



(51) International Patent Classification:

F16L 53/34 (2018.01) H05B 3/00 (2006.01)

F16L 53/35 (2018.01) H05B 3/02 (2006.01)

F16L 53/37 (2018.01)

(21) International Application Number:

PCT/NO2020/050056

(22) International Filing Date:

03 March 2020 (03.03.2020)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

1903364.6 12 March 2019 (12.03.2019) GB

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,

(54) Title: EXTENSION OF DIRECT ELECTRICAL HEATING SYSTEMS

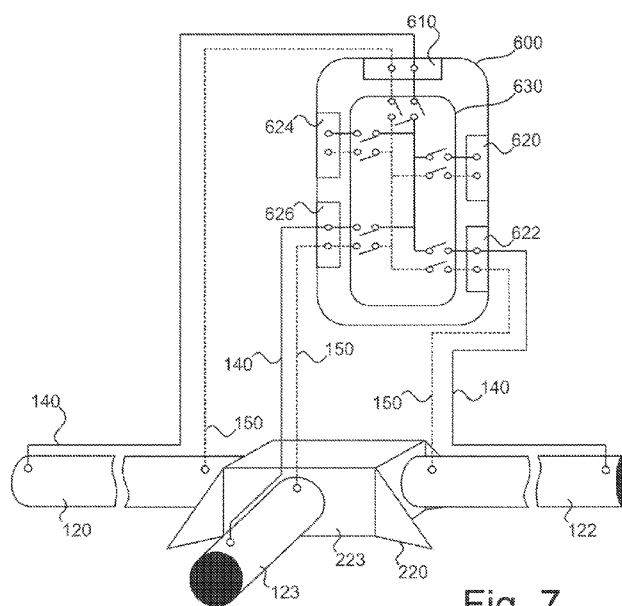


Fig. 7

(57) Abstract: A method of providing direct electrical heating, DEH, to one or more of at least three subsea pipelines is disclosed. The pipelines are attached to a common structure and a first set of DEH cables associated with a first subsea pipeline terminates at or near the structure. Terminal ends of the first set of DEH cables are coupled into an input of a switching device. Terminal ends of sets of DEH cables respectively associated with further pipelines are coupled to respective outputs of the switching device. The switching device couples the terminal ends of the first set of DEH cables either together or to terminal ends of the one or more further sets of DEH cables.

EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,
MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

EXTENSION OF DIRECT ELECTRICAL HEATING SYSTEMS

Technical Field

The present invention relates to the extension of direct electrical heating ('DEH') systems used for heating subsea pipelines and in particular to such extension from a first pipeline to two or more further pipelines.

Background

Within the field of subsea extraction fields for oil and gas, the formation of hydrates and wax, as well as so-called gelling, within subsea pipelines used to convey hydrocarbons are well-known problem and occurs when free water and natural gas or oil combine under conditions of high pressure and low temperature. Their subsequent crystallization can result in large and lengthy plugs, severely inhibiting the transit of hydrocarbons.

Several thermodynamic techniques are known to mitigate this problem, which variously include controlling the internal pressure of pipelines, injecting thermal threshold-modifying inhibitors such as methanol, and heating the well stream to maintain its temperature above hydrate formation thresholds. More traditional methods of clearing wax and hydrates deposits, and removing gelling, in pipelines rely upon chemical inhibitors, and are both expensive to implement and environmentally dangerous in case of leakage.

A pipeline heating technique that has gained recognition in the oil and gas industry is commonly referred as direct electrical heating ('DEH'), and is based upon the principle of ohmic loss, wherein a non-trivial current is applied to the pipeline, effectively through the pipeline itself, causing it to warm up due to the electrical resistance of its metallic composition, whereby thermal conduction then transfers heat from the pipeline wall to the well contents therein. The current supplied to the pipeline is an AC current such that the electromagnetic force acting between the cable and the ferromagnetic pipe steel ensures a significant current returning in the pipeline.

With reference to Figure 1, a subsea direct electrical heating ('DEH') system typically consists of an electrical loop including a power supply 110 located topside, directly coupled to the wall of a subsea pipeline 120 adjacent both ends 127, 128 thereof. The pipeline 120 further includes sacrificial anodes 121 to mitigate corrosion. The DEH loop is formed by a riser cable 130 extending from the power supply 110 towards the sea floor, a feeder cable 140 extending from the riser cable 130 towards the pipeline 120 and then installed piggybacked along an extended section 129 of heated pipeline, and a return cable 150. The distal end 141 of the

feeder cable 140 is coupled to the pipeline wall at or adjacent the pipeline end 128 distal the riser cable 130, and the distal end 151 of the return cable 150 is coupled with the pipeline wall at or adjacent the pipeline end 127 proximate the riser cable 130, opposite the feeder cable connection 151. Although not shown in Figure 1, both ends 127, 128 of the pipeline 120 are connected to ground to ensure that current transfer to seawater is controlled. The current density needs to be kept below certain acceptable levels to avoid AC corrosion on pipe steel (and anode material). The grounding at both ends ensures that the potential between the pipe steel and seawater is as low as possible reducing AC corrosion to a minimum.

With reference to Figure 2, a subsea pipeline is typically coupled with a manifold 210, which includes a variety of pipes and valves and which is designed to transfer oil or gas from wellheads into the pipeline 120. Such manifolds 210 can be mounted on a variety of structures, ranging from platforms above water to subsea structures known in the art as "templates" 220. A template 220 is typically made of steel and is designed as a common node in an undersea pipeline network for anchoring a variety of subsea sub-structures. A template 220 may itself be fitted with, or integrate, a still larger protective cover structure, designed to mitigate accidental damage from fishing, dredging and similar activities.

In view of this subsea structural context, and giving due consideration to factors inherent to offshore work such as non-trivial installation, maintenance and operational costs, operational environment and safety, and meteorological variations and risks, extending an existing a DEH system to any number of additional pipeline(s), when these are added to an existing and DEH-equipped subsea pipeline network as illustrated in Figures 1 and 2, is a challenging operation, because it is highly dependent upon the existing configuration of cover, template and any other subsea structures and pipeline(s) already on site.

With reference to Figures 3 and 4, it is known to extend both the functionality and the control of a DEH system equipping a first pipeline, to a second pipeline coupled with an end of the first pipeline, by means of a subsea junction box located intermediate the riser cable and the feeder and return cables. A junction box 310 usefully implements a bypass loop, when both the original pipeline 120 and an additional pipeline 122 are coupled with a same subsea template 220 on opposed ends 221, 222 thereof, wherein the subsea template 220 breaks the circuit segment which the two pipelines 120, 122 could otherwise constitute, and so needs to be bypassed.

Known methods of providing direct electrical heating in circuits as illustrated in Figure 3 are still applied when DEH systems are extended, and Figure 4 shows an example pipeline network wherein an additional two pipelines 123, 124 are coupled with a subsea template 220 on a side

opposed to the two original pipelines 120, 122 equipped with a first DEH circuit 100, and wherein heating the additional two pipelines 123, 124 requires a second power supply 112 topside thus, effectively, what amounts to a second DEH system 102. Such methods of the prior art are clearly wasteful and sub-optimal.

