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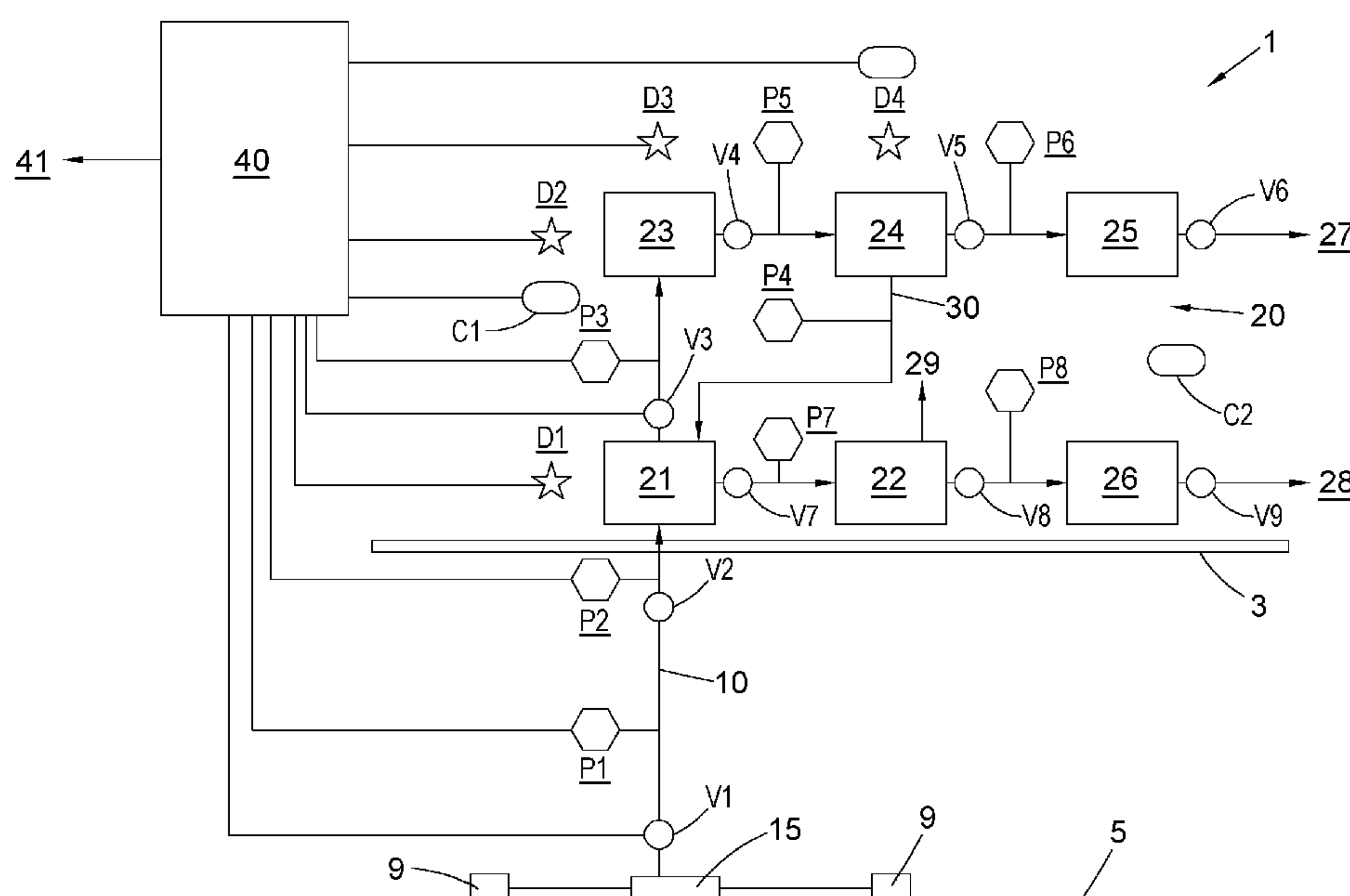


Fig. 2

(57) Abstract: A method and system for determining whether there is a leak of gas from hydrocarbon handling equipment 20-26 on an offshore platform 1, the hydrocarbon handling equipment comprising a plurality of conduits. The method comprises the steps of: a) providing a shut-off valve V1-V9 in each of a plurality of the conduits whereby one or more pair(s) of shut-off valves each define a segment of the hydrocarbon handling equipment that is isolated when the shut-off valves are closed; b) providing a pressure sensor P1-P8 to sense the pressure within each segment; c) obtaining pressure data from the pressure sensor(s) and the location of the corresponding segment(s); d) when the shut-off valves are closed, determining based upon the pressure data, whether there is a leak of gas from the hydrocarbon handling equipment and, if a leak of gas is determined to have occurred, further determining a segment from which gas is leaking and thereby determining the location of the leak. The method may be implemented after a shutdown condition of a platform to

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Remote Start-Up of an Unmanned Platform

The present invention relates to unmanned offshore oil and gas production platforms, and in particular, to the re-starting of such platforms following the
5 activation of an alarm, such as one indicating the presence of free gas or a fire.

Conventional, offshore platforms used for producing hydrocarbons are relatively massive structures that are designed for operation by a large crew. In addition to the production equipment itself, there is typically also processing apparatus, such as separators, compressors, etc. and of course the
10 accommodation and support services required to allow the crew to live and work on-board the platform.

Such platforms are well suited for the exploitation of large hydrocarbon reserves, but there is a growing need to be able to exploit smaller and/or more remote reserves in an economical manner. This may be done by means of satellite
15 platforms that are located remotely from a host platform but which are operated in conjunction with the host to which they may be 'tied back' by means of submarine pipelines to allow transportation of the produced fluids. Alternatively, shuttle tankers and other vessels may be used for this purpose and to otherwise facilitate operation of the satellite platform.

