Title: TANDEM AND SIDE-BY-SIDE MOORING OFFLOADING SYSTEMS AND ASSOCIATED METHODS

Abstract: A mooring system comprising: an offshore structure comprising one or more hawsers; a vessel; a first mooring line; and a second mooring line.
TANDEM AND SIDE-BY-SIDE MOORING OFFLOADING SYSTEMS AND ASSOCIATED METHODS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 61/879,503, filed September 18, 2013, which is incorporated herein by reference.

BACKGROUND

[0002] The present disclosure relates generally to mooring systems. More specifically, in certain embodiments the present disclosure relates to systems for mooring a vessel to a structure and associated methods.

[0003] Floating production storage and offloading vessels (FPSOs) and floating storage and offloading vessels (FSOs) are commonly used in offshore oil and gas operations to temporarily store and then offload produced oil from subsea wells. An FPSO may be designed to receive crude oil produced from subsea wells or a nearby platform, process that crude oil, and then store the processed oil until it can be offloaded to a tanker or transported through a pipeline. An FSO is a simplified FPSO without the ability to process crude oil. An FSO typically receives and stores oil that has already been processed at a platform, and then offloads the stored oil to a tanker or through a pipeline. FPSOs and FSOs are particularly suited in offshore regions where there is no pipeline infrastructure in place for transporting produced oil to shore. In particular, the FPSO/FSO is employed to store the produced oil until it can be offloaded for transport to another location.

[0004] Typically, FPSOs and FSOs are ship-shaped floating vessels or barges that are moored to the sea floor when receiving crude or processed oil from a platform. In order to offload crude oil, a shuttle vessel may be moored and connected to the FPSO or FSO, or alternatively to the platform itself, and then transfer can take place. U.S. Patent Application Publication No. 2010/00212570, the entirety of which is hereby incorporated by reference, describes an example of such a system.

[0005] Conventional mooring systems for offloading, such as offloading buoys or tandem offloading using tugs for station keeping, may suffer from several drawbacks. These conventional systems may not be designed for the transfer of natural gas or for emergency offloads, and can be prohibitively costly or risky to operate safely. It is desirable to develop a mooring system that is particularly suited for the transfer of natural gas and also for emergency or temporary offloading.
SUMMARY

[0006] The present disclosure relates generally to mooring systems. More specifically, in certain embodiments the present disclosure relates to systems for mooring a vessel to a structure and associated methods.

[0007] In one embodiment, the present disclosure provides a mooring system comprising: an offshore structure comprising one or more hawsers; a vessel; a first mooring line; and a second mooring line.

[0008] In another embodiment, the present disclosure provides a method for mooring a vessel comprising: providing a vessel; providing an offshore structure comprising one or more hawsers; providing a first mooring line; providing a second mooring line; attaching the first mooring line to the vessel; attaching the second mooring line to the vessel; and attaching the one or more hawsers to the vessel.

[0009] In another embodiment, the present disclosure provides a method for offloading oil and/or gas from a structure comprising: providing a side-by-side mooring system comprising an offshore structure comprising two hawsers, a vessel, a first mooring line, and a second mooring line; connecting the vessel to the first mooring line, the second mooring line, and the two hawsers; transferring oil and/or gas from the offshore structure to the vessel; and disconnecting the vessel from the first mooring line, the second mooring line, and the two hawsers.

[0010] In another embodiment, the present disclosure provides a method for offloading oil and/or gas from an offshore structure comprising: providing a tandem mooring system comprising an offshore structure comprising a hawser, a vessel, a first mooring line, and a second mooring line; connecting the vessel to the first mooring line, the second mooring line, and the hawser; transferring oil and/or gas from the offshore structure to the vessel; and disconnecting the vessel from the first mooring line, the second mooring line, and the hawser.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] So that the above recited features and advantages of the disclosure may be understood in detail, a more particular description of the disclosure, briefly summarized above, may be had by reference to the embodiments thereof that are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this disclosure and are, therefore, not to be considered limiting of its scope. The figures are not necessarily to scale, and certain features and certain views of
the figures may be shown exaggerated in scale or in schematic in the interest of clarity and conciseness. 

[0012] Figure 1 illustrates a mooring system.

[0013] Figure 2 illustrates a side-by-side mooring system.

[0014] Figure 3 illustrates a tandem mooring system.

[0015] The features and advantages of the present disclosure will be readily apparent to those skilled in the art. While numerous changes may be made by those skilled in the art, such changes are within the spirit of the invention.