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It is noted that DEH may be applied to pipelines that terminate at a platform rather than a template. Analogous to the approach described above, DEH may be extended between two pipelines in order to bypass the platform.

10 There is accordingly a need for an improved method of providing direct electrical heating in subsea pipeline systems in order to mitigate disadvantages of known techniques described above.

WO2006/075913 describes a system for selectively using cables running along a pipeline to
15 facilitate DEH of the pipeline or to provide three-phase power for subsea electrical equipment such as a water injection motor.

Summary

20 The disadvantages of the prior art are solved by a method of providing direct electrical heating in subsea pipeline networks, according to the appended claims.

The present method of providing DEH is particularly suited to the extension of an existing DEH system to two or more further pipelines, which occurs for instance when one or more new
25 pipelines need to be laid for accommodating additional well streams.

A subsea direct electrical heating (DEH) system is also provided, wherein DEH may be provided to a plurality of subsea pipelines according embodiments of the method.

30 Other aspects are as set out in the claims herein.

Brief Description of the Drawings

Figure 1 is a functional diagram of a subsea direct electrical heating (DEH) system of the prior
35 art, comprising a subsea pipeline.

Figure 2 illustrates a subsea template, to which one or more subsea pipelines as shown in Figure 1 are typically coupled.

Figure 3 is a functional diagram of another subsea direct electrical heating (DEH) system of the prior art, comprising two DEH circuits of Figure 1 across a subsea template of Figure 2.

5 Figure 4 is a functional diagram of yet another subsea direct electrical heating (DEH) system of the prior art, comprising two loops across a pipeline network.

Figure 5 illustrates steps of a method of controlling power supply in the subsea direct electrical heating (DEH) system of Figure 3, when a third subsea pipeline with DEH requirement is added thereto, including steps of providing a subsea switching device and controlling DEH circuits.

10 Figure 6 is a functional diagram of the subsea switching device of Figure 5.

Figure 7 shows the circuit of Figure 6 being used to provide DEH to a network of three pipelines.

Figure 8 illustrates sub steps of an embodiment of the step of controlling DEH circuits in Figure 5.

15 Figure 9 shows the circuit of Figure 6 being used to provide DEH to a network of four pipelines.

Detailed Description

There will now be described by way of example a specific mode contemplated by the inventors.

20 In the following description numerous specific details are set forth in order to provide a thorough understanding. It will be apparent however, to one skilled in the art, that the present invention may be practiced without limitation to these specific details. In other instances, well known methods and structures have not been described in detail so as not to unnecessarily obscure the description.

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Embodiments described herein relate to a method of providing Direct Electrical Heating (DEH) to one (120) or more (122, 123, 124) of a plurality of pipelines attached to a subsea template 220, wherein a set of two of DEH cables 140, 150 associated with a first subsea pipeline 120 terminate at a junction box at or adjacent to the template 220. It will be readily understood by

30 the skilled reader that the approach is not restricted to the extension of DEH across templates, and may be applied, for example, to the extension of DEH across other structures, for instance a platform above the water at which multiple pipelines are terminated. Likewise it will be readily understood by the skilled reader that the approach is not restricted to DEH supplied with a single phase current through a set of two cables 140, 150, and may be applied to DEH supplied

35 with current through at least one set of a plurality of cables (e.g., three or more cables; not shown) wherein the current of each set is more preferably single phase than, less preferably, multi, e.g., three, phase.

A general principle of the method of the invention is to replace that junction box with a switching device, for extending the first set of DEH cables 140, 150 associated with the first subsea pipeline 120 into that switching device, then to couple terminal ends of respective sets 140, 150 of DEH cables associated with further pipelines 122-124 to the switching device. A base configuration of the switching device couples the terminal ends of the first set of DEH cables 140, 150 selectively either together for providing DEH to the first pipeline 120 only, or to terminal ends of DEH cables 140, 150 associated with one or more of the further subsea pipeline 122-124, thereby providing DEH to the first subsea pipeline 120 and extending the DEH to one or more of the further subsea pipelines 122-124.

With reference to Figures 5 to 7, an embodiment of the method of providing direct electrical heating in a subsea direct electrical heating (DEH) system begins at step 501, wherein a first DEH circuit 100 is provided, which comprises first and second pipelines 120, 122 associated with, respectively, first and second sets of cables 140-150. The first circuit 100 further comprises a junction box 310 coupled between the first and second pipelines 120, 122 for implementing a bypass loop about the subsea template 220, operable to selectively extend supply to the second pipeline 122. This initial step effectively corresponds to an existing DEH circuit 100 applied to two pipelines 120, 122 as illustrated in Figure 3, which a user needs to extend with one (123) or more (124) additional pipelines for operational purposes.

At a next step 502, a subsea switching device 600 is provided which, with reference to Figure 6, comprises at least one power "input" 610 selectively and respectively connectable with a plurality of power "outputs" 620, 622, 624, 626 by a power distribution bus 630 having a plurality of switchable contactors 640, 642, 644, 646, 650. At least one switchable contactor 650 (hereinafter the 'intermediate contactor' 650) is located intermediate the at least one power input 610 and switchable contactors 640-646 associated with respective power outputs 620-626, which is operable to couple together the terminal ends of a set of DEH cables 140, 150 coupled with the at least one power input 610, so as to close the electrical circuit implemented by that set of DEH cables.

Characteristics of the subsea switching device 600 are determined according to, for example: output and capacity of the existing power supply 110; operational requirements of the DEH system, giving due consideration to the operational environment of the pipelines that includes prevalent sea temperature adjacent the pipelines, pipeline material and wall thickness, pipeline heated length and well stream temperature; compatibility of connectivity with existing power

couplers; and more. In principle, the subsea switching device 600 may be of any type and may include, for example, vacuum circuit breakers, contactors, disconnectors, reclosers or the like, and have electric poles provided with mobile contacts that can be actuated by suitable actuators, for example of the electromagnetic type.

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At a next step 503, terminal ends of the first set of DEH cables 140, 150 associated with the first pipeline 120 are uncoupled from the input of the junction box 310, and coupled with the input 610 of the subsea switching device 600. Accordingly, when closing the intermediate contactor 650, the circuit defined by a topside power supply 110 and the first set of DEH cables 140, 150 extending therefrom, would be closed whereby the first pair of DEH cables 140, 150 associated with the first pipeline 120 gets supplied with power, and the first pipeline 120 gets heated.

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At a next step 504, terminal ends of the second set of DEH cables 140, 150 associated with the second pipeline 122 are coupled with a first (622) of the outputs 620-626 available at the subsea switching device 600. Accordingly, upon opening the intermediate contactor 650 and closing the subsea switching device contactor 642 respectively associated with the first-selected output 622 of the subsea switching device 600, terminal ends of the second set of DEH cables 140, 150 associated with the second pipeline 120 are coupled with terminal ends of the first set of DEH cables 140, 150 associated with the first pipeline 120, wherein both sets of DEH cables are supplied with power and DEH is provided to both pipelines 120, 122.