In order to further reduce costs, unmanned production platforms may be used at remote locations. By "unmanned" it is meant that the platform has no permanent personnel and may only be occupied for particular operations such as maintenance and/or installation of equipment. The unmanned platform may be a
20 platform where no personnel are required to be present for the platform to carry out its normal function, for example day-to-day functions relating to handling of oil and/or gas products at the platform. An example of a known unmanned platform is disclosed in the applicant's earlier patent application GB 2554075.

It will be appreciated that it is desirable on both economic and safety grounds to minimise the number of personnel-hours spent on such platforms, for
30 example for purposes of maintenance and service. One area of interest is in reducing the number of personnel-hours required at an unmanned platform to restart its normal operation following shutdown due to activation of an alarm.

It goes without saying that hydrocarbons are highly flammable and therefore that great care is taken in both the design and operation of production platforms to
35 reduce the risk of fire and to mitigate its effects should a fire take place. Clearly, a

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leak of hydrocarbon fluid (of which gas poses the greater concern) is undesirable in itself and particularly as it poses a significant fire risk. Accordingly, offshore platforms are provided with sophisticated gas leak ("free gas") and fire detection systems, along with fire suppression systems, etc. The applicant's aforementioned
5 patent application concerns systems for optimising fire protection on such platforms in particular when personnel are stationed thereon.

On typical (manned or unmanned) production platforms, upon activation of a gas/fire (or certain other alarms), the production platform is configured to automatically shut down. Such shutdown usually involves the closing of emergency
10 shut-off valves (ESV) on the platform and/or in the hydrocarbon conduits leading to the platform, which in turn leads to a total shutdown of the platform.

In the case of an unmanned platform, after shutdown of operations on the platform, an inspection crew is typically sent to the platform (either via ship or helicopter). There they carry out an inspection of the platform in order to assess the
15 source of the alarm, e.g. to ascertain whether there has been a gas leak or to assess whether there has been (or is) a fire and to take action if necessary.

Such inspection usually involves a visual inspection of the platform's equipment, and an inspection using a gas detector to detect for leaked/free gas. Once the required action has been taken by the inspection crew (or if no action is
20 deemed necessary), the inspection crew then have the job of restarting operations at the platform. This typically involves a manual resetting of the ESVs and shut-down signals by the inspection crew to allow production to be restarted.

It will be appreciated that this typical inspection/restart operation at the platform is a high risk operation since it involves the shuttling of personnel to a
25 potentially unsafe platform. This inspection/restart operation is also costly in terms of production downtime, operational costs associated with transportation and the capital costs associated with the infrastructure required at the platform to receive an inspection crew (e.g. a helicopter landing pad).

WO 2018/052675 A1 discloses a method for detecting a leak or rupture from
30 a pipeline, for example a pipeline carrying hydrocarbons between different refineries, petrochemical production facilities, pumping stations, offshore production platforms and the like. The method disclosed in WO 2018/052675 A1 is reliant on the detection of a pressure wave to determine a leak or rupture within the pipeline. Analysis of the characteristics of the pressure wave received at a sensor within the
35 pipeline allows for a determination on whether it has resulted from a leak or rupture

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in the pipeline. The location of the leak or rupture can also be determined by recording the time at which the resultant pressure wave is received at two separate sensors. The 'time of flight' of the pressure wave can then be used to locate the leak or rupture. Use of pressure waves allows for the detection of leak or ruptures to be identified quickly in a pipeline, which might otherwise be difficult to do accurately given typical pipeline lengths.

According to the invention, there is provided a method of determining whether there is a leak of gas from hydrocarbon handling equipment on an offshore platform, the hydrocarbon handling equipment comprising a plurality of conduits, the method comprising the steps of: (a) providing a shut-off valve in each of a plurality of the conduits whereby one or more pair(s) of shut-off valves each define a segment of the hydrocarbon handling equipment that is isolated when the shut-off valves are closed; (b) providing a pressure sensor to sense the pressure within each segment; (c) obtaining pressure data from the pressure sensor(s) and, optionally, the location of the corresponding segment(s); (d) when the shut-off valves are closed, determining based upon the pressure data whether there is a leak of gas from the hydrocarbon handling equipment and, optionally, if a leak of gas is determined to have occurred, further determining a segment from which gas is leaking and thereby determining the location of the leak.

Thus, the invention operates on the basis that, if the pressure in the hydrocarbon handling apparatus remains at a constant pressure following closure of the shut-off valves, there cannot be a leak of gas to the atmosphere. In other words, there is "full containment" and it is safe to restart. Accordingly, by means of the invention it is possible to make a thorough check of the integrity of the equipment on the platform simply by monitoring the outputs of the pressure sensor(s). Moreover, if a leak is found to be occurring, its location may be provided because the pressure data is correlated to the respective segment(s) of the equipment that are defined by adjacent valves.

The invention is particularly useful in the case when the shut-off valves are closed to shut down the hydrocarbon handling equipment on the platform following the detection of a gas leak and/or fire, and wherein step (d) is performed to determine whether the shut-off valves may be re-opened in order to restart the hydrocarbon handling equipment. This is because, as discussed above, significant risk is associated with deploying personnel to a platform to make such checks following an alarm situation. This is particularly the case when the platform is an

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unmanned production platform (as defined below). In such a situation, the data obtained in step (c) is preferably transmitted to a remote host where step (d) is performed. Thus, the status of the platform may be safely verified without the need for personnel to attend and, if such attendance is required, it will be on the basis of improved knowledge regarding the risks that the personnel may face.

