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(54) Title: A METHOD FOR CONTROLLING USAGE OF A REPLACEMENT PART OF A VEHICLE

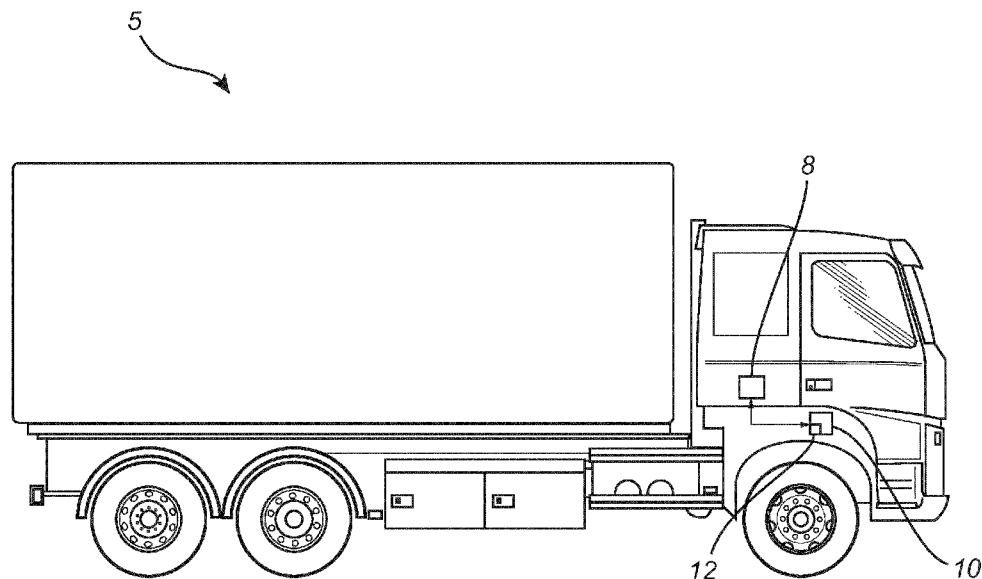


Fig. 1

(57) Abstract: The invention relates to a method (100) for controlling usage of a temporary 3-D printed replacement part installed in a machine or vehicle, the temporary 3-D printed replacement part having an associated characteristics and being configured to permit usage monitoring, wherein the method comprises the steps of: determining (140) a usage restriction of the temporary 3-D printed replacement part in the machine or vehicle based on the characteristics of the temporary 3-D printed replacement part; and monitoring (150) usage of the temporary 3-D printed replacement part in the machine or vehicle based on the determined usage restriction.



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A method for controlling usage of a replacement part of a vehicle**TECHNICAL FIELD**

The invention relates to a method for controlling usage of a temporary 3-D printed replacement part installed in a machine or vehicle.

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Although the invention will be described in relation to a truck, the invention is not restricted to this particular vehicle, but may also be used in other types of vehicles such as buses, construction equipment, cars, industrial construction machines, working machines, wheel loaders, etc. Furthermore, the invention may not be restricted to vehicles, but may also be

10 used in various types of stationary machines.

BACKGROUND

In connection with maintenance work and services of machines and vehicles, it may sometimes be required to use replacement parts, i.e. spare parts, for the repair of the machine or vehicle, or replacement of damaged parts. However, replacement parts may both differ in quality relative each other and differ in quality relative the original quality of the original components. That said, there is often a need for a trade-off between the quality of the replacement part and the lead time for receiving a high-quality replacement part since a long lead time may be detrimental for the users of the machines and vehicles.

20 Further, there is an increasing demand on e.g. plant managers to control costs and reduce costs related to having a comprehensive replacement part inventory. Similarly, performing maintenance work of failed parts of machines and vehicles may involve a considerable amount of labour work, while causing the machines to be shut down or vehicles to be at standstill during service and maintenance work. In other words, extensive lead times for receiving high quality replacements parts or performing services on the machines and vehicle generally cause performance disruption for the users of the machines and vehicles. Still, if failed components of a vehicle are not replaced with new parts, the vehicle may be more severely damaged, thus leading to a longer performance disruption.

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Further, there is an increasing demand for identifying various processes and systems to reduce operational costs, while increasing, or at least maintaining, the efficiency of the machines and vehicles.

In addition, it would be desirable to minimize operational disruption of machines or vehicles, while maintaining reliable operations of the machines and vehicles during everyday use thereof.

5 SUMMARY

An object of the invention is to provide an improved method for ensuring that temporary replacement parts installed in machines and vehicles, and obtained from 3-D printers, are used under appropriate operational conditions. The object is at least partly achieved by a method according to claim 1.

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According to a first aspect of the invention, there is provided a method for controlling usage of a temporary 3-D printed replacement part installed in a machine or vehicle. The temporary 3-D printed replacement part has an associated characteristic and being configured to permit usage monitoring. The method comprises the steps of determining a
15 usage restriction of the temporary 3-D printed replacement part in the machine or vehicle based on the characteristic of the temporary 3-D printed replacement part; and monitoring usage of the temporary 3-D printed replacement part in the machine or vehicle based on the determined usage restriction.

In this manner, the method according to the example embodiments allows for operating a
20 machine or vehicle using one or more temporary replacement parts in a reliable and efficient manner by taking the durability of the temporary 3-D printed replacement part into consideration. In other words, the present invention relates to operations of machines and vehicles that are using one or more 3-D printed components as replacement parts until a conventional spare part or original component is available to be installed in the machine
25 or vehicle. The temporary 3-D printed replacement part is intended to be used temporarily to support uptime until a more permanent part can be delivered in the form of a conventional spare part or an original component. The temporary 3-D printed replacement part thus serves the purpose of providing a provisional means for the operator or user of the vehicle to ensure that the vehicle can be set back in operation. That is, temporary 3-D
30 printed replacement parts are typically used for urgently needed parts that cannot be supplied quick enough with the traditional supply chain.

Typically, temporary 3-D printed parts may generally not have the same material qualities as standard parts, including conventional spare parts and original components. At least

for this reason, 3-D printed parts may not be as durable as standard parts. If the 3-D printed part is used e.g. in a different manner than intended, or above its material characteristic, it may break and cause damages to the machine or vehicle. Further, 3-D printed parts may be produced by a number of different technologies and from a number of different materials, thus causing a variation in quality of the parts during use in the machine or vehicle.