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At a next step 505, an additional pipeline 123 is located adjacent the first two pipelines 120, 122. For example, an additional volume of oil or gas needs to be extracted from an existing well, whereby a new well head and manifold 210 are installed at the existing subsea template 220, and an end of the additional pipeline 123 is secured thereto. The additional pipeline 123 is lowered from the topside, conventionally ready-equipped with a respective set of DEH cables 140, 150 for purposes of operational and cost efficiency, wherein the feeder cable 140 is secured to the length of pipeline to be heated. The end of the additional pipeline 123 distal the feeder cable 140 and proximate the return cable 150 is then coupled with the subsea template 220, on a side 223 orthogonal to those bearing the existing pipelines 120, 122 in the example case of template with a substantially square structure.

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At a next step 506, terminal ends of the additional set of DEH cables 140, 150 associated with the third pipeline 123 are coupled with a next output (626) selected amongst the three outputs 620, 624, 626 remaining available at the subsea switching device 600 of the example. A next DEH circuit is accordingly created, extending from and returning to that next-selected subsea

switching device output 626 with which the third set of DEH cables 140, 150 is coupled, and which is uniquely associated with that additional pipeline 123.

Upon opening the intermediate contactor 650 and closing the subsea switching device contactor 646 associated with that next-selected subsea switching device output 626, terminal ends of the third set of DEH cables 140, 150 associated with the third pipeline 123 are accordingly coupled with terminal ends of the first set of DEH cables 140, 150 associated with the first pipeline 120, wherein both sets of DEH cables are supplied with power and DEH provided to both pipelines 120, 123.

A question is next asked at step 507, about whether a further pipeline 124 needs to be located at the subsea template 220 adjacent the three pipelines 120-123. When the question of step 507 is answered negatively, operational control of the subsea DEH system resumes for heating connected pipelines 120, 122, 123 at step 508, wherein the sets of DEH cables 140, 150 respectively coupled with the input 610 and the two outputs 642, 646 of the subsea switching device 600, thus the sets of DEH cables 140, 150 respectively associated with the first, second and third pipelines 120, 122, 123, are selectively supplied with power according to operational requirements, implemented through relevant switching of the switchable contactors 650, 642, 646. In DEH systems supplied with a single phase current, at step 508 the current supplied in the first set of cables 140, 150 associated with the first pipeline 120 can thus be selectively supplied individually to a further one of the second set of cables 140, 150 associated with the second pipeline 122 or the third set of cables 140, 150 associated with the third pipeline 123, and so on and so forth as additional pipelines may be added to the DEH system.

Alternatively, if the extended DEH system is operated in parallel, then at step 508 the current supplied in the first set of cables 140, 150 associated with the first pipeline 120 may be divided between the sets of cables respectively associated with each of the first, second and third pipelines 120-123, pro rata their impedance. For example, upon opening the intermediate contactor 650 and closing both subsea switching device contactors 642, 646 respectively associated with the second- and third-selected subsea switching device outputs 622, 626, terminal ends of the second and third sets of DEH cables 140, 150 respectively associated with the second and third pipelines 122, 123 are accordingly coupled with terminal ends of the first set of DEH cables 140, 150 associated with the first pipeline 120, wherein all three sets of DEH cables are supplied with power divided therebetween, and DEH is provided to all three pipelines 120, 122, 123.

Alternatively, the question of step 507 is answered positively wherein, with reference to Figure 9, the method returns to the additional pipeline location step 505, in the example for locating a fourth pipeline 124 about the subsea template 220, co-axially with the third pipeline 123 and orthogonally to the first and second pipelines 120, 122.

Consequently, upon connecting the terminal ends of the additional set of DEH cables 140, 150 associated with the fourth pipeline 124 to a next (620) amongst the two outputs 620, 624 remaining available at the subsea switching device 600, a next DEH circuit is accordingly created, extending from and returning to that next-selected subsea switching device output 620 with which the fourth set of DEH cables 140, 150 are coupled, and which is uniquely associated with the fourth pipeline 124. Upon opening the intermediate contactor 650 and closing the subsea switching device contactor 640 associated with that next-selected subsea switching device output 620, the fourth set of DEH cables 140, 150 associated with the fourth pipeline 124 is accordingly supplied with power, and the additional pipeline 124 suitably heated.

Embodiments of the present method of providing direct electrical heating may advantageously be automated. In particular, for a DEH system supplied with a level of power that is insufficient for achieving satisfactory heating of all the pipelines 120-124 concurrently, the operational control of step 508 may usefully implement a sequential provision of power to connected pipelines 120-124 within the extended DEH system, with switching made dependent on, by way of non-limitative for example, the level of power available to supply DEH, and/or operational status of pipelines and/or environmental conditions about pipelines.

An example embodiment of logic for controlling the sequential supply of direct electrical heating at step 508 is shown in Figure 8, with switching made dependent on an operational status of each pipeline, and which begins with the supply of power to the first set of cables 140, 150 associated with the first pipeline at step 801, wherein the intermediate contactor 650 is closed.

A first question is asked at step 802, about whether production has begun or will shortly begin in a next pipeline 122-124 of the DEH system, for example the second pipeline 122. If the question of step 802 is answered negatively, control returns to step 801. Alternatively, when the question of step 802 is answered positively, then at step 803 the next pipeline 122 is supplied with DEH, by opening the intermediate contactor 650 and closing the subsea switching device contactor 642 associated with the second subsea switching device outputs 622, whereby DEH is provided to both the first pipeline 120 and the additional, second pipeline 122.

A waiting step 804 is provided to allow the second pipeline 122 to heat up under the supplied DEH and, at step 805, a second question is asked, about whether production within the second pipeline 122 has reached a stable level of operation. If the question of step 805 is answered negatively, control returns to the waiting step 804, providing additional time for the pipeline 122 to heat up and for its production to stabilise.

Eventually, the question of step 805 is answered positively, whereby a third question is asked at step 806, about whether production has begun or will shortly begin in a further pipeline 123-124 of the DEH system, in the example the third pipeline 123. If the question of step 806 is answered negatively, control returns to the supply step 803, whereby DEH continues to be provided to both the first and the second pipelines 120, 122.

Alternatively, when the question of step 806 is answered positively, then the last additional pipeline to be supplied with DEH at step 803, in the example the second pipeline 122, is identified at step 807, the supply of DEH to the identified pipeline is interrupted at step 808, for instance by opening the subsea switching device contactor 642 associated with the second subsea switching device output 622, and the third pipeline 123, is selected at step 809. Control then returns to step 803, wherein the third pipeline 123 is supplied with DEH, by maintaining the intermediate contactor 650 opened and closing the subsea switching device contactor 646 associated with the third subsea switching device output 626, whereby DEH is provided to both the first and now the third pipelines 120, 123.

An alternative embodiment of the logic described with reference to Figure 8 considers the sequential supply of DEH to two pipelines additional to the first, if the level of power available to supply DEH is sufficient for achieving satisfactory heating of at least 3 pipelines 120-123 out of the total number of pipelines 120-124 connected to the system.