The invention may employ one or more of several techniques for determining from the pressure data whether there is a leak of gas. Each of these techniques will typically comprise the comparison of the sensed pressure (i.e. the measured pressure value within the pipeline segment) with another pressure to determine that there has been a sustained pressure loss. This is different to the techniques employed for monitoring pipelines within WO 2018/052675 A1 which, as discussed above, rely on the detection of a pressure wave to determine a leak or rupture rather than the comparison of actual pressure values.

One approach is by comparing the sensed pressure value for each segment to a predetermined reference value. Thus, there may be provided a set of data comprising normal pressure values, or ranges, for each segment. In order to identify a leak of gas, the measured value may be compared directly to a reference value in the form of a minimum pressure threshold (i.e. the lowest of a range of values that may be expected to occur under normal conditions).

Another useful technique is for a leak of gas to be detected by comparing the sensed pressure value for each segment to a previous value thereof sensed subsequent to the closure of the shut-off valves. In other words, the pressure of each segment may be monitored over time to determine whether it decreases, thereby indicating a loss of gas.

However, such a loss may be due to internal leakage between segments, for example due to the shut-off valves not fully closing. Thus, preferably the invention accounts for such effects. Accordingly, if a loss of pressure is sensed in one segment, the pressure data from adjacent segments may be analysed to determine whether there has been a leak of gas to the atmosphere or whether there has been a loss of gas to an adjacent segment. In other words, if there is a reduction in pressure from a first segment, the pressure of the immediately adjacent segments may be checked to identify a higher-than-expected value or an increase in pressure over time. Where such a situation is found, it may be concluded that there is an internal leak rather than a leak of gas to the atmosphere. Such leaks are not uncommon and do not necessarily pose a risk to the safety of the equipment.

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5 The invention may only be applied to specific parts of the hydrocarbon handling equipment on the platform, such as those most susceptible to the risk of leaks and associated fires. However, it is preferred that the entire hydrocarbon handling equipment on the platform be divided into segments by means of shut-off valves, with each segment is provided with a pressure sensor, such that a leak of gas may be detected and located at any point within the hydrocarbon handling equipment from which gas may escape.

The invention is preferably provided in combination with other fire and leak detection steps and risk mitigation strategies.

10 Accordingly, the method preferably further comprises providing gas detectors on the platform and providing data therefrom to a remote host to determine whether free gas is present at the platform. These detectors are preferably used to detect free gas and thus leaks under any circumstances and are preferably used to trigger the initial shut-down of the platform. The use of such gas
15 detectors is particularly beneficial in scenarios in which the platform is unmanned.

It is also useful to be able to check for damage, such as caused by fire or explosion, etc. and for indications of physical damage that may have caused a leak of gas in the first place. The method therefore preferably further comprises providing video (CCTV) cameras on the platform and providing data therefrom to a
20 remote host to enable a visual inspection of the platform therefrom. The use of such video cameras is particularly beneficial in scenarios in which the platform is unmanned.

The invention also extends to a corresponding system and therefore, viewed from another aspect, the invention provides a system for determining whether there
25 is a leak of gas from hydrocarbon handling equipment on an offshore platform, the hydrocarbon handling equipment comprising a plurality of conduits, the system comprising: a shut-off valve in each of a plurality of the conduits whereby one or more pair(s) of shut-off valves each define a segment of the hydrocarbon handling equipment that is isolated when the shut-off valves are closed; a pressure sensor
30 arranged to sense the pressure within each segment; and wherein the system is arranged to determine, when the shut-off valves are closed, and based upon the data from the pressure sensor(s), whether there is a leak of gas from the hydrocarbon handling equipment and, if a leak of gas is determined to have occurred, the system is optionally further arranged, based on a location of the

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corresponding segment(s), to determine a segment from which gas is leaking and thereby determining the location of the leak.

As discussed above, the invention is particularly useful when the platform is an unmanned production platform (as defined herein) and the system further
5 comprises a remote host, and whereby the remote host is arranged to determine, when the shut-off valves are closed, and based upon the data from the pressure sensors and the location of the corresponding segments, whether there is a leak of gas from the hydrocarbon handling equipment and, if a leak of gas is determined to have occurred, the remote host is further arranged to determine a segment from
10 which gas is leaking and thereby determining the location of the leak..

The system is preferably configured to operate according to the method of the first aspect of the invention including the preferred or optional forms thereof.

An “unmanned platform” as used herein is a platform that has no permanent personnel and may only be occupied for particular operations such as maintenance
15 and/or installation of equipment. The unmanned platform may be a platform where no personnel are required to be present for the platform to carry out its normal function, for example day-to-day functions relating to handling of oil and/or gas products at the platform.

An unmanned platform may be a platform with no provision of facilities for
20 personnel to stay on the platform, for example there may be no shelters for personnel, no toilet facilities, no drinking water and/or no personnel operated communications equipment. The unmanned platform may also include no heli-deck and/or no lifeboat, and advantageously may be accessed in normal use solely by a gangway to a vessel or bridge a bridge to another platform, for example via a Walk
25 to Work (W2W) system as discussed below.

An unmanned platform may alternatively or additionally be defined based on the relative amount of time that personnel are needed to be present on the platform during operation. This relative amount of time may be defined as maintenance
30 hours needed per annum, for example, and an unmanned platform may be a platform requiring fewer than 10,000 maintenance hours per year, optionally fewer than 5000 maintenance hours per year, perhaps fewer than 3000 maintenance hours per year.

