there is provided a sensor (6) for determining a first measurement value, the sensor (6) being provided for the first technical component, the second technical component, or the assembly (5) as a whole,

   further comprising a transmission module (9) for sending the first measurement value to the remote server (10),
   characterized in that
   a first threshold value, a second threshold value, and preferably also a third threshold value are stored on the remote server (10), wherein the first threshold value corresponds to a tolerance range of the first technical component, the second threshold value corresponds to a tolerance range of the second technical component and the optional third threshold value corresponds to a tolerance range of the assembly (5) as a whole, and wherein at least two of the threshold values are different from each other, and
   wherein the remote server (10) is configured to receive the measurement value from the transmission module (9) and to issue an alarm when the measurement value exceeds at least one of the threshold values.

2. System according to claim 1, wherein the assembly (5) comprises a carrier frame (2) for mounting the technical components together, and the third threshold value preferably corresponds to a tolerance range of the carrier frame (2).

3. System according to claim 1 or 2, wherein the sensor (5) is a shock sensor, preferably an accelerometer, and the first threshold value corresponds to a maximum permissible shock value of the first technical component, the second threshold value corresponds to a maximum permissible shock value of the second technical component, the third threshold value corresponds to a maximum permissible shock value of the assembly (5) as a whole.

4. System according to any one of claim 1 to 3, wherein the alarm is only issued for the technical component or for the assembly (5) as a whole, respectively, of which the threshold value is exceeded by the measurement value.

5. System according to any one of claim 1 to 4, wherein the transmission module (9) is further configured to transmit a unique identifier of the assembly (5) and/or a list of unique identifiers of the technical components of the assembly (5) to the remote server (10).

6. System according to any one of claim 1 to 5, wherein the transmission module (9) is further configured to transmit a type of the assembly (5) and/or a list of types of the technical components of the assembly (5) to the remote server (10).

7. System according to any one of claim 1 to 6, wherein the remote server (10) comprises a database (13), which lists one or more tolerance ranges for types and/or identifications of technical components and/or assemblies (5).

8. System according to any one of claim 1 to 7, wherein the assembly (5) further comprises a third technical component, which is of a different type than the first and second technical component, wherein a fourth threshold value is stored on the remote server (10), wherein the fourth threshold value corresponds to a tolerance range of the third technical component.

9. System according to claim 8, wherein the first and second technical components are gas cylinders (1) and the third technical component is a tubing (3) between the gas cylinders (1).

10. System according to any one of claim 1 to 9, wherein the remote server (10) is configured to send a control

signal to a controllable entity, preferably a valve (4), of the assembly (5) or of one of the technical components when issuing an alarm.