Another alternative embodiment of the logic described with reference to Figure 8 considers the sequential supply of DEH in dependence on environmental conditions about the pipelines, rather than, or in addition to, the operational status and availability of power already described. The embodiment of such an alternative logic may usefully rely upon the inclusion of one or more sensors (not shown) in extended DEH systems as described herein, adapted to detect at least one environmental value amongst a hydrothermal value adjacent extremities of pipelines 120-124 distal the subsea template 220, a temperature value of the outer wall of the pipelines 120-124, a temperature value of the well stream within each pipeline 120-124 and a power supply value of each feeder cable 140.

Such sensor(s) may be operably coupled with the subsea switching device 600, specifically with control means of the power hub 630, wherein the hub 630 is operable to automatically close switchable actuators for coupling terminal ends of sets of DEH cables 140, 150 associated with the pipelines 120-124, when the value or values detected by the sensor(s) correspond to actuation value(s) by reference to predetermined threshold(s), for instance a local sea temperature relative to a pre-set minimum.

In the specification the terms "*comprise, comprises, comprised and comprising*" or any variation thereof, and the terms "*include, includes, included and including*" or any variation thereof, are considered interchangeable and should be afforded the widest possible interpretation.

The inventive principle described herein is not limited to the embodiments hereinbefore described but may be varied in both construction and detail.

Claims

1. A method of providing direct electrical heating, DEH, to one or more of at least three subsea pipelines, where all of the pipelines are attached to a common structure and wherein a first set of DEH cables associated with a first of said subsea pipelines terminate at or adjacent to the structure, the method comprising:

coupling terminal ends of said first set of DEH cables associated with said first subsea pipeline into an input of a switching device;

coupling terminal ends of sets of DEH cables respectively associated with the further pipelines to outputs of said switching device; and

configuring the switching device to

a) couple together the terminal ends of said first set of DEH cables associated with said first subsea pipeline in order to provide DEH only to said first subsea pipeline, or

b) couple the terminal ends of said first set of DEH cables associated with said first subsea pipeline to terminal ends of one or more of said sets of DEH cables respectively associated with said further subsea pipelines in order to provide DEH to said first subsea pipeline and extend the DEH to one or more of said further subsea pipelines.

2. A method according to claim 1, wherein step b) further comprises configuring the switching device to couple the terminal ends of said first set of DEH cables sequentially to terminal ends of each of said sets of DEH cables respectively associated with said further subsea pipelines, in order to provide DEH to said first subsea pipeline and extend the DEH sequentially to each of said further subsea pipelines.

3. A method according to claim 1 wherein, when the method provides DEH to at least four subsea pipelines, the method comprises the further step of detecting a level of power available to supply DEH and, when the determined power level is sufficient to provide DEH to at least three pipelines concurrently, step b) further comprises configuring the switching device to couple terminal ends of said first set of DEH cables sequentially to terminal ends of at least two of said sets of DEH cables respectively associated with said further subsea pipelines, in order to provide DEH to said first subsea pipeline and extend the DEH sequentially to at least two of said further subsea pipelines

4. A method according to claim 2 or 3, comprising the further step of determining an operational status for the further subsea pipeline provided with DEH, before sequentially

coupling the terminal ends of said first set of DEH cables to terminal ends of another set of DEH cables respectively associated with another of said further subsea pipelines.

5. A method according to any of claims 2 to 4, comprising the further step of detecting at least one environmental value at or adjacent the further subsea pipeline provided with DEH, before sequentially coupling the terminal ends of said first set of DEH cables to terminal ends of another set of DEH cables respectively associated with another of said further subsea pipelines.

6. A method according to any of claims 1 to 5, wherein each set of DEH cables comprises a plurality of cables adapted to supply single- or three-phase power.

7. A subsea direct electrical heating (DEH) system, comprising:
at least three sets of DEH cables, wherein each set is associated with a respective subsea pipeline, and each pipeline is attached to a common structure ;
a switching device having at least one input and a plurality of outputs, wherein terminal ends of a first set of DEH cables associated with a first of said at least three pipelines are coupled into said at least one input, and terminal ends of remaining sets of DEH cables are coupled with respective outputs ; and
a controller for configuring the switching device to

- a) couple together the terminal ends of said first set of DEH cables associated with said first subsea pipeline in order to provide DEH only to said first subsea pipeline, or
- b) couple the terminal ends of said first set of DEH cables associated with said first subsea pipeline to terminal ends of DEH cables associated with one or more of said further subsea pipelines in order to provide DEH to said first subsea pipeline and extend the DEH to one or more of said further subsea pipelines.

8. A system according to claim 7, wherein the controller is further configured to couple the terminal ends of said first set of DEH cables sequentially to terminal ends of each of said sets of DEH cables respectively associated with said further subsea pipelines, in order to provide DEH to said first subsea pipeline and extend the DEH sequentially to each of said further subsea pipelines.

9. A system according to claim 7 wherein, when the system comprises at least four subsea pipelines, the controller being configured to cause the switching device to couple terminal ends of said first set of DEH cables sequentially to terminal ends of at least two of said

sets of DEH cables respectively associated with said further subsea pipelines, in order to provide DEH to said first subsea pipeline and extend the DEH sequentially to at least two of said further subsea pipelines

5 10. A system according to any of claims 7 to 9, wherein the subsea switching device further comprises actuation means operably coupled to said controller for switching switches of the switching device automatically.

10 11. A system according to any of claims 7 to 10, further comprising at least one sensor operably coupled with said controller, whereby the controller uses data provided by the sensor to operate said switches via the actuation means.

12 A system according to any of claims 7 to 11, wherein each set of DEH cables comprises a plurality of cables adapted to supply single- or three-phase power.