To this end, the example embodiments of the method provide not only for determining a usage restriction for the 3-D printed replacement part when installed in e.g. a vehicle, but also for monitoring the usage of the 3-D printed replacement part in the vehicle. In this manner, it becomes possible to limit the use of the temporary 3-D printed replacement part based on its characteristic (e.g. the material of the part). By way of example, the example embodiments of the method may allow for regulating the use of the temporary 3-D printed replacement part based on a time period and/or based on operational parameters and conditions of the vehicle. As such, the method according to the example embodiments provides for monitoring that 3-D printed replacement parts are not used more extensively than they can endure in the vehicle.

Further, the method according to the example embodiments allows for securing that temporary replacement parts are not used outside defined operational restrictions.

In the context of the example embodiments, the term “temporary 3-D printed replacement part” refers to an interchangeable part obtained by a 3-D printer. A temporary 3-D printed replacement part is thus a so called “bridge part” for the machine or vehicle, and is a component related to at least one function of the machine or the vehicle and/or at least one safety aspect of the vehicle or the machinery. Due to the manufacturing and the materials of the temporary 3-D printed replacement part, the part typically has an associated characteristic, i.e. an inherent characteristic, that is different to a corresponding characteristic of an ordinary (sometimes also denoted as a genuine) corresponding part or a corresponding standard replacement part for the ordinary (genuine) part.

The characteristic of the 3-D printed replacement part is often, although not always, of a different quality than the corresponding characteristic of the ordinary corresponding part or the corresponding standard replacement part for the ordinary part. At least for this

reason, the 3-D printed replacement part is only intended for being used in the vehicle for a defined period of time. Thus, a 3-D printed replacement part is generally considered and used as a temporary replacement part.

- 5 Accordingly, a temporary 3-D printed replacement part is a component having an associated characteristic that is lower than a corresponding characteristic of a standard component. Further, the temporary 3-D printed replacement part has at least one associated characteristic making it less suitable for conventional use in the machine or the vehicle. In the context of the example embodiments, the term “associated characteristic”,
10 as used herein, typically refers to any one of a function, material, structure, quality and shape of the temporary 3-D printed replacement part. In some example embodiments, the temporary 3-D printed replacement part replace an assembly of a number of components or parts.
- 15 By way of example, the temporary 3-D printed replacement part may be any one of a holder for a side view mirror, an underrun protective device and a side panel. However, the type of temporary 3-D printed replacement part is not limited to these components, but may be any type of part of the machine or vehicle.
- 20 It may also be noted that the machine or the vehicle may include other 3-D printed non-temporary parts which do not need to be monitored.

The usage restriction for the temporary 3-D printed replacement part can be provided in several different manners and may typically vary depending on type of part and type of
25 machine/vehicle. Typically, the usage of the temporary 3-D printed replacement part is restricted during use of the machine or the vehicle. Further, the usage restriction of the temporary 3-D printed replacement part is typically based on when the temporary 3-D printed replacement part will be replaced with an ordinary component, i.e. the genuine component.

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When the monitored usage of the temporary 3-D printed replacement part is above a threshold, the method may provide a notification to the machine or the vehicle. In addition, or alternatively, when the monitored usage of the temporary 3-D printed replacement part is above a threshold, the method may provide a notification to the user of the machine or
35 the driver of the vehicle. In addition, or alternatively, when the monitored usage of the

temporary 3-D printed replacement part is above a threshold, the method may provide a notification to a fleet management system or a so-called VAS (vehicle alarm system). Accordingly, the monitored usage of the temporary 3-D printed replacement part may trigger a notification to the operator of the machine or the vehicle. In this manner, it becomes possible to prevent overuse of the temporary 3-D printed replacement part in the machine or the vehicle.

The usage restriction may be a predetermined value of an operational parameter associated with any one of the temporary 3-D printed replacement part, the machine and vehicle. In addition, or alternatively, the usage restriction is a value of an operational parameter that is updated based on the ordinary use of the machine or vehicle. The usage restriction may e.g. refer to a critical safety operational condition of any one of the temporary 3-D printer replacement part and the machine/vehicle.

The usage restriction of the temporary 3-D printed replacement part is determined based on the associated characteristic of the part, and may e.g. be determined from the material and structure of the temporary 3-D printed replacement part, derivable from the manufacturer of the 3-D printer, derivable from the type of 3-D printer replacement part, determined based on the type of machine/vehicle, determined based on the type of installation of the 3-D printed replacement part in the machine/vehicle or any combination thereof. The usage restriction of the temporary 3-D printed replacement part is subsequently stored in the control unit.

By way of example, the usage restriction corresponds to any one of an operational parameter of the temporary 3-D printed replacement part and an operational parameter of the machine or vehicle. Such operational parameter may advantageously be used for monitoring the status of the temporary 3-D printer replacement part. In one example embodiment, the usage restriction is an operational parameter of the temporary 3-D printed replacement part. In another example embodiment, the usage restriction is an operational parameter of the machine or vehicle. In another example embodiment, the usage restriction is a combination of an operational parameter of the temporary 3-D printed replacement part and an operational parameter of the machine or vehicle.

Further, the operational parameter of the temporary 3-D printed replacement part may be any one of a maximum operational time period of the temporary 3-D printed replacement

part, a maximum travelling distance of the temporary 3-D printed replacement part and a maximum load of the temporary 3-D printed replacement part. Such operational parameter may advantageously be used for monitoring the status of the temporary 3-D printed replacement part.

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In one example embodiment, the maximum operational time period is a dynamic time period depending on the use of the machine or vehicle.

Typically, the operational parameter of the machine or vehicle is any one of a maximum travelling distance, maximum operational time, maximum speed, maximum payload level and geographical location of the machine or vehicle. Such operational parameter may advantageously be used for monitoring the status of the temporary 3-D printed replacement part.