DETAILED DESCRIPTION

[0016] The present disclosure relates generally to mooring systems. More specifically, in certain embodiments the present disclosure relates to systems for mooring a vessel to a structure and associated methods.

[0017] The description that follows includes exemplary apparatuses, methods, techniques, and instruction sequences that embody techniques of the inventive subject matter. However, it is understood that the described embodiments may be practiced without these specific details.

[0018] Referring now to Figure 1, Figure 1 illustrates mooring system 100. In certain embodiments, mooring system 100 may comprise offshore structure 110; vessel 120; first mooring line 130; second mooring line 140; and hawser 150.

[0019] In certain embodiments, offshore structure 110 may comprise a floating liquid natural gas facility. The floating liquid natural gas facility may comprise one or more liquid natural gas storage tanks and cryogenic offloading equipment. In other embodiments, offshore structure 110 may comprise a floating structure floating on sea surface 170. Examples of suitable floating structures include FPSOs, FSOs, spars, TLPs, semi-submersibles, or other floating structures known in the art. In certain embodiments, offshore structure 110 may be connected to sea floor 160 with one or more catenary or taut mooring lines 165. Alternatively offshore structure 110 may be a fixed structure such as a pier, compliant tower, gravity based structure, jack-up platform, or jacket platform resting on sea floor 160.

[0020] In certain embodiments, offshore structure 110 may comprise one or more winches 111. In certain embodiments, offshore structure 110 may comprise one or more transfer devices 112. In certain embodiments, the one or more transfer devices 112 may be capable of offloading oil and/or gas from offshore structure 110. In certain embodiments, the
one or more transfer devices 112 may comprise a hose or a loading arm.

[0021] In certain embodiments, vessel 120 may comprise any vessel capable of transporting oil and/or natural gas. In certain embodiments, vessel 120 may be a liquid natural gas carrier vessel. In other embodiments, vessel 120 may be a shuttle tanker. Vessel 120 may comprise storage facilities 121 capable of storing oil and/or gas. In certain embodiments, not illustrated in Figure 1, one or more hoses 112 of offshore structure 110 may be connected to storage facility 121 of vessel 120 to facilitate transfer of oil and/or gas from offshore structure 110 to vessel 120.

[0022] In certain embodiments, vessel 120 may further comprise one or more bollards or mooring bitts 122. In certain embodiments, not illustrated in Figure 1, first mooring line 130, second mooring line 140, and hawser 150 may be attached individually to at least three different bollard or mooring bitts 122 of vessel 120.

[0023] In certain embodiments, first mooring line 130 and second mooring line 140 may each comprise chain, wire, polyester, HMPE segments, or any combination thereof. In certain embodiments, first end 131 of first mooring line 130 may be anchored to sea floor 160. In certain embodiments, first end 131 of first mooring line 130 may be attached to chain 132 which is attached to anchor or pile 133 on sea floor 160. In certain embodiments, first end 141 of second mooring line 140 may be anchored to sea floor 160. In certain embodiments, first end 141 of second mooring line 140 may be attached to chain 142 which is attached to anchor or pile 143 on sea floor 160. In certain embodiments, anchor 133 and/or anchor 143 may comprise mooring connectors linked to conventional anchors, vertical load anchors, or suction piles.

[0024] In certain embodiments, first mooring line 130 may comprise buoy 134 attached directly or indirectly to first mooring 130 at buoyed point 135. In certain embodiments, second mooring line 140 may comprise buoy 144 attached directly or indirectly to second mooring 140 at buoyed point 145. In certain embodiments, buoy 134 and/or buoy 144 may be submersible buoys. In certain embodiments, buoy 134 and/or buoy 144 may be modular or single mooring buoys of elastomer or foam construction, connected via chain-throughs, pick-ups, or pendants. In certain embodiments, buoy 134 and buoy 144 may be connected to buoyed points 135 and 145 respectively through buoy lines 136 and 146.

[0025] In certain embodiments, first mooring line 130 may further comprise marker buoy 138. In certain embodiments, marker buoy 138 may be floating on sea surface 170.
In certain embodiments, marker buoy 138 may be a small float or high-visibility buoy to help pick up messenger lines. In certain embodiments, second mooring line 140 may further comprise marker buoy 148. In certain embodiments, marker buoy 148 may be floating on sea surface 170. In certain embodiments, marker buoy 148 may be a small float or high-visibility buoy to help pick up messenger lines. In certain embodiments, marker buoy 138 and marker buoy 148 may be connected to each other by chord line 180. In certain embodiments, chord line 180 may comprise a lightweight synthetic line composed of polyester or HMPE segments.