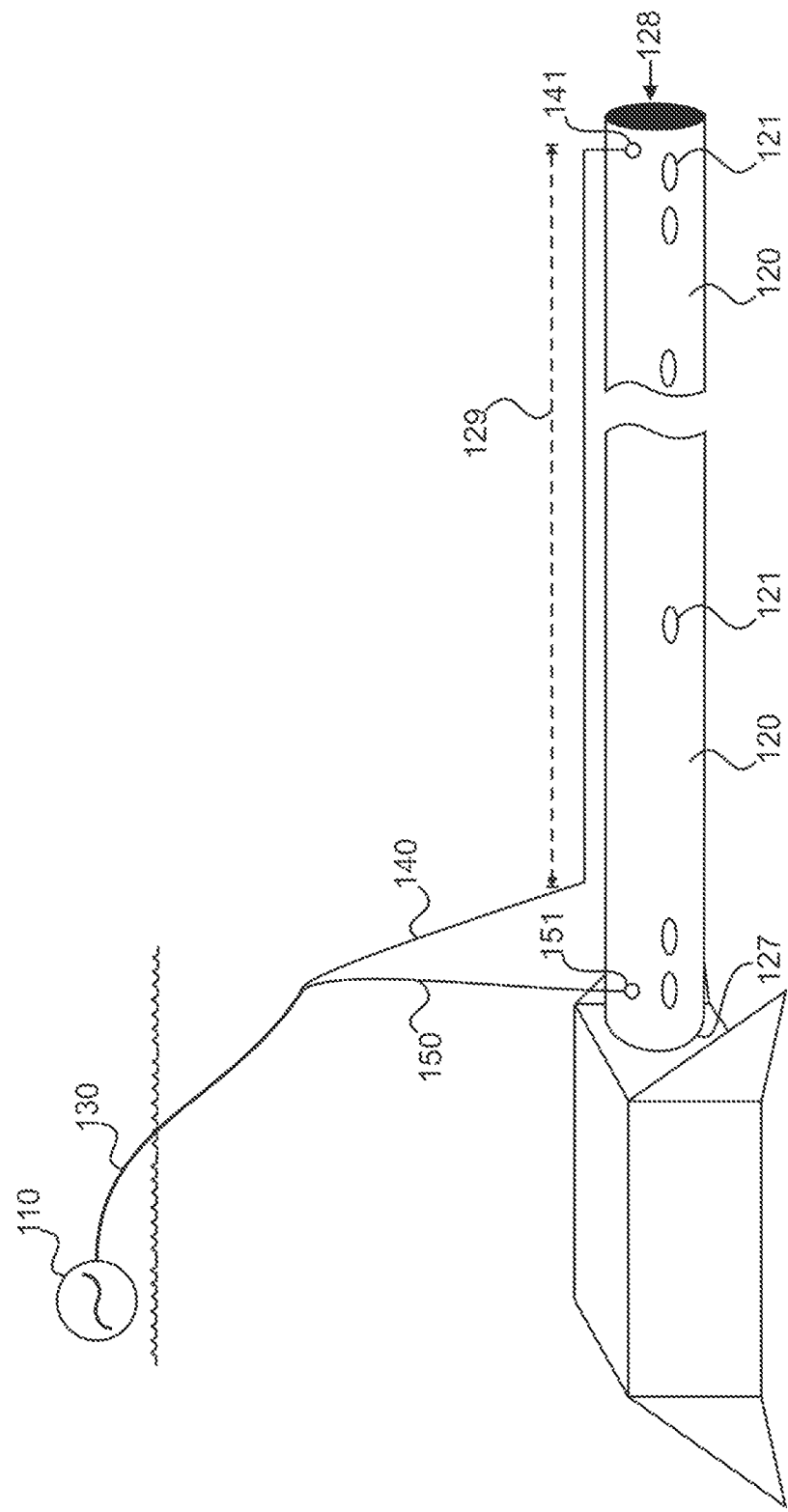


Fig. 1 [prior art]