15 According to one example embodiment, the usage restriction is based on a lead time for receiving an ordinary machine or vehicle component. By way of example, if the temporary 3-D printed replacement part will be replaced with an original part associated with a long lead time, the usage restriction may have a more severe restriction or many different usage restrictions compared to a part associated with a short lead time.

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According to one example embodiment, the method comprises the step of further adjusting usage of the temporary 3-D printed replacement part in the machine or vehicle based on the monitored usage of the temporary 3-D printed replacement part in the machine or vehicle.

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By way of example, the step of further adjusting usage of the temporary 3-D printed replacement part in the machine or vehicle based on the monitored usage of the temporary 3-D printed replacement part in the machine or vehicle comprises further restricting usage of the temporary 3-D printed replacement part in the machine or vehicle if the monitored usage of the temporary 3-D printed replacement part exceeds a threshold. Depending on the type of usage restriction, replacement part and machine/vehicle, the threshold may refer to any one of a time limit, a payload weight, a distance and a vehicle speed. In this manner, it becomes possible to further restrict the usage of the temporary 3-D printed replacement part if the monitored usage of the part indicates a critical change in operation of the machine/vehicle. The threshold value may

typically be a predetermined value stored in the control unit. In addition, or alternatively, the threshold value may be updated based on the ordinary use of the machine or vehicle.

According to one example embodiment, the step of further adjusting usage of the

5 temporary 3-D printed replacement part in the machine or vehicle based on the monitored usage of the temporary 3-D printed replacement part comprises setting the machine or vehicle in a reduced minimum operational state. In this manner, it may be possible to safeguard that the machine or vehicle can reach a service station without having the replacement part broken or the vehicle becomes damaged.

10

Monitoring usage of the temporary 3-D printed replacement part in the vehicle can be performed in several different ways and depends on e.g. type of part, type of machine/vehicle and type of usage restriction. According to one example embodiment, the step of monitoring usage of the temporary 3-D printed replacement part in the machine or
15 vehicle based on the determined usage restriction is performed by using a digital twin model of the machine or vehicle. In this context, the “digital twin model” typically refers to a digital copy of the machine/vehicle. A digital twin model is arranged to monitor the current state of all critical components in the machine/vehicle and typically also arranged to keep track of the components of the machine/vehicle. By way of example, each
20 component may have a unique identification and a means for communicating its usage to a control unit or the like. In this manner, the method is capable of identifying the temporary 3-D printed replacement part in the vehicle.

Typically, although strictly not required, the digital twin model is stored locally in the
25 machine or vehicle. Further, the digital twin model may be updated on a regular basis. In addition, or alternatively, the digital twin model may be stored in a cloud server arranged in networked communication with the machine or vehicle for immediate monitoring of the temporary 3-D printed replacement part.

30 The usage of the installed temporary 3-D printed replacement part in the vehicle can be detected in several different manners. Typically, the temporary 3-D printed replacement part comprises a sensor arranged to gather data indicating usage of the temporary 3-D printed replacement part. Typically, although not strictly required, the step of monitoring usage of the 3-D printed replacement part in the vehicle is performed by a sensor unit
35 configured to monitor the usage based on the determined usage restriction. Thus, the

sensor is configured to receive information indicative of the usage of the 3-D printed replacement part at a given point in time. It should be readily appreciated that the step of monitoring the usage of the 3-D printed replacement part is typically performed over time.

- 5 According to one example embodiment, the replacement part comprises the sensor. The sensor may be any type of sensor capable of measuring a usage of the replacement part. These types of sensors are commonly available, and several different options are conceivable depending on type of replacement part and usage restriction to be monitored. By way of example, the sensor is any one of an accelerometer, a gyro, an angle sensor,
10 an optical fiber, a pressure transducers, a temperature sensor, a strain gauge and a position sensors.

The sensor may be arranged in communication with the control unit of the machine or vehicle, thereby allowing for transfer of data indicative of the usage of the temporary 3-D
15 printed replacement part to the control unit.

According to one example embodiment, the method further comprises the initial steps of: identifying a damaged or failed component part in the machine or vehicle; identifying a 3-D printer to produce a 3-D printed replacement part corresponding to the identified
20 damaged or failed component part; and receiving and installing the produced 3-D printed replacement part in the machine or vehicle. The 3-D printer is typically a standard 3-D printer used for printing 3-D shaped articles.

Optionally, the method may also comprise the step of ordering the 3-D printed
25 replacement part from a remote 3-D printer service manufacturer. In addition, or alternatively, the method may comprise the step of producing the 3-D printed replacement part at a remote 3-D printer service manufacturer. In some occasion, even the standard replacement part will be able to be printed at the remote 3-D printer service manufacturer.

30 By way of example, the step of identifying a damaged or failed component part in the machine or vehicle is performed by a software of a portable device. The portable device may e.g. be an app installed in a portable device.

According to one example embodiment, the method further comprises the steps of
35 ordering a genuine component part corresponding to the identified damaged or failed

component part, replacing the temporary 3-D printed replacement part with the genuine component part, and subsequently the step of terminating the reduced minimum operational state.

- 5 According to one example embodiment, the steps of the method are performed in sequence. However, at least some of the steps of the method can be performed concurrently.

The method according to the example embodiments can be executed in several different
10 manners. Generally, the steps of the method according to the example embodiments may be performed by a control unit. According to one example embodiment, the steps of the method are performed by a control unit during use of the machine or vehicle. The method may be continuously running as long as the machine or vehicle is operative, but also continuously running when the machine or vehicle is in a non-operative state, e.g. during
15 a charging operation (if the machine or vehicle comprises an electric propulsion system). The sequences of the method may likewise be performed by other types of components and by other technologies as long as the method can provide the associated functions and effects.

- 20 The term “control unit”, as used herein, is typically, although strictly not necessary, an electronic control unit. The control unit may include a microprocessor, microcontroller, programmable digital signal processor or another programmable device. Thus, the control unit comprises electronic circuits and connections as well as processing circuitry such that the control unit can communicate with the machine, or vehicle, and with different parts of
25 the machine, or vehicle, such as the temporary 3-D printed replacement part and any other parts in need of being operated in order to provide the functions of the example embodiments. The control unit may comprise modules in either hardware or software, or partially in hardware or software and communicate using known transmission buses such as CAN-bus and/or wireless communication capabilities. The processing circuitry may be
30 a general-purpose processor or a specific processor. The control unit typically comprises a non-transistory memory for storing computer program code and data upon. Thus, the control unit may be embodied by many different constructions.