An embodiment of the invention will now be described, by way of example only, and with reference to the accompanying drawings in which:

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Figure 1 is a perspective overview of an unmanned production platform according to an embodiment of the invention; and

Figure 2 is a schematic view of the platform of Figure 1.

As may be seen from Figure 1, an unmanned production platform 1
5 is provided in the form of a floating spar buoy 2 with a superstructure 3 mounted thereon in a region of the sea 4 remote from a host platform (not shown). The platform is moored to the sea bed 5 by means of suitable catenary moorings 6. A shuttle tanker 7 is located at the surface 8 nearby. An exemplary wellhead 9 and associated manifold is provided at the seabed.

10 The wellhead 9 is connected to the platform 1 by means of a riser 10, with further risers 11 being connected to additional wellheads (not shown). Conduits 12 and 13 interconnect the platform 1 with the shuttle tanker 7.

During operation, produced hydrocarbons from the wellhead 9 and other wellheads flow via risers 10, 11 to the platform 1 for processing. Processed
15 hydrocarbons (e.g. separated and stabilised or semi-stabilised oil and/or gas) flow from the platform 1 to the shuttle tanker 7 via conduits 12 and 13 where they are stored pending transportation. Once the shuttle tanker is fully loaded, it is replaced by another shuttle tanker and transports the fluids to the host.

The production and processing of produced fluids is described further with
20 reference to Figure 2. This shows, in highly schematic form the unmanned production platform 1 and associated apparatus at the sea bed 5. In this figure, the superstructure 3 is represented by its deck, with components located above the deck in the figure representing those located on board the platform.

At the sea bed 5 there are shown two wellheads 9 connected to a subsea
25 manifold 15 via respective conduits. The manifold 15 is connected to the superstructure of the platform by means of riser 10.

An illustrative and greatly simplified two-stage separation system 20 is shown on board the platform 1. This comprises first stage separator 21, second stage separator 22, cooler 23, scrubber 24, compressor 25 and pump 26
30 interconnected by conduits as shown and leading to gas outlet conduit 27 and oil outlet conduit 28.

In use, hydrocarbons from a subsea reservoir (not shown) flow via wellheads 9 manifold 15 and riser 10 to the platform 1. At the first stage separator 21, oil-rich fluid is separated and flows to second stage separator 22 where
35 remaining gas is separated therefrom and flows to a scrubber (not shown) via outlet

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29. The oil then passes via pump 26 to outlet conduit 28. This leads, in the present embodiment, to conduit 12 leading to the shuttle tanker 7 (see Figure 1). In alternative embodiments, it may lead to a transport pipeline.

5 Gas-rich fluid leaves first stage separator 21 and flows to cooler 23 and then to scrubber 24 where liquid (oil) is removed and returns via conduit 30 to the first stage separator 21. The gas from scrubber 24 flows to compressor 25 where it is pressurised and flows along outlet conduit 27. Depending on the installation, this gas may be re-injected, used on board as fuel or exported via conduit 13 to shuttle tanker. In other embodiments, it may be exported via a transport pipeline.

10 The platform 1 is provided with a fire and gas leak detection and management system, which will now be described. It operates in conjunction with valves V1-V9 provided as part of the hydrocarbon processing and separation system previously described. These valves are provided with actuators so that they may be closed automatically and/or by remote control in order to close the conduit
15 in which they are located. They are each connected by means of a signal connection (a wired connection is shown) to control unit 40.

Also located on the conduits are pressure sensors P1-P8. These are all provided with signal connections to control unit 40 (wired connections are shown only for P1 to P3 for clarity). These sensors provide a measurement of the pressure
20 within the relevant section of conduit. The pressure sensors are positioned so as to monitor the pressure throughout the entirety of the hydrocarbon handling equipment on the production platform. This is achieved by having each pressure sensor positioned in every 'segment' of the hydrocarbon handling equipment on the platform, with each segment being defined as a section within the hydrocarbon
25 handling equipment between two adjacent valves that close during a shutdown condition of the platform.

Thus, for example, pressure sensor P5 is located between valves V4 and V5 such that it is able to measure the pressure in the 'segment' of conduit and apparatus located between them. Accordingly, as will be discussed in more detail
30 below, these sensors may be used to check the integrity of their respective segments.

For completeness, the figure shows pressure sensors in segments that (as described) would contain fluid in the liquid phase. These may nevertheless be useful for leak detection and also serve to illustrate how sensors would be
35 implemented in a gas production platform.

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The system further comprises a number of gas and fire detectors (four of which are illustrated) D1-D4, which are located as required about the superstructure 3 of the platform 1. They are also connected to the control unit 41 by means of a signal connection (again, a wired connection is shown, though for reasons of clarity, the connection for D4 has been omitted). The gas and fire detectors may be single units that are capable of detecting both fire and gas, or there may be dedicated units for each purpose (e.g. D1, D3, etc. may be fire detectors and D2, D4, etc. may be gas detectors).

Finally, an array of CCTV cameras (only two of which are shown) C1, C2 arranged to allow all important areas of the superstructure to be examined visually. These are also connected via a signal connection (again wired here) to the control unit 40.

Control unit 40 comprises a microprocessor-based computer running software that enables it to process the input signals received from the fire/gas detectors D1, etc., pressure sensors P1, etc. and cameras C1, etc. as well as to output control signals to the actuators of valves V1, etc.. It is also able to communicate with a remote host platform via datalink 41. The valves V1 etc. may be actuated either as a result of autonomous action under software control or in response to signals received from the host via the datalink 41.