[0026] In certain embodiments, not illustrated in Figure 1, second end 139 of first mooring line 130 may be connected to bollard or mooring bitt 122 of vessel 120 and second end 149 of second mooring line 140 may be connected to bollard or mooring bitt 122 of vessel 120.

[0027] In certain embodiments, hawser 150 may comprise a nylon or HMPE line with pick-up equipment such as messenger lines, connecting shackles, floats, and weight chains. In certain embodiments, hawser 150 may comprise a single hawser 150 or multiple hawsers 150. In certain embodiments, first end 151 of hawser 150 may be attached to the winch 111 of vessel 110. In certain embodiments, not illustrated in Figure 1, second end 152 hawser 150 may be attached to the one or more bollards or mooring bitts 122 of vessel 120.

[0028] Referring now to Figure 2, Figure 2 illustrates a side-by-side mooring system 200. In certain embodiments, side-by-side mooring system 200 may comprise any of the features of mooring system 100. Furthermore, each of the individual components of side-by-side mooring system 200 may comprise the same features of each of the individual components of mooring system 100.

[0029] As can be seen in Figure 2, side-by-side mooring system 200 may comprise structure 210, vessel 220, first mooring line 230, second mooring line 240, and two hawsers 250.

[0030] In certain embodiments, structure 210 may be floating on sea surface 170 and attached to sea floor 160 by one or more mooring lines 265. In certain embodiments, two hawsers 250 may connect structure 210 to vessel 220. In certain embodiments, ends 251 of hawsers 250 may be attached to one or more winches 211 of structure 210. In certain embodiments, second ends 252 of hawsers 250 may be attached to one or more bollards or mooring bitts 222 of vessel 220. In certain embodiments, one or more transfer
devices 212 of structure 210 may be connected to storage facility 221 of vessel 220 to facilitate transfer of oil and/or gas from structure 210 to vessel 220.

[0031] In certain embodiments, vessel 220 may be moored to the seafloor 260 by mooring lines 230 and 240. In certain embodiments, mooring line 230 may comprise a first end 231 anchored to sea floor 260 by anchor 233 and chain 232, second end 239 connected to bollard or mooring bitt 222 of vessel 220, buoy 234 connected to buoyed point 235 by buoyed line 236, and marker buoy 238. In certain embodiments, mooring line 240 may comprise a first end 241 anchored to sea floor 260 by anchor 243 and chain 242, second end 249 connected to bollard or mooring bitt 222 of vessel 220, buoy 244 connected to buoyed point 245 by buoyed line 246, and marker buoy 248. In certain embodiments, a chord line 280 may connected marker buoy 238 to marker buoy 248.

[0032] As can be seen in Figure 2, side-by-side mooring system 200 allows for a vessel to be moored to a structure in a side-by-side fashion where the vessel is secured to the seafloor by 2 points of contact and secured to the structure by two points of contact. In such a system, the vessel is pointed parallel with the structure. In such a system, the relative motions between the vessel and the structure are smaller compared to a tandem mooring system, allowing for shorter loading arms. Shorter loading arms may minimize heat loss and mechanical stresses during transfers.

[0033] Referring now to Figure 3, Figure 3 illustrates a tandem mooring system 300. In certain embodiments, tandem mooring system 300 may comprise any of the features of mooring system 100 and certain features of side-by-side mooring system 200. Furthermore, each of the individual components of tandem mooring system 300 may comprise the same features of each of the individual components of mooring system 100.

[0034] As can be seen in Figure 3, tandem mooring system 300 may comprise an offshore structure 310, a vessel 320, a first mooring line 330, a second mooring line 340, and hawser 350.

[0035] In certain embodiments, offshore structure 310 may be floating on sea surface 370 and attached to sea floor 360 by one or more mooring lines 370. In certain embodiments, hawser 350 may connect offshore structure 310 to vessel 320. In certain embodiments, first end 351 of hawser 350 may be attached to winch 311 of offshore structure 310. In certain embodiments, second end 352 of hawser 350 may be attached to one or more bollards or mooring bitts 322 of vessel 320. In certain embodiments, one or more transfer devices 312 of offshore structure 310 may be connected to storage facility.
321 of vessel 320 to facilitate transfer of oil and/or gas from offshore structure 310 to vessel 320.