In other words, the control functionality of the example embodiments of the method may
35 be implemented using existing computer processors, or by a special purpose computer

processor for an appropriate system, incorporated for this or another purpose, or by a hardwire system. Embodiments within the scope of the present disclosure include program products comprising machine-readable medium for carrying or having machine-executable instructions or data structures stored thereon. Such machine-readable media

5 can be any available media that can be accessed by a general purpose or special purpose computer or other machine with a processor. By way of example, such machine-readable media can comprise RAM, ROM, EPROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to carry or store desired program code in the form of

10 machine-executable instructions or data structures and which can be accessed by a general purpose or special purpose computer or other machine with a processor. When information is transferred or provided over a network or another communications connection (either hardwired, wireless, or a combination of hardwired or wireless) to a machine, the machine properly views the connection as a machine-readable medium.

15 Thus, any such connection is properly termed a machine-readable medium. Combinations of the above are also included within the scope of machine-readable media. Machine-executable instructions include, for example, instructions and data which cause a general purpose computer, special purpose computer, or special purpose processing machines to perform a certain function or group of functions. While the example embodiments of the

20 method described above includes a control unit being an integral part of the machine or vehicle, it is also possible that the control unit may be a separate part of the vehicle, and/or arranged remote from the vehicle and in communication with the vehicle.

According to a second aspect of the present invention, there is provided a computer

25 program comprising program code means for performing the steps of any one of the example embodiments of the first aspect when the program is run on a computer. Effects and features of the second aspect of the invention are largely analogous to those described above in connection with the first aspect.

30 According to a third aspect of the present invention, there is provided a computer readable medium carrying a computer program comprising program code means for performing the steps of any of the embodiments of the first aspect when the program product is run on a computer. Effects and features of the third aspect of the invention are largely analogous to those described above in connection with the other aspects.

According to a fourth aspect of the present invention, there is provided a vehicle system comprising a control unit in communication with a 3-D printed replacement part arranged in a machine or vehicle. The control unit is configured to perform any one of the steps of any one of the example embodiments as described above in connection with the first
5 aspect. Effects and features of the fourth aspect of the invention are largely analogous to those described above in connection with the other aspects.

According to one example embodiment, the control unit is an electronic control unit comprised on-board the machine or vehicle. According to one example embodiment, the
10 control unit is a cloud server arranged in networked communication with the vehicle or machine. According to one example embodiment, the control unit is implemented using a cloud server being network connected to an electronic control unit (ECU) comprised with the vehicle or machine.

15 According to a fifth aspect of the present invention, there is provided a vehicle comprising a vehicle system according to any one of the example embodiments mentioned above in connection with the fourth aspect, as well as in connection with any one of the other aspects. Effects and features of the fifth aspect of the invention are largely analogous to those described above in connection with the other aspects.

20

Further features of, and advantages with, the present invention will become apparent when studying the appended claims and the following description. The skilled person realize that different features of the present invention may be combined to create embodiments other than those described in the following, without departing from the
25 scope of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

30 The above, as well as additional objects, features and advantages of the present invention, will be better understood through the following illustrative and non-limiting detailed description of exemplary embodiments of the present invention, wherein:

Fig. 1 is a side view of a vehicle in the form of a truck, in which a temporary 3-D printed replacement part may be incorporated and monitored by a method according to the present invention;

- 5 Fig. 2 is a flow-chart of a method according to an example embodiment of the invention, in which the method comprises a number of steps for controlling usage of the temporary 3-D printed replacement part installed in the vehicle in Fig. 1;

- Fig. 3 is a flow-chart of additional steps of the method in Fig. 2 according to an example
10 embodiment of the invention, in which the method comprises a number of steps for controlling usage of the temporary 3-D printed replacement part installed in the vehicle in Fig. 1;

- Fig. 4 is a flow-chart of additional steps of the method in Fig. 3 according to an example
15 embodiment of the invention, in which the method comprises a number of steps for controlling usage of the temporary 3-D printed replacement part installed in the vehicle in Fig. 1.

- With reference to the appended drawings, below follows a more detailed description of
20 embodiments of the invention cited as examples.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS OF THE INVENTION

- 25 The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. The invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided for thoroughness and completeness. The skilled person will recognize that many
30 changes and modifications may be made within the scope of the appended claims. Like reference character refer to like elements throughout the description.

- Referring now to the drawings and to Fig. 1 in particular, there is depicted an exemplary vehicle, here illustrated as a truck 5. Although not shown, the truck typically comprises a
35 propulsion system configured to provide traction power to one or more ground engaging

members, e.g. one or more wheels. In this example, the truck comprises an internal combustion engine arranged to provide traction power to the wheels. Optional, the propulsions system comprises a transmission (not shown) for transmitting a rotational movement from the engine to a propulsion shaft, sometimes denoted as the driven shaft
5 (not shown). The propulsion shaft connects the transmission to the pair of wheels.

In the vehicle illustrated in Fig. 1, there is also installed a replacement part in the form of a temporary 3-D printed replacement part 10. While the temporary 3-D printed replacement part is here illustrated as an engine part, it may likewise be a cab part, a side view mirror
10 or an underrun protective device etc. The temporary 3-D printed replacement part has an inherent characteristic that is different to a corresponding characteristic of an ordinary corresponding part or a corresponding standard replacement part for the ordinary part. Accordingly, the temporary 3-D printed replacement part 10 has an associated characteristic. Further, the characteristic of the 3-D printed replacement part is here of a
15 different quality than a corresponding characteristic of the ordinary corresponding part. At least for this reason, the 3-D printed replacement part is only intended for being used in the vehicle for a defined period of time. As such, the 3-D printed replacement part is generally a temporary replacement part.

