Abstract: A subsea spill containment system comprising: a funnel structure positioned over a subsea leak; a plurality of inter-connected skirts serially joined above the funnel; a collection dome above the skirts; and a hose connected to the dome. The skirts may be supported by one or more central internal longitudinal supports, such as a drillpipe or solid rods. There may be multiple supports and/or multiple skirts per support. The skirts are preferably sealed to the dome, the funnel, and each other. The system may be held in place over the leak using cables secured to two or more anchor points, such as suction piles. The system may be moved aside by manipulating the cables, thereby providing access to the leak.
TITLE OF THE INVENTION

Oil Collection System and Method for Deepwater Spills

CROSS REFERENCE TO RELATED APPLICATIONS


STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable.

REFERENCE TO APPENDIX

Not applicable.

BACKGROUND OF THE INVENTION

Field of the Invention. The inventions disclosed and taught herein relate generally to offshore oil field tools; and more specifically relate to systems and methods for collecting oil from deepwater spills.

Description of the Related Art.

Known systems and methods for dealing with a sub-surface leak or spill involve efforts to contain and skim spilled oil at the surface and/or the use of dispersants.

The inventions disclosed and taught herein are directed to an improved system and method for capturing the oil before it gets to the surface.
A subsea spill containment system comprising: a funnel structure positioned over a subsea leak; a plurality of interconnected skirts serially joined above the funnel; a collection dome above the skirts; and a hose connected to the dome. The skirts may be supported by one or more central internal longitudinal supports, such as drill pipe or solid rods. There may be multiple supports and/or multiple skirts per support. The skirts are preferably sealed to the dome, the funnel, and each other. The system may be held in place over the leak using cables secured to two or more anchor points, such as suction piles. The system may be moved aside by manipulating the cables, thereby providing access to the leak.

Figure 1 illustrates a particular embodiment of a deepwater oil spill collection system utilizing certain aspects of the present inventions;

Figure 2 illustrates alternative embodiments of a deepwater oil spill collection system utilizing certain aspects of the present inventions; and

Figure 3 illustrates an alternative embodiment of a deepwater oil spill collection system utilizing certain aspects of the present inventions.

The Figures described above and the written description of specific structures and functions below are not presented to limit the scope of what Applicants have invented or the scope of the appended claims. Rather, the Figures and written description are provided to teach any person skilled in the art to make and use the inventions for which patent protection is sought. Those skilled in the art will appreciate that not all features of a commercial embodiment of the inventions are described or shown for the sake of clarity and understanding. Persons of skill in this art will also appreciate that the development of an actual commercial embodiment incorporating aspects of the present inventions will require numerous implementation-specific decisions to achieve the developer's
ultimate goal for the commercial embodiment. Such implementation-specific decisions may include, and likely are not limited to, compliance with system-related, business-related, government-related and other constraints, which may vary by specific implementation, location and from time to time. While a developer's efforts might be complex and time-consuming in an absolute sense, such efforts would be, nevertheless, a routine undertaking for those of skill in this art having benefit of this disclosure. It must be understood that the inventions disclosed and taught herein are susceptible to numerous and various modifications and alternative forms. Lastly, the use of a singular term, such as, but not limited to, "a," is not intended as limiting of the number of items. Also, the use of relational terms, such as, but not limited to, "top," "bottom," "left," "right," "upper," "lower," "down," "up," "side," and the like are used in the written description for clarity in specific reference to the Figures and are not intended to limit the scope of the invention or the appended claims.

[0022] Applicants have created a subsea spill containment system comprising: a funnel structure positioned over a subsea leak; a plurality of interconnected skirts serially joined above the funnel; a collection dome above the skirts; and a hose connected to the dome. The skirts may be supported by one or more central internal longitudinal supports, such a drillpipe or solid rods. There may be multiple supports and/or multiple skirts per support. The skirts are preferably sealed to the dome, the funnel, and each other. The system may be held in place over the leak using cables secured to two or more anchor points, such as suction piles. The system may be moved aside by manipulating the cables, thereby providing access to the leak.