[0036] In certain embodiments, vessel 320 may be moored to the seafloor 360 by mooring lines 330 and 340. In certain embodiments, mooring line 330 may comprise a first end 331 anchored to sea floor 360 by anchor 333 and chain 332, second end 339 connected to bollard or mooring bitt 322 of vessel 320, buoy 334 connected to buoyed point 335 by buoyed line 336, and marker buoy 338. In certain embodiments, mooring line 340 may comprise a first end 341 anchored to sea floor 360 by anchor 343 and chain 342, second end 349 connected to bollard or mooring bitt 322 of vessel 320, buoy 344 connected to buoyed point 345 by buoyed line 346, and marker buoy 348. In certain embodiments, a chord line 380 may connected marker buoy 338 to marker buoy 348.

[0037] As can be seen in Figure 3, tandem mooring system 200 allows for a vessel to be moored to a structure in a tandem fashion where the vessel is secured to the seafloor by 2 points of contact and secured to the structure by one point of contact. In such a system, the vessel is pointed directly toward the structure. Such a system may allow for an easier, more controlled approach maneuvering to the structure. Lines 330 and 340 may provide increasing resistance to the vessel as it advances. Such an orientation also makes use of bow chain stoppers that are commonly found in most tankers, and that easily and safely connected to hawsers.

[0038] In one embodiment, the present disclosure provides a method for offloading oil and/or gas from a structure comprising: providing a side-by-side mooring system comprising a structure, a vessel, a first mooring line, a second mooring line, and two hawsers; connecting the vessel to the first mooring line, the second mooring line, and the two hawsers; transferring oil and/or gas from the offshore structure to the vessel; and disconnecting the vessel from the first mooring line, the second mooring line, and the two hawsers.

[0039] As used herein, the term "side-by-side" is used to indicate that the vessel and the offshore structure are in a parallel arrangement as illustrated in Figure 2.

[0040] In another embodiment, the present disclosure provides a method for offloading oil and/or gas from a structure comprising: providing a tandem mooring system comprising an offshore structure comprising a hawser, a vessel, a first mooring line, and a second mooring line; connecting the vessel to the first mooring line, the second mooring line, and the hawser; transferring oil and/or gas from the offshore structure to the vessel;
and disconnecting the vessel from the first mooring line, the second mooring line, and the hawser.

[0041] As used herein, the term "tandem" is used to indicate that the vessel and the offshore structure are in a perpendicular arrangement as illustrated in Figure 3.

[0042] To facilitate a better understanding of the present invention, the following examples of specific embodiments are given. In no way should the following examples be read to limit, or to define, the scope of the invention.

**Examples**

[0043] **Example 1 - Side-by-Side Offloading Procedure**

[0044] The following example provides details on how side-by-side offloading may be performed. A liquid natural gas carrier vessel may approach a floating liquid natural gas facility. The vessel may then be connected to two mooring lines and then two hawsers from the facility. The facility may then winch in the hawsers by first winching in a single hawser and then winching in the remaining hawser. Once the vessel is in a side-by-side arrangement with the facility, liquid natural gas loading arms from the facility may be attached to the vessel and liquid natural gas may be transferred from the facility to the vessel. After the transfer is complete, the loading arms may be disconnected from the vessel and the facility may winch out the two hawsers allowing the mooring lines to pull the vessel away from the facility. The vessel may then be disconnected from the hawsers and the mooring lines and the facility may take back in the hawsers.

[0045] **Example 2 - Tandem Offloading Procedures**

[0046] The following example provides details on how side-by-side offloading may be performed. A liquid natural gas carrier vessel may approach a floating liquid natural gas facility. The vessel may then be connected to two mooring lines and then a hawser from the facility. The facility may then winch in the hawser. Once the vessel is in a side-by-side arrangement with the facility, liquid natural gas loading arms from the facility may be attached to the vessel and liquid natural gas may be transferred from the facility to the vessel. After the transfer is complete, the loading arms may be disconnected from the vessel and the facility may winch out the hawser allowing the mooring lines to pull the vessel away from the facility. The vessel may then be disconnected from the hawser and the mooring lines and the facility may take back in the hawser.

[0047] While the embodiments are described with reference to various implementations and exploitations, it will be understood that these embodiments are
illustrative and that the scope of the inventive subject matter is not limited to them. Many variations, modifications, additions and improvements are possible.

[0048] Plural instances may be provided for components, operations or structures described herein as a single instance. In general, structures and functionality presented as separate components in the exemplary configurations may be implemented as a combined structure or component. Similarly, structures and functionality presented as a single component may be implemented as separate components. These and other variations, modifications, additions, and improvements may fall within the scope of the inventive subject matter.
CL A I M S

1. A mooring system comprising: an offshore structure comprising one or more hawsers; a vessel; a first mooring line; and a second mooring line.