During operation of the platform 1, the control unit 40 monitors the input signals from the fire/gas detectors D1, etc. and may provide information regarding their state to the host via datalink 41. In the event that one or more detectors D1, etc. outputs a signal indicating that there is a fire or free gas, the control unit 40 may cause some or all of the valves V1, etc. to close in order to prevent further flow of flammable hydrocarbons to the fire or source of a leak and/or to entirely shut down the platform 1. For the purpose of the present explanation, it is assumed that the platform 1 is to be completely shut down. A signal indicating that shut down has occurred is transmitted to the host via datalink 41.

Alternatively, an operator at the host may determine, based on output data received from the fire/gas detectors D1, etc. via the control unit 40 and datalink 41 that the platform 1 should be shut down. In this scenario, a control signal is sent to the control unit 40 to command it to close the valves V1, etc. and shut down the platform 1.

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In either case, it is assumed that the platform 1 either had no personnel on board at the time of the incident or that any personnel were evacuated when fire or free gas was detected.

5 The remaining part of this discussion describes the inspection and restart operation, which is performed remotely from the host. This involves four main stages: 1) an inspection involving the use of the gas detectors D1, etc. situated at the platform 1 to detect for leaked/free gas; 2) a visual inspection of the production platform 1 using the cameras C1, etc. situated at the platform 1; 3) a pressure mapping of the hydrocarbon handling equipment on the production
10 platform 1 to assess for gas leakage based on the pressure sensors P1, etc.; and 4) a remote resetting of the closed valves V1, etc. and shut-down signals at the platform 1.

Step 1) of the method of inspection involves the remote detection of leaked gas at the platform 1. The gas detectors D1, etc. used are the same gas detectors
15 used to trigger the alarm on the platform 1 to indicate a gas leak (assuming that detection of free gas was the cause of the alarm). As described above, the gas detectors D1, etc. are in communication with the remote host via datalink 41. If any of the gas detectors D1, etc. detect leaked gas, a signal is sent via the control unit 40 to the remote host indicating this, and also indicating where on the platform 1 the
20 detection has occurred (based upon the known location of the gas detector(s) D1, etc. in question). This step of the method may occur, before after or simultaneously to steps 2) and/or 3) of the method as described below.

Step 2) of the method involves a visual inspection of the platform 1 using cameras C1, etc. (e.g. CCTV cameras) positioned on the platform. As noted above,
25 the cameras C1, etc. are preferably positioned such that they are collectively able to cover (visually) a full area of the platform 1, and are at least positioned such that can cover those areas most susceptible to fire and/or gas leaks. The cameras C1, etc. on the platform 1 are in communication via the control unit 40 and datalink 41 with the remote host and allow for a visual inspection of the platform 1 at the remote
30 host. Personnel at the remote host may therefore inspect the platform 1 visually by virtue of the cameras C1, etc. to check for fires and/or any obviously malfunctioning equipment. This step of visual inspection may occur, before after or simultaneously to steps 1) and/or 3) of the method as described above and below.

Step 3) of the method involves the 'pressure mapping' of the hydrocarbon
35 handling equipment on and leading to the production platform 1. Such equipment

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includes one or more of the risers, hydrocarbon pipes, compressors, pumps etc. as described above. The pressure mapping is achieved by virtue of the pressure sensors P1, etc. positioned within the hydrocarbon handling equipment. The pressure sensors are preferably positioned so as to monitor the pressure
5 throughout the entirety of the hydrocarbon handling equipment on the production platform 1, or at least those conduits containing gas.

This is achieved by having each pressure sensor positioned in every 'segment' of the hydrocarbon handling equipment on the platform 1, with each segment being defined as a section within the hydrocarbon handling equipment
10 between two adjacent valves V1, etc. that close during a shutdown condition of the platform 1. Each of the pressure sensors P1, etc. is in communication with the remote host via the control unit 40 and datalink 41 and is configured to measure the pressure within the segment of the hydrocarbon handling equipment in which it is disposed. Software running on a computer located at the host receives and
15 processes this pressure data. The software includes information (i.e. a 'map') provided in a database or look-up table that correlates the pressure sensors P1, etc. to both their physical location on the platform 1 of the segment to which they relate and to their relative position of that segment to other segments (in particular, adjacent segments).

20 Upon shutdown of the production platform 1, closing the valves V1, etc. has the effect of isolating each segment. The pressure sensors P1, etc. will then measure the pressure in each of their respective segments within the hydrocarbon handling equipment. This measured pressure is then sent to the remote host. At the remote host, the recorded pressure at each of the sensors P1, etc. is then
25 compared with a reference value indicative of a 'normal' (tolerable) pressure for each segment. From this comparison, any significant decrease of the recorded pressures from the reference values can be ascertained and used to identify a gas leak at a particular segment and hence the approximate location of the leak on the platform 1.

30 The pressure sensors P1, etc. continue to measure pressure over time so that any change in the pressure in each of these segments over time after shutdown, and the rate of change of pressure, will also be communicated to the host. The host software can then ascertain if there is a decrease in pressure over time in a particular segment and from the sensor map can identify that a gas leak
35 has occurred/is occurring at a particular segment.

In addition, based on the map of pressure sensor P1, etc. locations, the host software can compare pressure values or changes in one segment with those of an adjacent segment or segments. In this way, the host software can identify whether a decrease in pressure over time in a particular segment is caused by a leak to atmosphere or by internal leakages between adjacent segments of the hydrocarbon equipment (e.g. due to a faulty valve). Such an identification involves a comparison of the change in pressure in adjacent segments of the hydrocarbon equipment to determine whether a decrease in one segment can be accounted for by an increase in pressure in an adjacent segment (or segments) or vice versa.