20 In this example, the associated characteristics refers to the material of the 3-D printed replacement part. The 3-D printed replacement part has typically been obtained by additive manufacturing. The process "additive manufacturing", sometimes also called free-form fabrication, is a method for forming three-dimensional articles through successive fusion of chosen parts of powder layers applied to a worktable. There are several different
25 types of additive manufacturing apparatus. One type of additive manufacturing technology is Powder Bed Fusion (PBF), which produces a solid part using a thermal source that induces fusion (sintering or melting) between the particles of a metal powder one layer at a time. One example of a PDF technology is Electron Beam Melting (EBM), which is an additive manufacturing where an electron emitting cathode in an electron acceleration
30 column is the source for electron beam generation, which in turn is acting as an energy beam for melting the power material. By way of example, the 3-D printed replacement part is obtained by an additive manufacturing process using a metallic powder material. In other words, in this example, the associated characteristics of the temporary 3-D printed replacement part refers to the metallic powder material used in the additive manufacturing
35 process for producing the 3-D printed replacement part. Due to the manufacturing and the

materials of the 3-D printed replacement part, the quality of the replacement part is slightly different than the quality of the original corresponding component.

Moreover, the temporary 3-D printed replacement part 10 is configured to be monitored
5 during use of the vehicle and the part. In this example, the usage of the temporary 3-D printed replacement part 10 is monitored by a sensor 12. As such, data and information indicative of the usage of the temporary 3-D printed replacement part 10 in the vehicle can be gathered from measurements by the sensor 12. While it may be sufficient that the sensor is arranged adjacent the temporary 3-D printed replacement part 10, the sensor 12
10 is here comprised with the temporary 3-D printed replacement part 10, as illustrated in Fig. 1. By way of example, the sensor 12 is arranged to gather data indicating usage of the temporary 3-D printed replacement part during use of the part in the truck 5. The sensor is selected from a non-exhaustive list of optical fibers sensors, pressure transducers/sensors, temperature sensors (thermocouples), strain gauges, position
15 sensors, including combinations thereof. Also, while the sensor is typically embedded in the temporary 3-D printed replacement part 10, the sensor can likewise be made elsewhere and integrated during manufacturing of the temporary 3-D printed replacement part 10 and/or during installation of the temporary 3-D printed replacement part 10 into the truck.

20

While only one sensor is shown in Fig. 1, it should be readily understood that additional sensors may be incorporated in the temporary 3-D printed replacement part 10. In such examples, with a plurality of sensors, the sensors are generally of different types to allow for monitoring a number of different usage parameters of the part.

25

The sensor 12 is arranged in communication with a control unit 8. In this manner, the gathered data relating to the usage of the temporary 3-D printed replacement part 10 can be transmitted to the control unit 8 for further processing. As shown in Fig. 1, the vehicle 5 here comprises the control unit 8. As such, the sensor unit 12 is in communication and
30 connected to the control unit 8 comprised with the vehicle. The communication between the sensor and the control unit can be made by a wire connection, wireless or by any other technology such as Bluetooth, as is commonly known.

The control unit is configured to determine a usage restriction for the temporary 3-D
35 printed replacement part 10 and also configured to monitor the usage of the temporary 3-

D printed replacement part 10 in the vehicle based on the determined usage restriction. Further, the control unit 8 is here arranged to determine a maximum operational condition for the vehicle for a given time period based on the determined usage restriction of the temporary 3-D printed replacement part 10. For this reason, each one of the temporary 3-D printed replacement parts in the vehicle is connected to the control unit in order to permit the control unit to monitor the usage of each one of the temporary 3-D printed replacement parts. If necessary, the control unit may be configured to adjust or restrict usage of the temporary 3-D printed replacement part 10 based on the monitored usage of the temporary 3-D printed replacement part 10.

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Moreover, the control unit 8 is arranged to perform the method according to example embodiments as described in relation to Figs. 2 to 4.

Thus, turning now to Fig. 2, there is depicted a flowchart of a method according to one example embodiment of the invention. The method 100 is intended for controlling usage of a temporary 3-D printed replacement part installed in the vehicle, as described in relation to Fig. 1. In this example embodiment, the method comprises a step of determining 140 a suitable usage restriction of the temporary 3-D printed replacement part in the vehicle. The usage restriction of the temporary 3-D printed replacement part is determined based on the characteristic of the temporary 3-D printed replacement part.

As the usage restriction may be different for different types of parts, the usage restriction of a given temporary 3-D printed replacement part is typically, although strictly not required, determined in view of the expected use of the part in the vehicle as well as in view of the type of vehicle.

In this example, the usage restriction is indicative of an operational parameter of the temporary 3-D printed replacement part, e.g. an estimated maximum operational time period of the temporary 3-D printed replacement part in the vehicle. If the temporary 3-D printed replacement part is used in an extensively manner, and ultimately exceeds the maximum operational time period, it may cause damages to the vehicle or result in that the vehicle can only be operated in an undesirable manner in terms of operational performances etc.

The maximum operational time period is typically a predefined static time period or a dynamic time period updated during operation of the vehicle. The static time period is a value stored in the control unit. In this example, the given maximum operational time period corresponds to about 1 month. Since the maximum operational time period may
5 change depending on the use of the vehicle and the behavior of the driver, the maximum operational time period may in some situation rather be defined as a dynamic time period depending on the use of the vehicle. The dynamic time period is generally a time period determined by the control unit during use of the vehicle.

10 In another example, the usage restriction is defined to correspond an operational parameter of the vehicle. The operational parameter of the vehicle may for example be a maximum travelling distance, a maximum operational time, a maximum speed or a maximum payload level. In another example, the usage restriction is set in view of the geographical location of the vehicle.

15

Typically, although not strictly required, the step 140 of determining a usage restriction of the temporary 3-D printed replacement part in the vehicle is performed by the control unit 8, and by means of the sensor unit 12, as described in relation to Fig. 1.

20 In step 150, as illustrated in Fig. 2, the usage of the temporary 3-D printed replacement part is monitored in the vehicle based on the determined usage restriction. The usage of the temporary 3-D printed replacement part is monitored by means of the sensor 12 and via the control unit 8, as described above in relation to Fig. 1. Typically, although not strictly required, the entire step of monitoring the usage of the temporary 3-D printed
25 replacement part is performed by the control unit 8, and by means of the sensor unit 12, as described in relation to Fig. 1.