2. The mooring system of claim 1, wherein the offshore structure is a floating liquid natural gas facility.

3. The mooring system of claim 1 or 2, wherein the vessel is a liquid natural gas carrier vessel.

4. The mooring system of any one of claims 1-3, wherein the first and second mooring lines are anchored to a sea floor.

5. The mooring system of any one of claims 1-4, wherein the first and second mooring lines each comprise a buoy and a marker buoy.

6. The mooring system of any one of claims 1-5, wherein the first and second mooring lines are connected to each other via a chord line.

7. The mooring system of any one of claims 1-6, wherein the vessel is connected to the first mooring line, the second mooring line, and the one or more hawsers.

8. The mooring system of claim 7, wherein the vessel and the offshore structure are parallel to each other.

9. The mooring system of claim 7, wherein the vessel and the offshore structure are perpendicular to each other.

10. A method for mooring a vessel comprising: providing a vessel; providing an offshore structure comprising one or more hawsers; providing a first mooring line; providing a second mooring line; attaching the first mooring line to the vessel; attaching the second mooring line to the vessel; and attaching the one or more hawsers to the vessel.

11. The method of claim 10, wherein the offshore structure is a floating liquid natural gas facility.

12. The method of claim 10 or 11, wherein the vessel is a liquid natural gas carrier vessel.

13. The method of any one of claims 10-12, wherein the first and second mooring lines are anchored to a sea floor.
14. The method of any one of claims 10-13, wherein the first and second mooring lines each comprise a buoy and a marker buoy.

15. The method of any one of claims 10-14, wherein the first and second mooring lines are connected to each other via a chord line.

16. The method of any one of claims 10-15, further comprising orienting the vessel parallel with the offshore structure.

17. The method of any one of claims 10-15, further comprising orienting the vessel perpendicular to the offshore structure.

18. A method for offloading oil and/or gas from a structure comprising: providing a side-by-side mooring system comprising an offshore structure comprising two hawsers, a vessel, a first mooring line, and a second mooring line, connecting the vessel to the first mooring line, the second mooring line, and the two hawsers in a side-by-side arrangement; transferring oil and/or gas from the structure to the vessel; and disconnecting the vessel from the first mooring line, the second mooring line, and the two hawsers.

19. A method for offloading oil and/or gas from a structure comprising: providing a tandem mooring system comprising an offshore structure comprising a hawser, a vessel, a first mooring line, a second mooring line, and a hawser; connecting the vessel to the first mooring line, the second mooring line, and the hawser in a tandem arrangement; transferring oil and/or gas from the structure to the vessel; and disconnecting the vessel from the first mooring line, the second mooring line, and the hawser.


### A. CLASSIFICATION OF SUBJECT MATTER

B63B 21/50(2006.01)i, B63B 22/02(2006.01)i

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)
B63B 21/50; B63B 21/00; B63B 35/44; B63B 22/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: mooring, offshore, hawser, vessel, line

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>US 6571723 BI (BECH et al.) 03 June 2003 See column 4, lines 43-64; column 5, lines 19-20; claim V, and figures 6-8.</td>
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<td>EP 1413511 BI (BLUEWATER EBERGY SERVICES B.V.) 06 July 2005 See paragraph [0018]; and figure 1.</td>
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<td>US 2010-0212570 AI (CORVALAN SAN MARTIN et al.) 26 August 2010 See paragraphs [0018]; and figure 1.</td>
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<td>WO 2012-072292 AI (SINGLE BUOY MOORINGS INC.) 07 June 2012 See page 11, line 26 - page 12, line 4; and figure 4.</td>
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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

  "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)

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  "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
11 December 2014 (11.12.2014)

Date of mailing of the international search report
12 December 2014 (12.12.2014)

Name and mailing address of the ISA/KR

International Application Division
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Form PCT/ISA/210 (second sheet) (July 2009)
### Box No. II  Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
   - because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 8-9
   - because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
     - Claims 8-9 are not clear because they refer to claim 7, which do not comply with PCT Rule 6.4(a). Therefore, claims 8-9 do not meet the requirement of PCT Article 6.

3. ☒ Claims Nos.: 4, 7, 13-17
   - because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

### Box No. III  Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☑ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☑ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of any additional fees.

3. ☑ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☑ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

### Remark on Protest
- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☑ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)
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