Thus, the pressure mapping of step 3) allows the determination of whether any gas is leaking and, if so, for gas leakages to be identified in the hydrocarbon equipment and the location (in terms of the segment) of the leak to be identified. As noted above, step 3) of the method may occur, before after or simultaneously to steps 1) and/or 2).

Taking all of the steps into account, the following requirements should be met before it is determined that the situation is normal and the platform 1 may be restarted: (i) all gas and fire detectors D1, etc. should indicate "normal"; (ii) video images should be satisfactory; and (iii) the pressure mapping should indicate that there are no leaks. In this situation, the valves V1, etc. may be prepared for remote reset and then they may be reset by means of a command from the control room at the host to the control unit on the platform 1.

However, if based on the outcome of each of steps 1) to 3), if it is found that there is a gas leak (or indeed a fire and/or any other problem at the platform 1, such as damage noted by means of the CCTV), then a decision is taken at the remote host to remedy the situation. This may involve sending a personnel crew to the platform 1 to carry out maintenance. However, such a manual intervention is only used if actually required. Alternatively, the unmanned platform 1 may have the capability for remote maintenance. Thus, the system has the great advantage of avoiding the need for attendance by personnel in the event of false alarms and certain other situations.

After the situation at the platform 1 has been remedied, or if no remedy was required (a false alarm), then normal production operation at the platform 1 can be restarted (step 4) by remotely opening the valves V1, etc. associated with the production platform 1 and resetting the shutdown signals from the host. This is carried out by sending suitable command signals from the host to the control unit 40

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via data link 41. Following such a restart, the control unit 40 monitors the various sensors etc. as previously.

Claims

1. A method of determining whether there is a leak of gas from hydrocarbon handling equipment on an offshore platform, the hydrocarbon handling equipment comprising a plurality of conduits, the method comprising the steps of:
- 5
- a. providing a shut-off valve in each of a plurality of the conduits whereby one or more pair(s) of shut-off valves each define a segment of the hydrocarbon handling equipment that is isolated when the shut-off valves are closed;
- 10
- b. providing a pressure sensor to sense the pressure within each segment;
- c. obtaining pressure data from the pressure sensor(s) and the location of the corresponding segment(s);
- 15
- d. when the shut-off valves are closed, determining based upon the pressure data, whether there is a leak of gas from the hydrocarbon handling equipment and, if a leak of gas is determined to have occurred, further determining a segment from which gas is leaking and thereby determining the location of the leak.
- 20
2. A method as claimed in claim 1, wherein the shut-off valves are closed to shut down the hydrocarbon handling equipment on the platform following the detection of a gas leak and/or fire, and wherein step (d) is performed to determine whether the shut-off valves may be re-opened in order to restart the hydrocarbon handling equipment.
- 25
3. A method as claimed in claim 1 or 2, wherein the platform is an unmanned production platform (as defined herein) and the data obtained in step (c) is transmitted to a remote host where step (d) is performed.
- 30
4. A method as claimed in any preceding claim, wherein a leak of gas is detected by comparing the sensed pressure value for each segment to a predetermined reference value.

5. A method as claimed in any preceding claim, wherein a leak of gas is detected by comparing the sensed pressure value for each segment to a previous value thereof sensed subsequent to the closure of the shut-off valves.
- 5
6. A method as claimed in any preceding claim wherein, if a loss of pressure is sensed in one segment, the pressure data from adjacent segments is analysed to determine whether there has been a leak of gas to the atmosphere or whether there has been a loss of gas to an adjacent segment.
- 10
7. A method as claimed in any preceding claim, wherein the entire hydrocarbon handling equipment on the platform is divided into segments by means of shut-off valves, and wherein each segment is provided with a pressure sensor such that a leak of gas may be detected and located at any point within the hydrocarbon handling equipment from which gas may escape.
- 15
8. A method as claimed in any preceding claim, further comprising providing gas detectors on the platform and providing data therefrom to a remote host to determine whether free gas is present at the platform.
- 20
9. A method as claimed in any preceding claim, further comprising providing video (CCTV) cameras on the platform and providing data therefrom to a remote host to enable a visual inspection of the platform therefrom.
- 25
10. A system for determining whether there is a leak of gas from hydrocarbon handling equipment on an offshore platform, the hydrocarbon handling equipment comprising a plurality of conduits, the system comprising:
- 30
- a shut-off valve in each of a plurality of the conduits whereby one or more pair(s) of shut-off valves each define a segment of the equipment that is isolated when the shut-off valves are closed;

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a pressure sensor arranged to sense the pressure within each segment; and

wherein the system is arranged to determine, when the shut-off valves are closed, and based upon the data from the pressure sensor(s) and the location of the corresponding segment(s), whether there is a leak of gas from the hydrocarbon handling equipment and, if a leak of gas is determined to have occurred, further to determine a segment from which gas is leaking and thereby determining the location of the leak.

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11. The system as claimed in claim 10, wherein the platform is an unmanned production platform (as defined herein) and the system further comprises a remote host, and whereby the remote host is arranged to determine, when the shut-off valves are closed, and based upon the data from the pressure sensors and the location of the corresponding segments, whether there is a leak of gas from the hydrocarbon handling equipment and, if a leak of gas is determined to have occurred, the remote host is further arranged to determine a segment from which gas is leaking and thereby determining the location of the leak.

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12. The system as claimed in claim 10 or 11, wherein the system is configured to detect a leak of gas by comparing the sensed pressure value for each segment to a predetermined reference value.

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13. The system as claimed in claim 10, 11 or 12, wherein the system is configured to detect a leak of gas by comparing the sensed pressure value for each segment to a previous value thereof sensed subsequent to the closure of the shut-off valves.