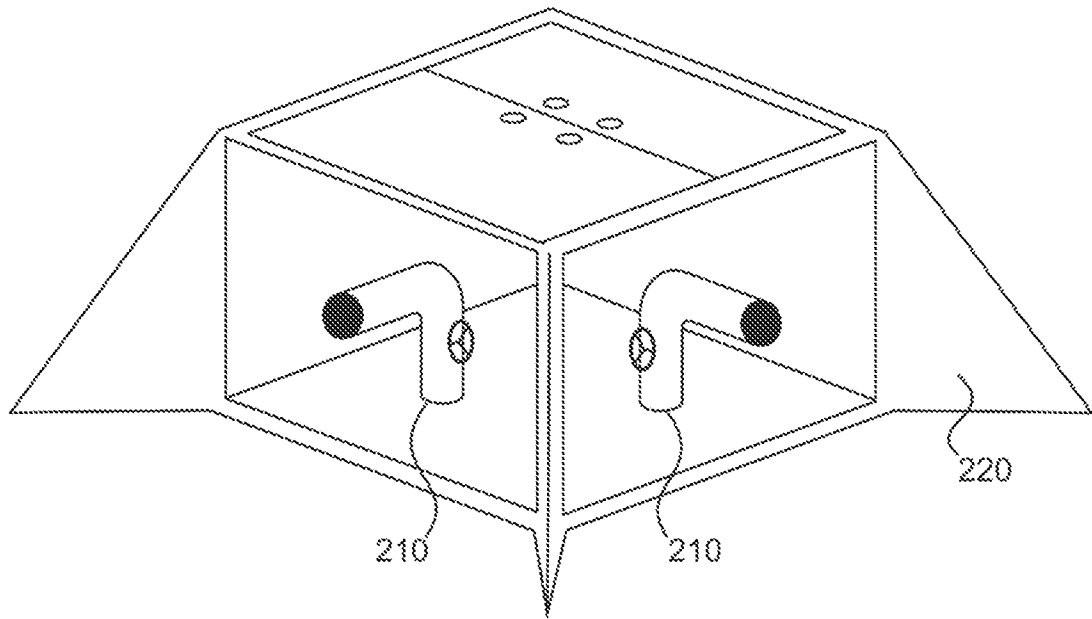


Fig. 2

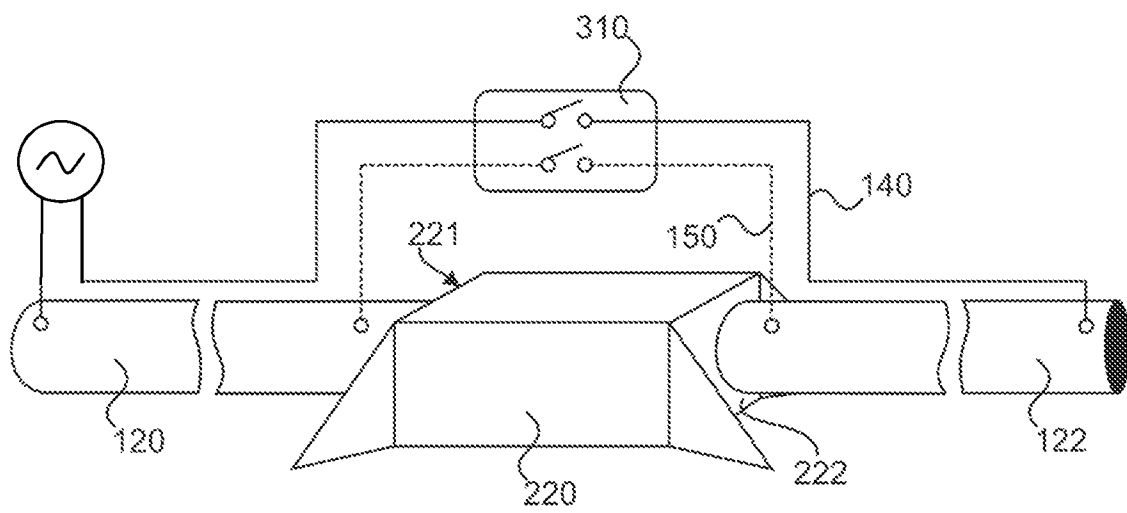


Fig. 3

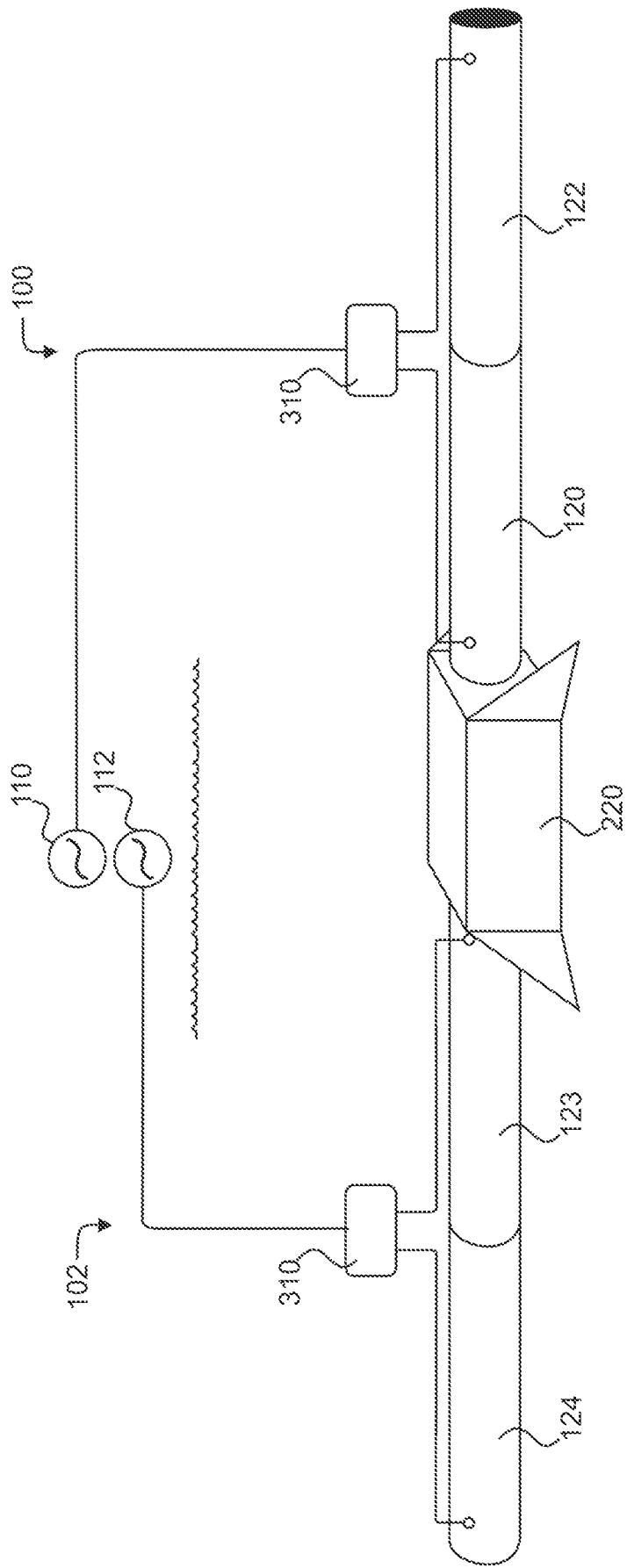


Fig. 4 [prior art]