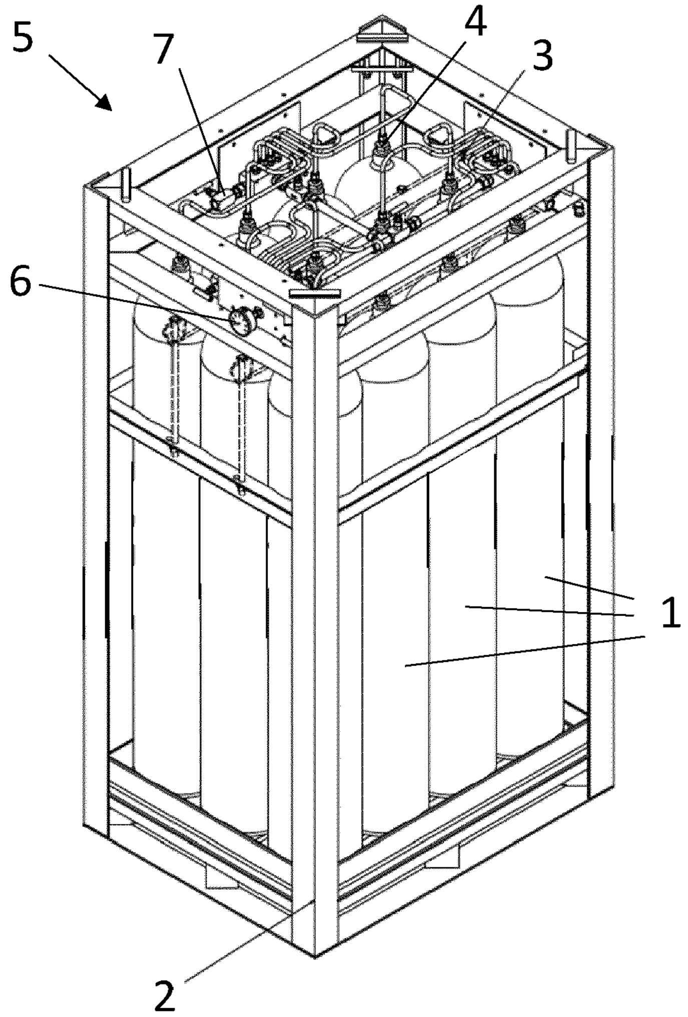

Fig. 1

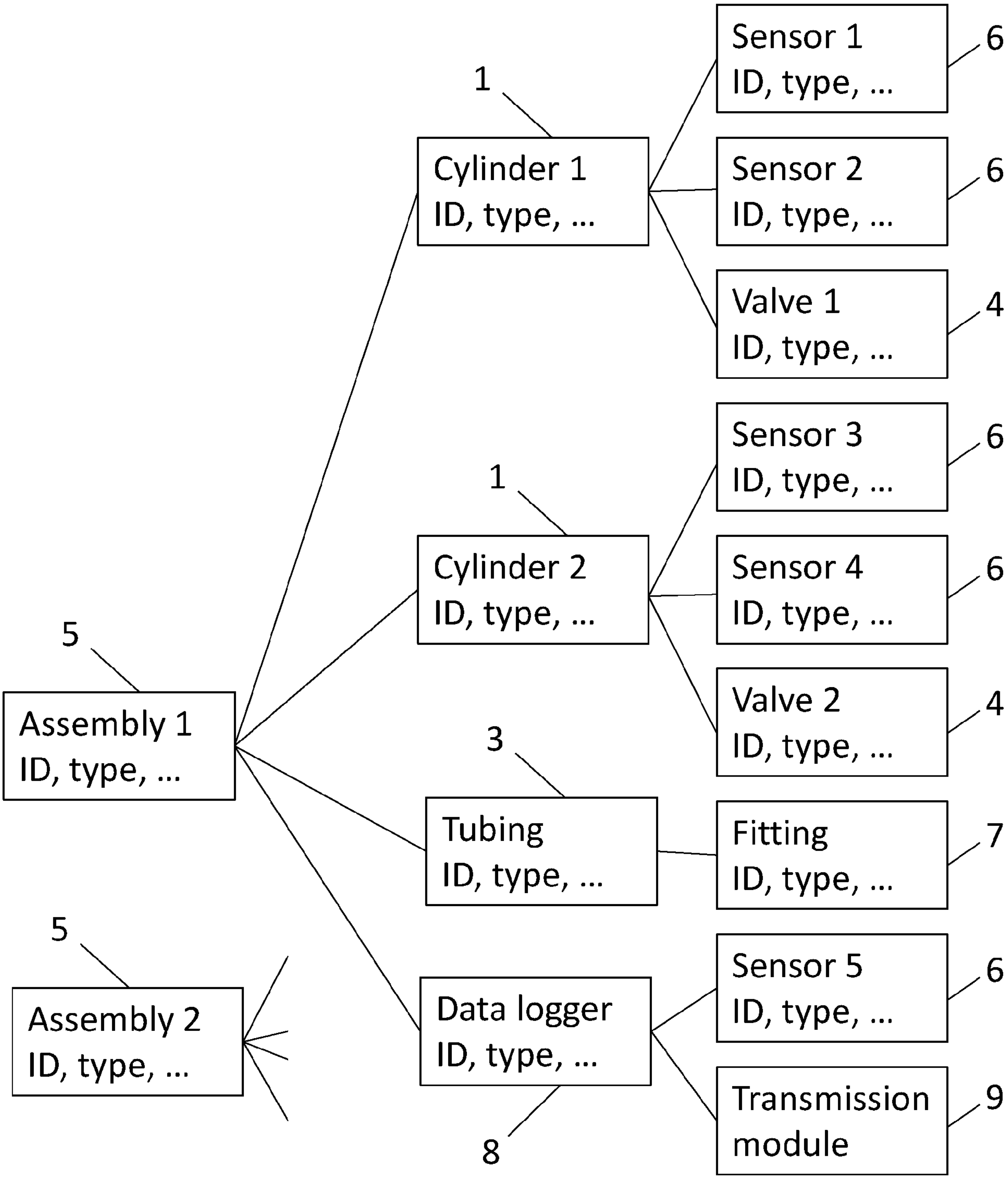
Sensor 1
ID, type, ...
6
1
Cylinder 1
ID, type, ...
Sensor 2
ID, type, ...
6
Valve 1
ID, type, ...
4
Sensor 3
ID, type, ...
6
1
Cylinder 2
ID, type, ...
Sensor 4
ID, type, ...
6
5
Valve 2
ID, type, ...
4
Assembly 1
ID, type, ...
3
Tubing
ID, type, ...
Fitting
ID, type, ...
7
5
Sensor 5
ID, type, ...
6
Assembly 2
ID, type, ...
Data logger
ID, type, ...
Transmission
module
9
8