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14. The system as claimed in any of claims 10 to 13, wherein, if a loss of pressure is sensed in one segment, the system is configured to analyse pressure data from adjacent segments to determine whether there has been a leak of gas to the atmosphere or a loss of gas to an adjacent segment.

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- 5 15. The system as claimed in any of claims 10 to 14, wherein the entire hydrocarbon handling equipment on the platform is divided into segments by means of shut-off valves and wherein each segment is provided with a pressure sensor such that a gas leak may be detected and located at any point within the hydrocarbon handling equipment from which gas may escape.
- 10 16. The system as claimed in any of claims 10 to 15, further comprising gas detectors on the platform arranged to provide data therefrom to a (the) remote host to determine whether free gas is present at the platform.
- 15 17. The system as claimed in any of claims 10 to 16, further comprising video (CCTV) cameras on the platform arranged to provide data therefrom to a (the) remote host to enable a visual inspection of the platform therefrom.

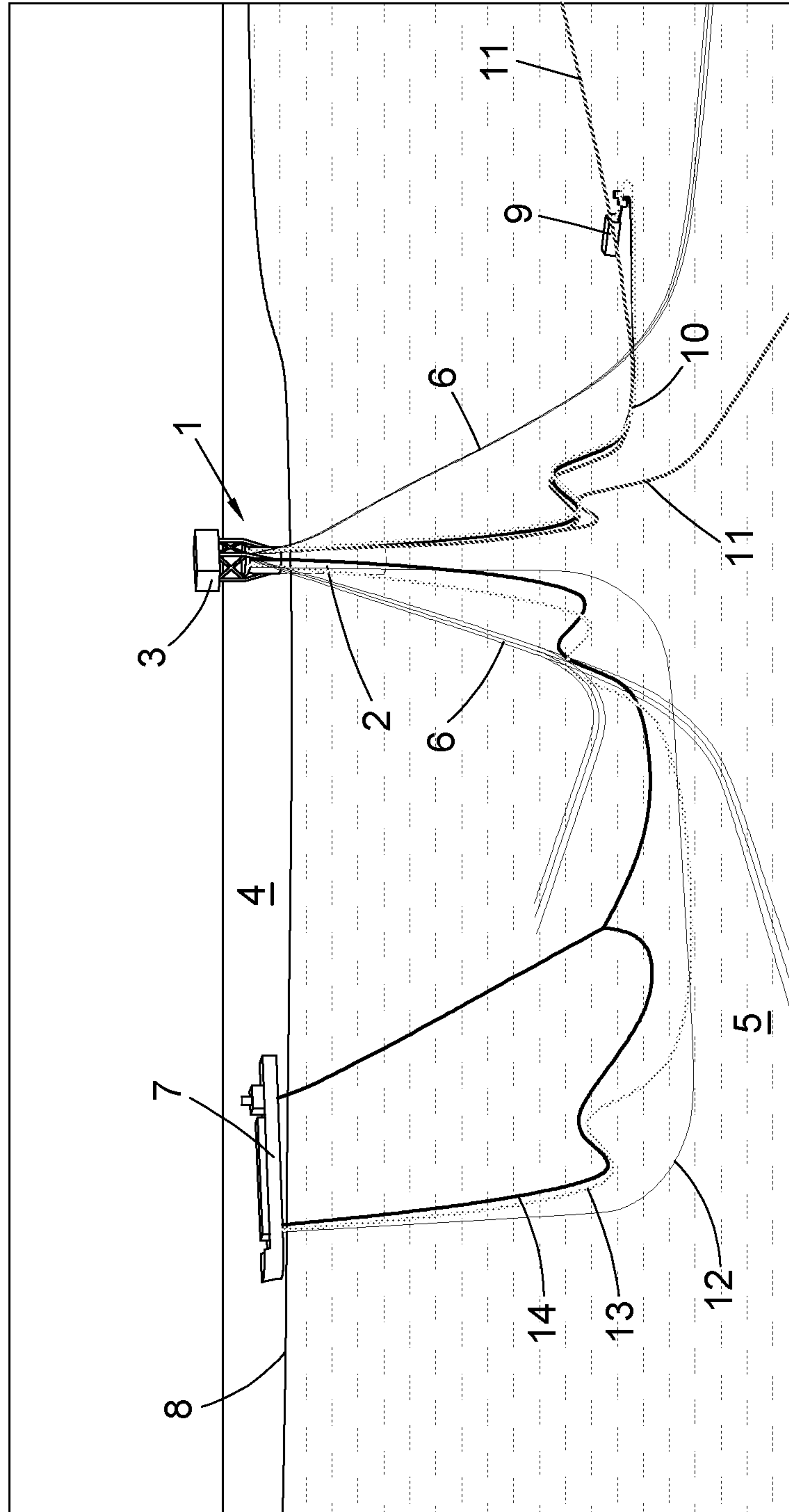


Fig. 1

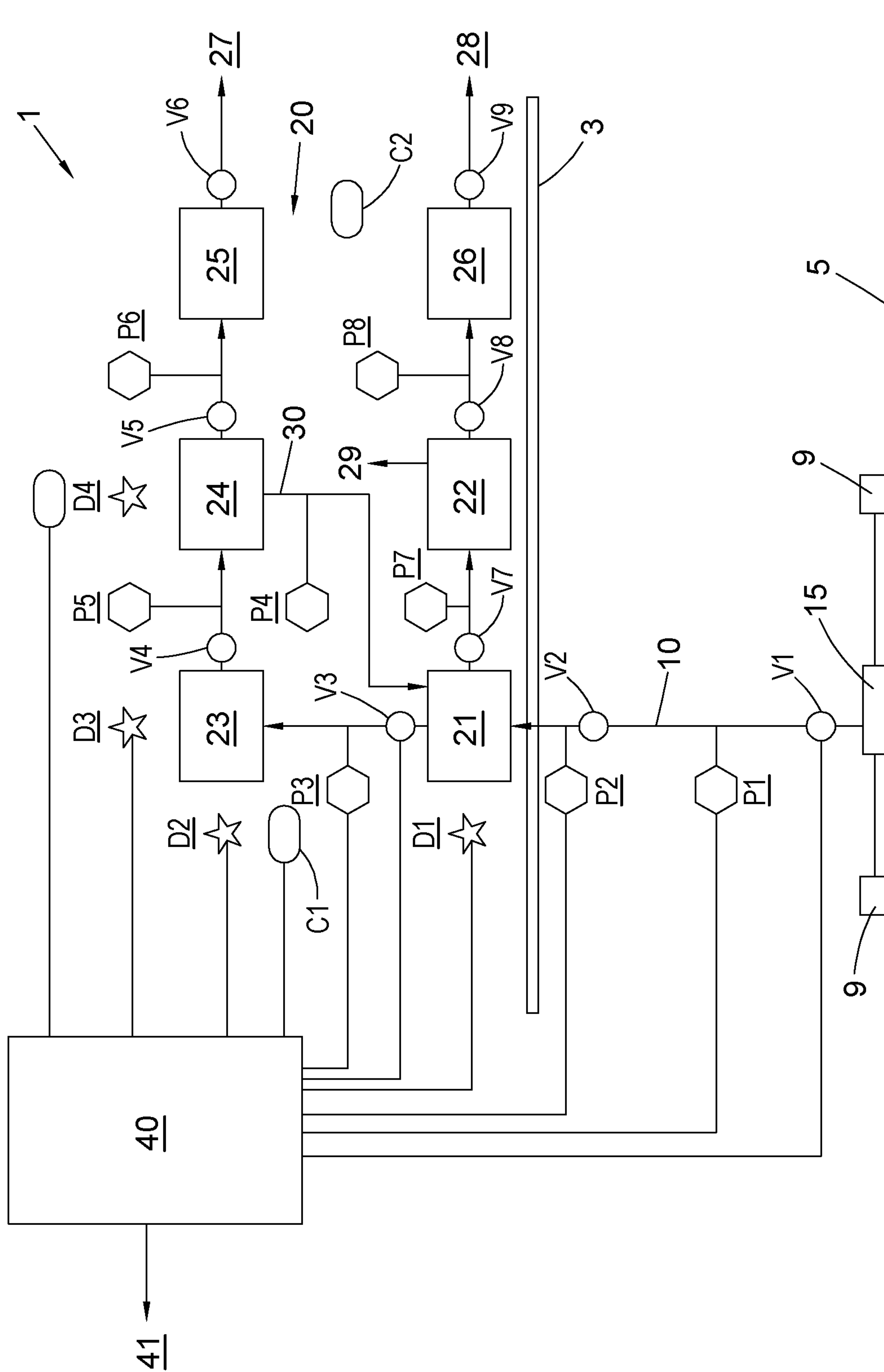


Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.

PCT/NO2020/050261

A. CLASSIFICATION OF SUBJECT MATTER		
B63B 35/44 (2006.01), E02B 17/00 (2006.01), G05B 23/00 (2006.01)		
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) B63B35/4413; B63B35/44; B63B25/12; E02b17/0034; G05b23/00		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched DK, NO, SE, FI: Classes as above.		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPODOC, WPI, FULL TEXT: ENGLISH, GERMAN, FRENCH, NORWEGIAN		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 0102242 A1 (BURBAGE P. J. et al.) 2001.01.11	1, 3-10, 12-17