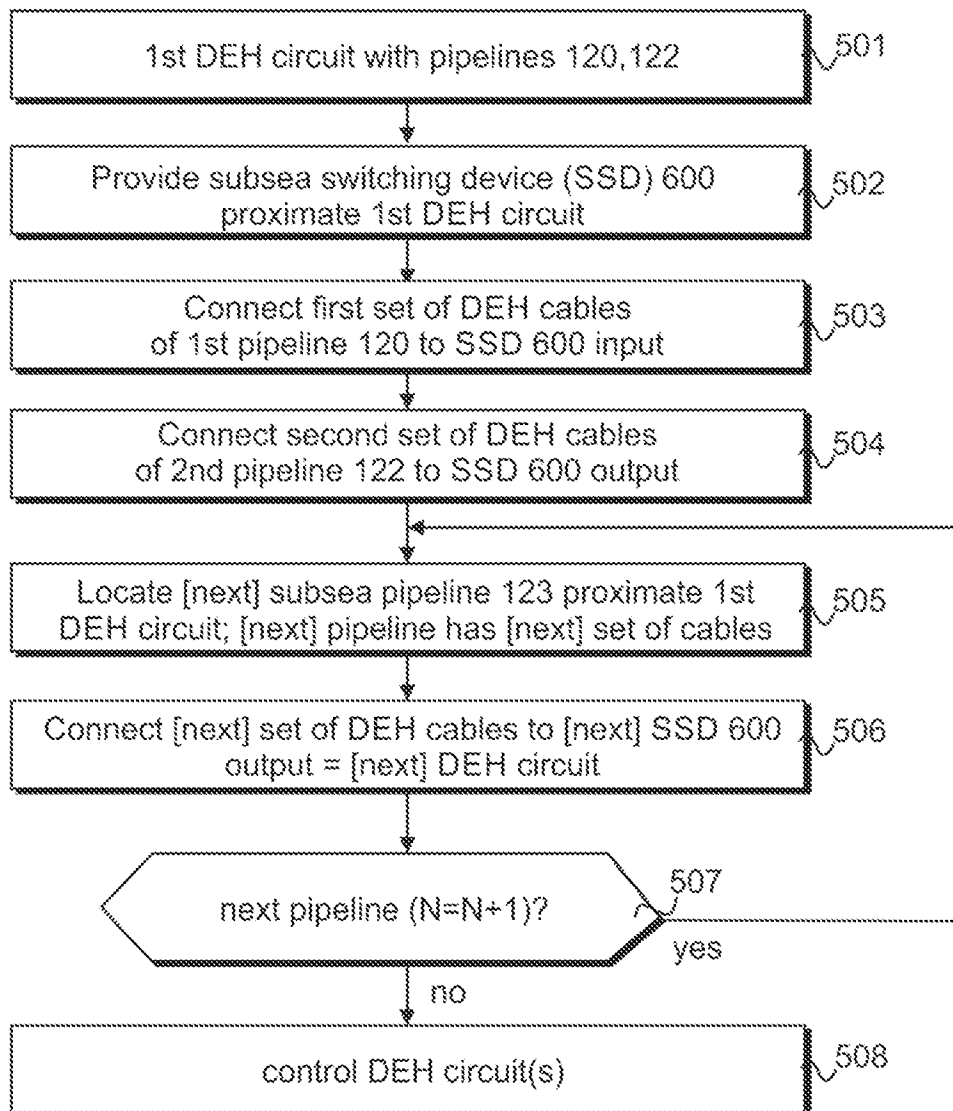


Fig. 5

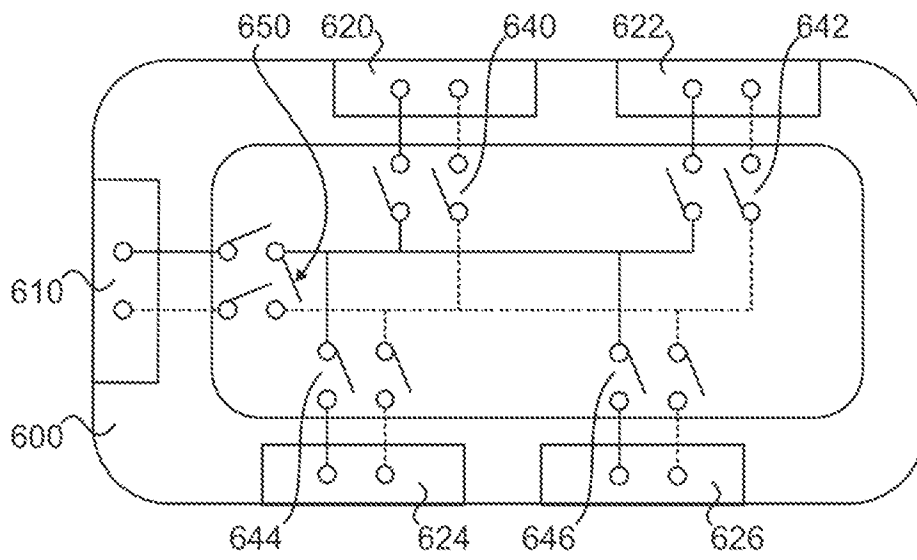


Fig. 6

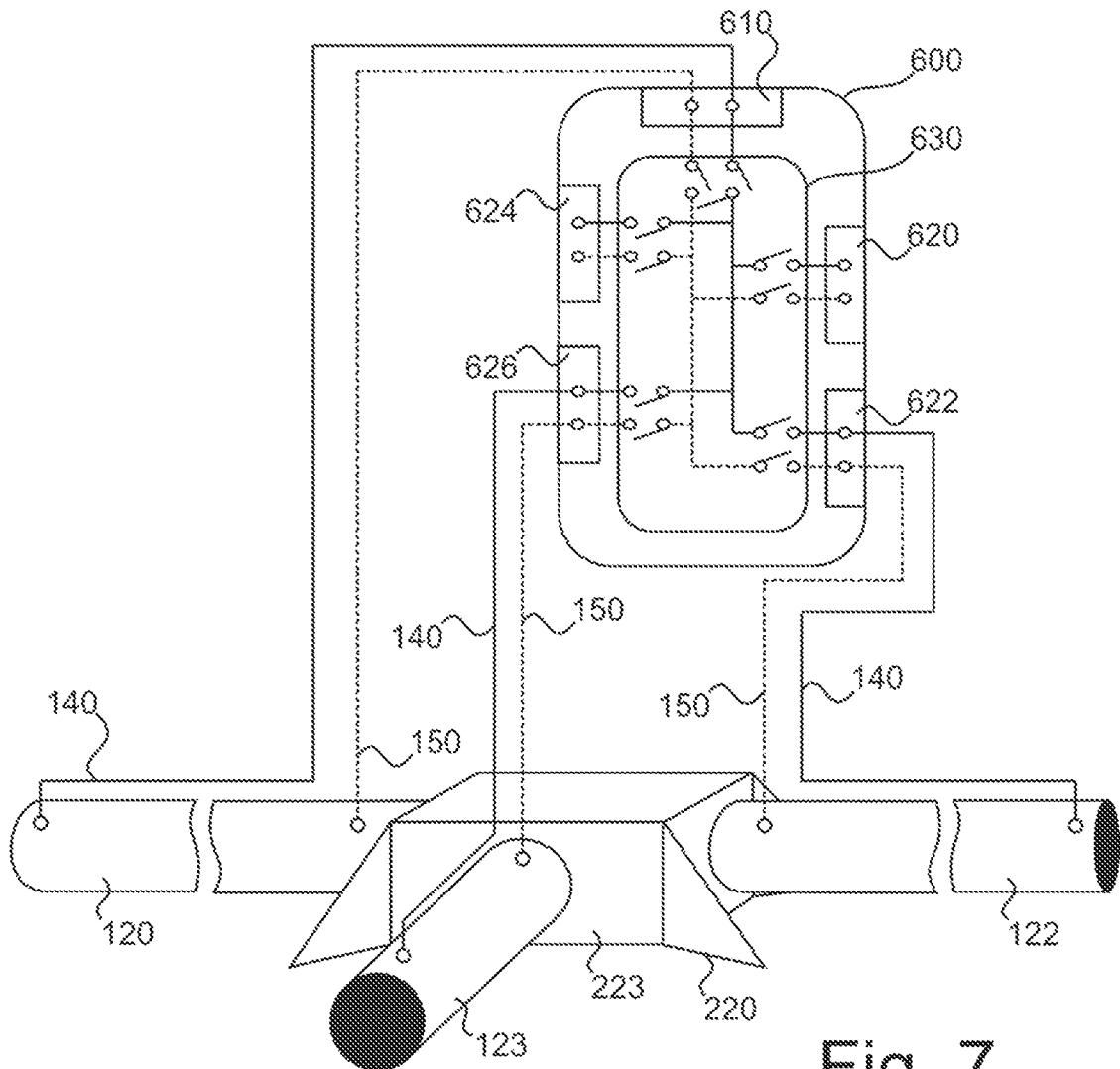


Fig. 7

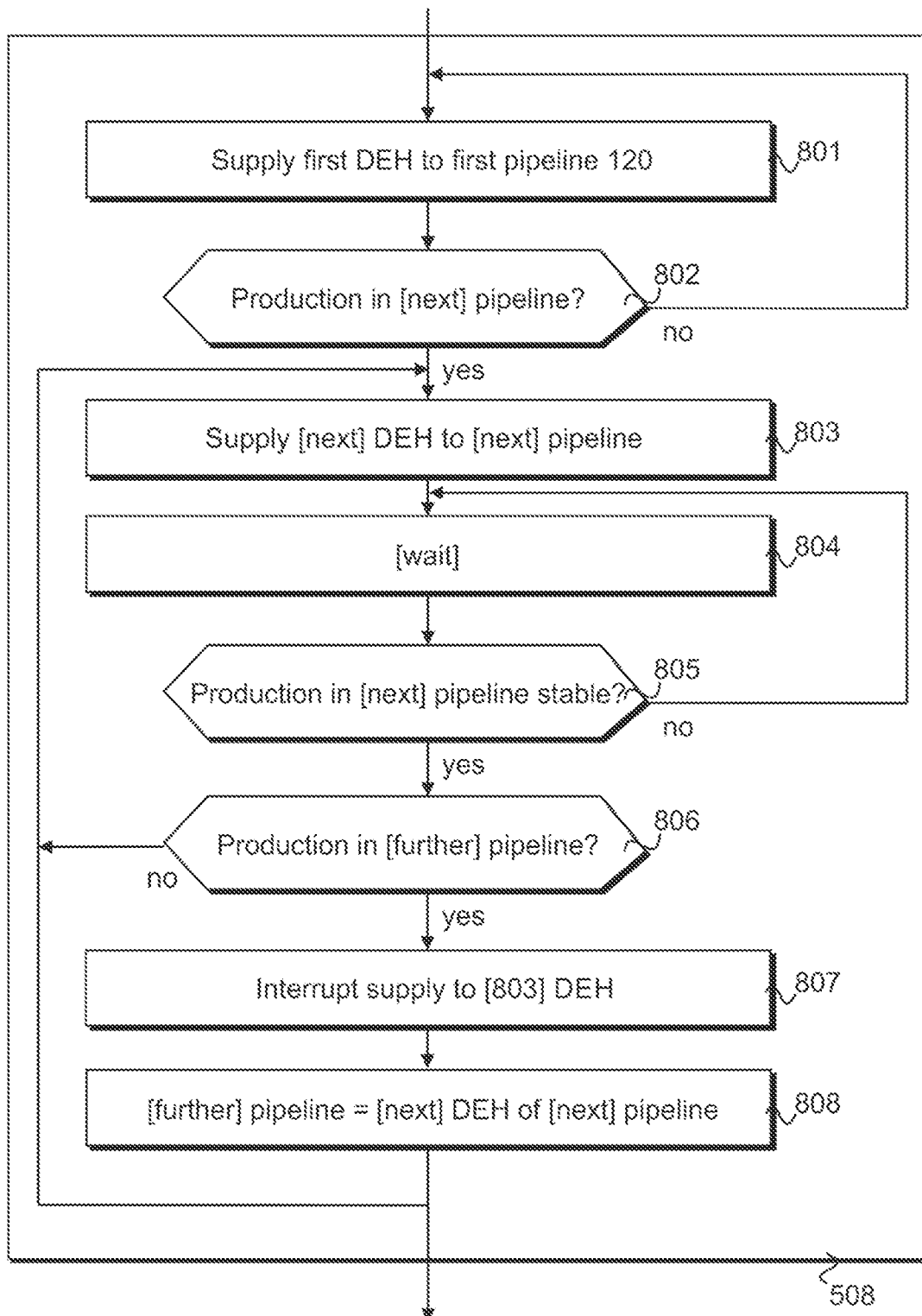


Fig. 8

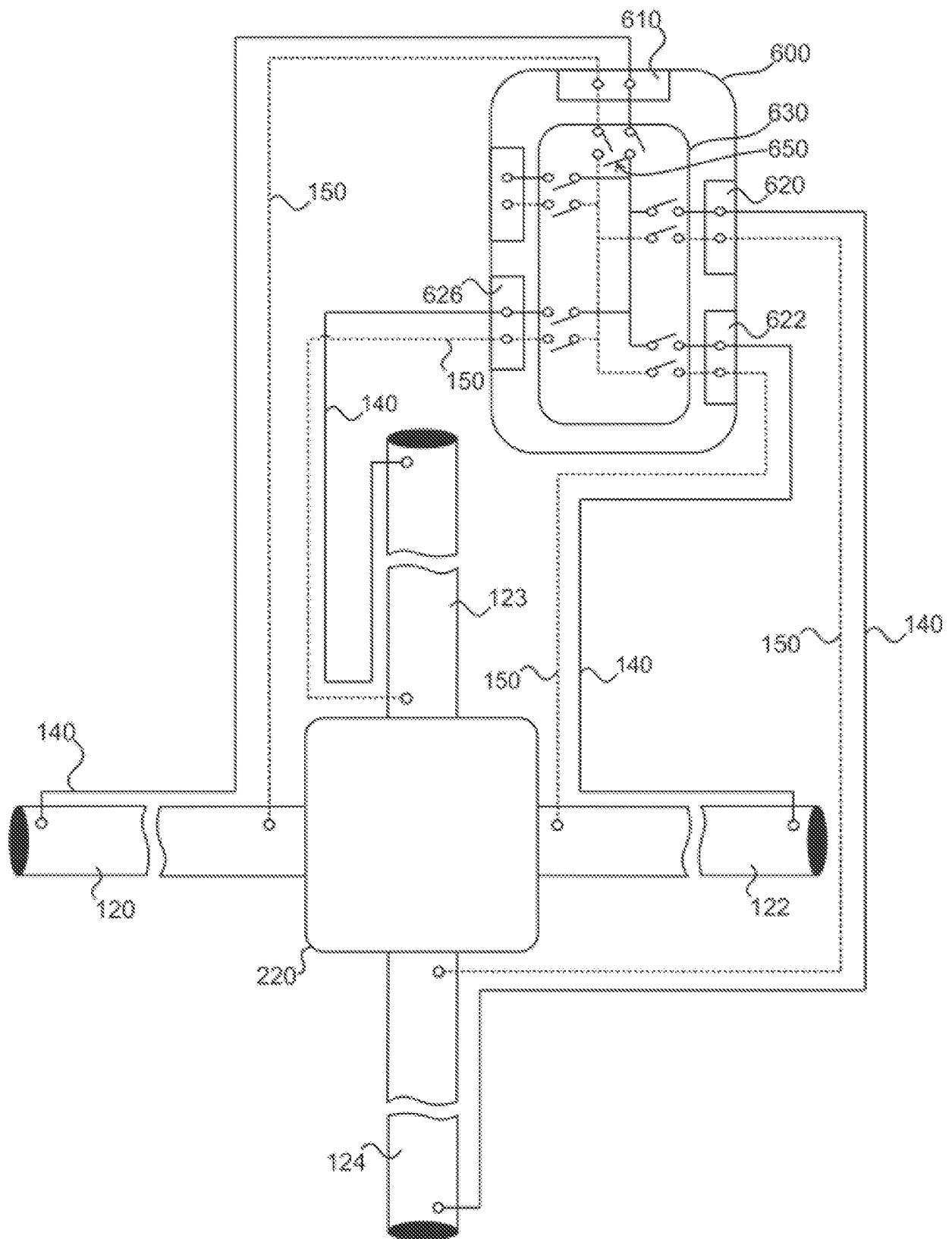


Fig.9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/NO2020/050056

A. CLASSIFICATION OF SUBJECT MATTER		
F16L 53/34 (2018.01), F16L 53/35 (2018.01), F16L 53/37 (2018.01), H05B 3/00 (2006.01), H05B 3/02 (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) F16L, H05B		
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		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2013/124270 A1 (AKER SUBSEA AS) 2013.08.29. Abstract; figures 18- 19; page 3, lines 10-21; page 7, lines 21-27; page 19, lines 5-22.	1-12
A	WO 2012/102624 A1 (SINVENT AS et al.) 2012.08.02. Abstract; figures 1A-17; paragraph [0013] - [0016].	1-12
A	EP 2624403 A1 (SIEMENS AG.) 2013.08.07. Abstract; figures 1-3; paragraph [0009], [0035]-[0036].	1-12
A	WO 2013/188012 A1 (EXXONMOBIL UPSTREAM RE. CO. et al.) 2013.12.19. Abstract, figures 2-4; paragraph [0010], [0023]-[0024].	1-12
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents:	"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	
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"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		
Date of the actual completion of the international search	Date of mailing of the international search report	
04/05/2020	05/05/2020	
Name and mailing address of the ISA Nordic Patent Institute Helgeshøj Allé 81 DK - 2630 Taastrup, Denmark. Facsimile No. + 45 43 50 80 08	Authorized officer Solomon, Sirak Zere Telephone No. +47 22 38 75 21	

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/NO2020/050056

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