Turning now to Fig. 3, which is a flow chart of an extended version of the example embodiment described in Fig. 2, the method comprises one or more additional steps for
30 further controlling the usage of the temporary 3-D printed replacement part in the vehicle. In particular, the control unit is arranged to further adjust 160 allowable usage of the temporary 3-D printed replacement part in the vehicle based on the determined usage restriction and monitored usage of the temporary 3-D printed replacement part in the vehicle. The usage restriction is typically determined as described in relation to Fig. 2.
35 Also, the usage of the temporary 3-D printed replacement part in the vehicle is typically

monitored as described in relation to Fig. 2. By way of example, the step of further adjusting 160 allowable usage of the temporary 3-D printed replacement comprises the step of further restricting 162 usage of the temporary 3-D printed replacement part in the vehicle if the monitored usage of the temporary 3-D printed replacement part exceeds a
5 usage restriction threshold. By way of example, the usage restriction threshold refers to the estimated maximum operational time period, such that the usage of the vehicle is further restricted if the vehicle is used above the threshold.

In one example embodiment, the step of further adjusting allowable usage of the
10 temporary 3-D printed replacement part in the vehicle comprises setting the vehicle in a reduced minimum operational state. In this context, the operational state may refer to state of the vehicle in which the vehicle can e.g. be operated to at least a service station, charging station etc.

15 The step of monitoring usage of the temporary 3-D printed replacement part in the vehicle based on the determined usage restriction is performed by using a digital twin model of the vehicle. The digital twin model provides a digital copy of the vehicle and the temporary 3-D printed replacement part installed in the vehicle. By way of example, the digital twin model is stored locally in the control unit of the vehicle. The digital twin model may be
20 updated on a regular basis, e.g. during services of the vehicle, at a charging station (if the vehicle is an electric vehicle) or stored in the cloud for immediate monitoring.

Referring now to Fig. 4, there is depicted another example embodiment of a method according to the present invention. The method in Fig. 4 typically comprises the steps as
25 described in relation to example embodiments in Figs. 2 and 3. However, the method here also comprises a number of initial steps that are performed prior to the step of determining the usage restriction of the temporary 3-D printed replacement part. That is, in step 110, the method identifies a damaged or failed component part in the machine or vehicle. The step of identifying a damaged or failed component part in the vehicle is here performed by
30 a software of a portable device, such as by an app of a cellular phone.

In step 120, a 3-D printer is identified to produce a 3-D printed replacement part corresponding to the identified damaged or failed component part.

In step 130, the produced 3-D printed replacement part is received and subsequently installed in the vehicle.

Optionally, the method also comprises the steps of ordering 210 a genuine component
5 part corresponding to the identified damaged or failed component part and replacing 220
the temporary 3-D printed replacement part with the genuine component part when the
genuine component is delivered to a service station or the like. As illustrated in Fig. 4, the
steps 210 and 220 are here performed in parallel to the other steps 110 to 162. Further, in
this example, the usage restriction of the temporary 3-D printed replacement part is based
10 on a lead time for receiving the ordinary vehicle component.

Moreover, as illustrated in Fig. 4, the method comprises terminating 170 the minimum
reduced operational state of the vehicle. Step 170 is generally performed when the
genuine component is installed in the vehicle.

15

As mentioned above, it is to be noted that all steps of the method are typically performed
by the control unit 8 during use of the vehicle. Thus, the control unit is configured to
perform any one of the steps of any one of the example embodiments as described above
in relation to the Figs. 2 – 4.

20

It is to be understood that the present invention is not limited to the embodiments
described above and illustrated in the drawings; rather, the skilled person will recognize
that many changes and modifications may be made within the scope of the appended
claims. For example, although the present invention has mainly been described in relation
25 to a truck, the invention should be understood to be equally applicable for any type of
vehicle and machine.

Although the figures may show a specific order of method steps, the order of the steps
may differ from what is depicted. In addition, two or more steps may be performed
30 concurrently or with partial concurrence. Such variation will depend on the software and
hardware systems chosen and on designer choice. All such variations are within the
scope of the disclosure. Likewise, software implementations could be accomplished with
standard programming techniques with rule-based logic and other logic to accomplish the
various connection steps, processing steps, comparison steps and decision steps.

35 Additionally, even though the disclosure has been described with reference to specific

exemplifying embodiments thereof, many different alterations, modifications and the like will become apparent for those skilled in the art.

The use of the terms "a" and "an" and "the" and similar referents in the context of
5 describing the disclosed embodiments (especially in the context of the following claims)
are to be construed to cover both the singular and the plural, unless otherwise indicated
herein or clearly contradicted by context. The terms "comprising," "having," "including,"
and "containing" are to be construed as open-ended terms (i.e., meaning "including, but
not limited to,") unless otherwise noted. The use of any and all examples, or exemplary
10 language (e.g., "such as") provided herein, is intended merely to better illuminate
embodiments of the disclosure and does not pose a limitation on the scope of the
disclosure unless otherwise claimed. No language in the specification should be
construed as indicating any non-claimed element as essential to the practice of the
disclosure. Variations to the disclosed embodiments can be understood and effected by
15 the skilled addressee in practicing the claimed disclosure, from a study of the drawings,
the disclosure, and the appended claims.