Y	Whole document, especially, fig. 1; page. 3, lines 24-29, page 4, line 18-page. 5, line 12, page. 8, lines 10-16.	2, 11
Y	NIELSEN A. et al. Unmanned wellhead platforms – UWHP summary report, March, 2016 [Retrieved December 2020 from the Internet]. (https://www.npd.no/globalassets/1-npd/publikasjoner/rapporter/unmanned-wellhead-platforms.pdf) Whole document, especially page. 9, section 3.7 “Type 3 platforms”.	2, 11
☐ 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 “D” document cited by the applicant in the international application “E” earlier application or patent but published on or after the international filing date “L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) “O” document referring to an oral disclosure, use, exhibition or other means “P” document published prior to the international filing date but later than the priority date claimed	“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention “X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone “Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art “&” document member of the same patent family	
Date of the actual completion of the international search	Date of mailing of the international search report	
14/12/2020	17/12/2020	
Name and mailing address of the ISA Nordic Patent Institute Helgeshøj Allé 81 DK - 2630 Taastrup, Denmark. Facsimile No. -	Authorized officer Nguyen, Hai Vu Telephone No. +4740902017	

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/NO2020/050261

Patent document cited in search report / Publication date	Patent family member(s) / Publication date
WO 0102242 A1 2001.01.11	AU 5419300 A 2001.01.22 NO 20016431L L 2002.03.04 EP 1189805 A1 2002.03.27 EP 1189805 B1 2003.11.26 US 6390733 B1 2002.05.21
NIELSEN A. et al. Unmanned wellhead platforms – UWHP summary report, March, 2016 [Retrieved December 2020 from the Internet]. (https://www.npd.no/globalassets/1-mpd/publikasjoner/rapporter/unmanned-wellhead-platforms.pdf)	None.