Fig. 2

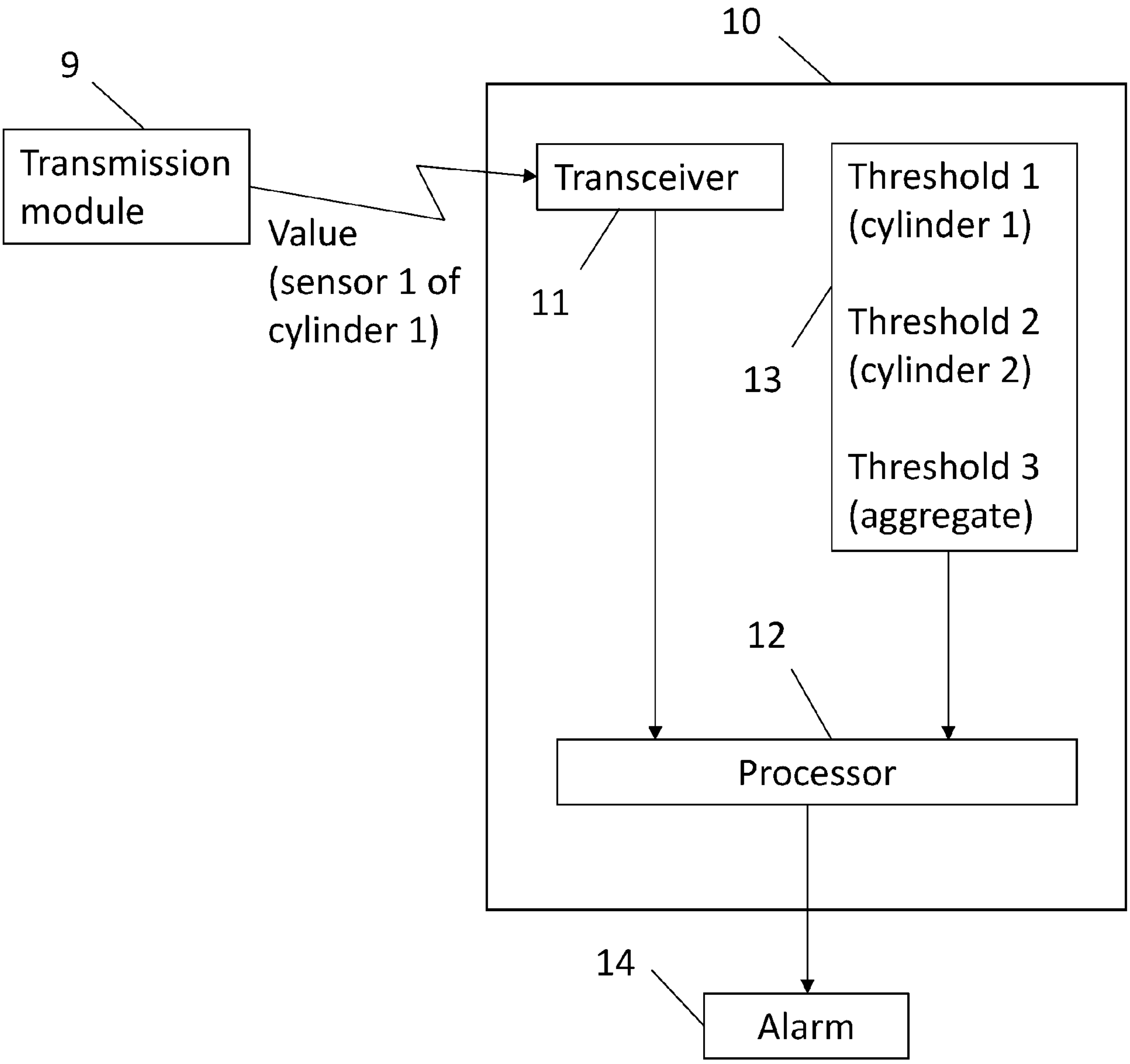
9
Transmission module
Value (sensor 1 of cylinder 1)
10
Transceiver
11
Threshold 1 (cylinder 1)
Threshold 2 (cylinder 2)
Threshold 3 (aggregate)
13
12
Processor
14
Alarm

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 23 16 2354

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 2015/014572 A1 (KRONES AG [DE]) 5 February 2015 (2015-02-05) * pages 12,29; figure 20 * -----	1-10	INV. F17C13/02 F17C13/08
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A	EP 3 250 438 B1 (FUELIE SYSTEMS INC [US]) 9 January 2019 (2019-01-09) * paragraphs [0052] - [0054] * -----	1-10	
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TECHNICAL FIELDS SEARCHED (IPC)

F17C

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	29 August 2023	Papagiannis, Michail

CATEGORY OF CITED DOCUMENTS

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