CLAIMS

1. A method (100) for controlling usage of a temporary 3-D printed replacement part installed in a machine or vehicle, the temporary 3-D printed replacement part having an associated characteristic and being configured to permit usage monitoring, wherein the
5 method comprises the steps of:
 - determining (140) a usage restriction of the temporary 3-D printed replacement part in the machine or vehicle based on the characteristic of the temporary 3-D printed replacement part; and
 - monitoring (150) usage of the temporary 3-D printed replacement part in the machine or
10 vehicle based on the determined usage restriction.
2. Method according to claim 1, wherein the usage restriction corresponds to any one of an operational parameter of the temporary 3-D printed replacement part and an operational parameter of the machine or vehicle.
15
3. Method according to claim 2, wherein the operational parameter of the temporary 3-D printed replacement part is any one of a maximum operational time period of the temporary 3-D printed replacement part, a maximum travelling distance of the temporary 3-D printed replacement part and a maximum load of the temporary 3-D printed
20 replacement part.
4. Method according to claim 3, wherein the maximum operational time period is a dynamic time period depending on the use of the machine or vehicle.
- 25 5. Method according to claim 2, wherein operational parameter of the machine or vehicle is any one of a maximum travelling distance, maximum operational time, maximum speed, maximum payload level and geographical location of the machine or vehicle.
6. Method according to any one of the preceding claims, wherein the usage restriction is
30 based on a lead time for receiving an ordinary machine or vehicle component.
7. Method according to any one of the preceding claims, further comprising the step of adjusting (160) usage of the temporary 3-D printed replacement part in the machine or vehicle based on the monitored usage of the temporary 3-D printed replacement part in
35 the machine or vehicle.

8. Method according to claim 7, wherein the step of further adjusting (160) usage of the temporary 3-D printed replacement part in the machine or vehicle based on the monitored usage of the temporary 3-D printed replacement part in the machine or vehicle comprises
5 further restricting (162) usage of the temporary 3-D printed replacement part in the machine or vehicle if the monitored usage of the temporary 3-D printed replacement part exceeds a threshold.

9. Method according to any one of the claims 7 or 8, wherein the step of further adjusting
10 usage of the temporary 3-D printed replacement part in the machine or vehicle based on the monitored usage of the temporary 3-D printed replacement part comprises setting the machine or vehicle in a reduced minimum operational state.

10. Method according to any one of the preceding claims, wherein the step of monitoring
15 usage of the temporary 3-D printed replacement part in the machine or vehicle based on the determined usage restriction is performed by using a digital twin model of the machine or the vehicle.

11. Method according to any one of the preceding claims, wherein the temporary 3-D
20 printed replacement part comprises a sensor arranged to gather data indicating usage of the temporary 3-D printed replacement part.

12. Method according to any one of the preceding claims, further comprising the initial steps of:
25 - identifying (110) a damaged or failed component part in the machine or vehicle;
- identifying (120) a 3-D printer to produce a 3-D printed replacement part corresponding to the identified damaged or failed component part; and
- receiving and installing (130) the produced 3-D printed replacement part in the machine or vehicle.

30

13. Method according to any one of the preceding claims, in which the steps of the method are performed by a control unit.

14. A computer program comprising program code means for performing the steps of any
35 one of claims 1 – 13 when said program is run on a computer.

15. A computer readable medium carrying a computer program comprising program means for performing the steps of any one of claims 1 – 14 when said program means is run on a computer.

5

16. A vehicle system comprising a control unit in communication with a 3-D printed replacement part arranged in a vehicle or machine, the control unit being configured to perform any one of the steps of any one of the claims 1 – 13.

10 17. Vehicle system according to claim 16, wherein the control unit is any one of an electronic control unit comprised on-board the machine or vehicle and a cloud server arranged in networked communication with the machine or vehicle, or implemented using a cloud server being network connected to an electronic control unit (ECU) comprised with the machine or vehicle.

15

18. A vehicle (5) comprising a vehicle system according to any one of the claims 16 to 17.

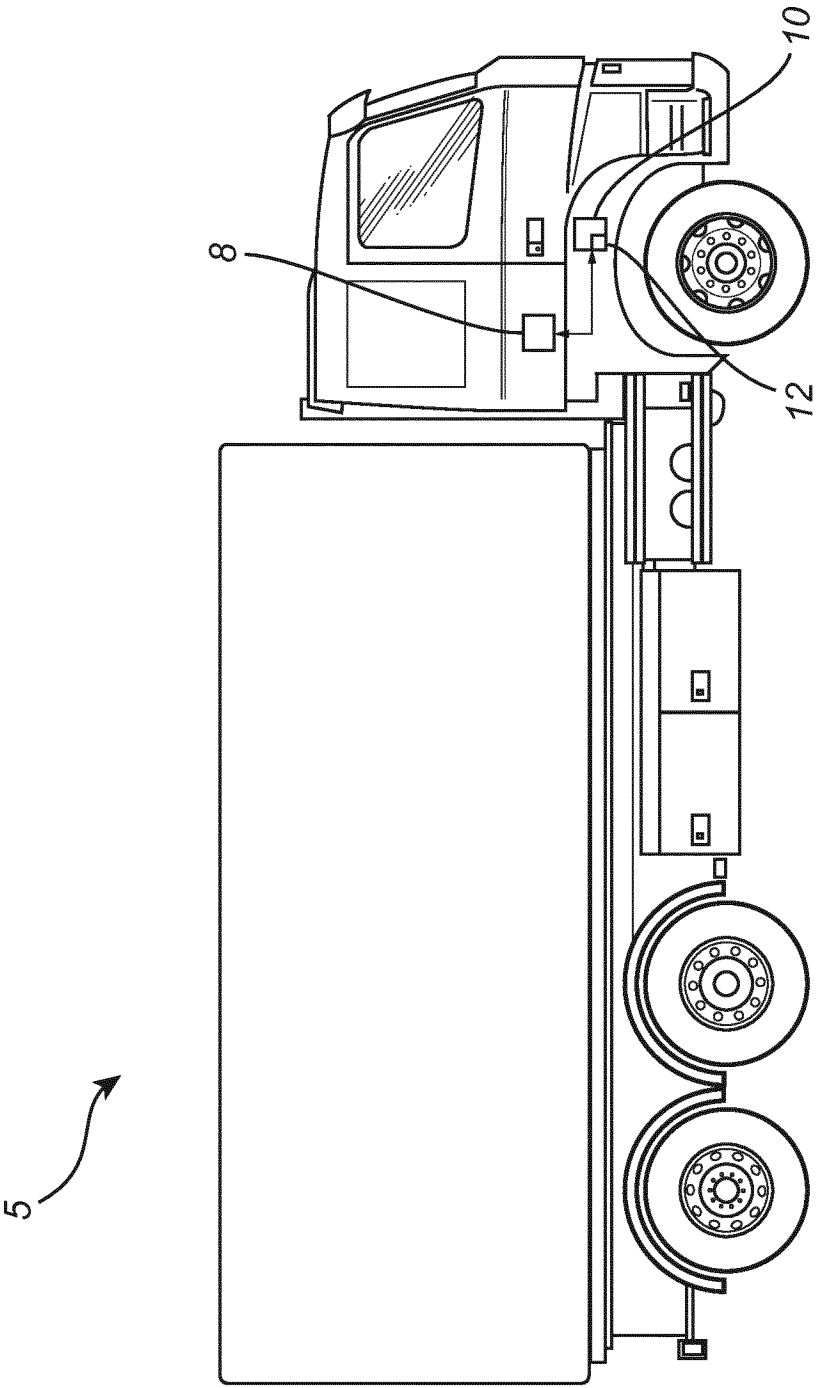
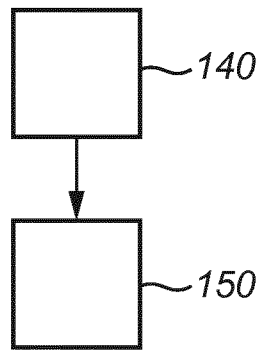
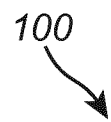
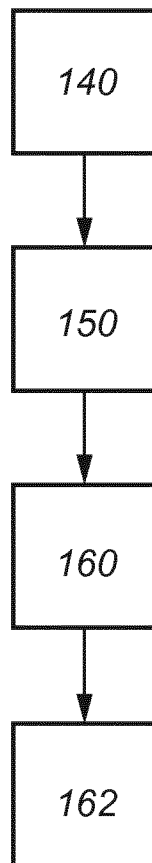
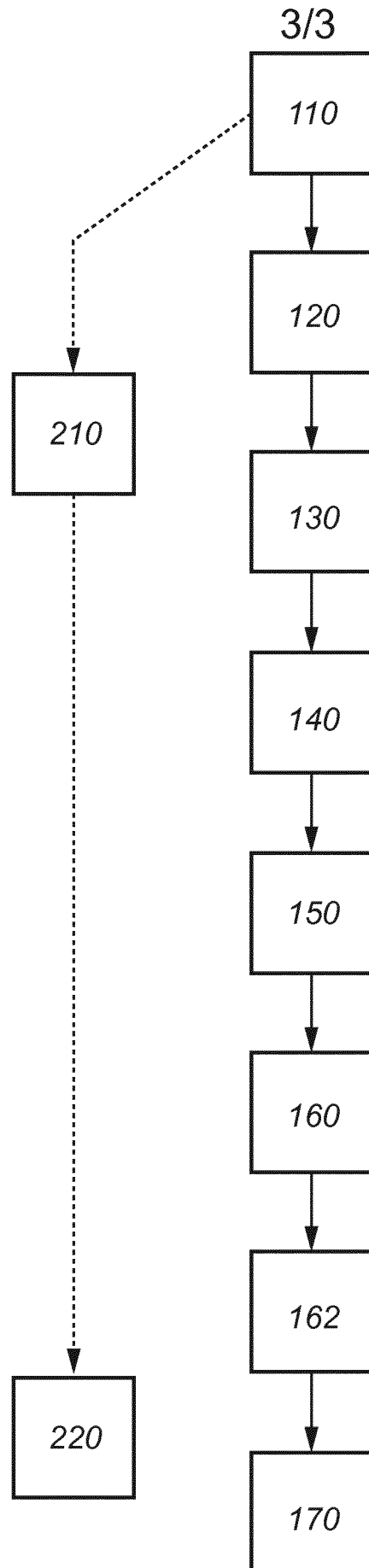


Fig. 1

2/3

100
*Fig. 2**Fig. 3*

*Fig. 4*

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/067710

A. CLASSIFICATION OF SUBJECT MATTER
INV. G05B23/02 G07C5/08
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G05B G07C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2019/196461 A1 (SAIGAL DINESH [US] ET AL) 27 June 2019 (2019-06-27) abstract; figures 1-3 paragraph [0037] -----	1-9, 11-15 10,16-18
X	JP 2017 142654 A (NIPPON TELEGR & TELEPH CORP <NTT>) 17 August 2017 (2017-08-17) abstract paragraphs [0010], [0011], [0026] - [0028], [0045] - [0047], [0100] -----	1-9, 11-18
X Y	JP 6 464928 B2 (KYOCERA DOCUMENT SOLUTIONS INC) 6 February 2019 (2019-02-06) abstract; figures 1,4 paragraphs [0014], [0015] ----- -/-	1-9, 11-15 10,16-18



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2019/067710

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 555 827 A (FUJITSU LTD [JP]) 16 May 2018 (2018-05-16) abstract; claim 12; figures 1,2 page 5, lines 21-31 page 11, lines 1-12 -----	1-9, 11-15
Y	DAVIS STEVE ET AL: "Digitalization sparks a quiet revolution", WORLD PUMPS, vol. 2017, no. 5, 31 May 2017 (2017-05-31) , pages 28-31, XP085017430, ISSN: 0262-1762, DOI: 10.1016/S0262-1762(17)30102-5 page 30, left-hand column, paragraph 3-5 page 31, middle column, last paragraph - right-hand column, paragraph 3 -----	10
Y	WO 2017/081200 A1 (ROLLS-ROYCE DEUTSCHLAND LTD & CO KG [DE]) 18 May 2017 (2017-05-18) abstract; figures 1-3 page 8, lines 24-32 page 21, lines 26-32 page 22, lines 19-20 -----	16-18

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2019/067710

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2019196461	A1	27-06-2019	NONE
JP 2017142654	A	17-08-2017	NONE
JP 6464928	B2	06-02-2019	JP 6464928 B2 06-02-2019
		JP 2016224592 A	28-12-2016
GB 2555827	A	16-05-2018	NONE
WO 2017081200	A1	18-05-2017	CA 3003827 A1 18-05-2017
		CN 108292375 A	17-07-2018
		EP 3374935 A1	19-09-2018
		US 2018322714 A1	08-11-2018
		WO 2017081200 A1	18-05-2017