[0023] FIG. 1 is an illustration of a particular embodiment of a deepwater oil spill collection system utilizing certain aspects of the present inventions. The system includes a plurality of interior longitudinal supports and a plurality of skirts surrounding the supports. The interior longitudinal supports may be commonly available steel drill pipe in high strength steel. In this case, the interior longitudinal supports may be approximately forty feet in length and two and three eights, two and seven eights, three, three and a half, four, or four and a half inches in outside diameter. Of course, larger drill pipe may be used, but it is anticipated that
smaller, lighter pipe will be more beneficial as the additional strength is not anticipated to typically be necessary.

[0024] Alternatively, the interior longitudinal supports may be purpose built, or otherwise differ from commonly available drill pipe. For example, the interior longitudinal supports may be twenty, thirty, forty, fifty feet in length, or fall into some range therein, such as between twenty and forty feet, between thirty and forty feet, between twenty five and forty five feet, or between thirty five and forty five feet.

[0025] The interior longitudinal supports may also be solid or partially solid, as the system of the present invention does not necessarily require them to be hollow thoughout, like commonly available drill pipe. Furthermore, interior longitudinal supports do not necessarily need to be steel. Rather, the interior longitudinal supports may be made of aluminum, an aluminum alloy, or even a composite material, such as fiberglass, carbon fiber, or plastic material.

[0026] In any case, the interior longitudinal supports preferably connect with one another using trenched connections typically found on commonly available drill pipe. Therefore, workers on a rig, drillship or other installing vessel will be accustomed to assembling the system of the present invention and may do so using equipment and techniques normally used in offshore drilling environments. The system may utilize one, two, three, four or more of the interior longitudinal supports, or may utilize a number falling within a range thereof, such as between two and four or between three and five of the interior longitudinal supports.

[0027] The skirts of the present invention are preferably constructed of a flexible, yet strong fabric and are designed to contain and funnel oil from the spill or leak up toward the surface. For example, in some embodiments, the skirts may be cylindrical, segmented cylindrical, conical, and/or segmented conical in shape, with a bottom portion of an upper skirt forming a seal with an upper portion of a lower skirt. Alternatively, the skirts may be rigid and/or reinforced. For example, the skirts may be made of aluminum, an aluminum alloy, or even a composite material, such as fiberglass, carbon fiber, or plastic material.

[0028] There may be one, two, three, four, five, six, seven, or eight skirts attached to each support, or may vary according or some range thereof, such as four or five, three to six, or two to seven skirts per support. Thus, the skirts may
be five, ten, fifteen, twenty, or even forty feet in length, or fall into some range therein, such as between five and ten feet, between five and fifteen feet, between five and twenty feet, between ten and fifteen feet, between ten and twenty feet, between ten and forty feet, between fifteen and twenty feet, or between fifteen and forty feet.

[0029] The skirts may be one, two, three, four, five, six, seven, eight, nine, ten, twelve, fifteen, or even twenty feet in diameter, and may be sized according to the capability of an installing drillship and/or the flow capacity of the leak or reservoir. Of course, the skirts may be designed to accommodate a range of situations, and may therefore be fall into some range therein, such as between three and five feet, between two and seven feet, between three and eight feet in diameter, or between ten and twenty feet in diameter. Additionally, the skirts' diameter may vary along their length, such that skirt is narrower at the top portion as opposed to the bottom portion. This variance in diameter may be gradual, relatively continuous, or may be localized to an area near the top or bottom of the skirt. In this manner, a bottom portion of an upper skirt forming a seal around the outside of an upper portion of a lower skirt. This seal may be a simple press-fit seal and/or may be an expanding seal operated by pneumatics and/or hydraulics.

[0030] The skirts may be attached to the supports by a cylindrical and/or conical frame. The frame may be made of steel, aluminum, an aluminum alloy, or even a composite material, such as fiberglass, carbon fiber, or plastic material. The frame may also include a plurality of hoops, or rings, to support the skirt. The frame may also include sealing rings, such as on an upper and/or lower most one of the supporting hoops, to a facilitate the seal between upper and lower skirts. The frame may attach to the interior longitudinal supports near the top of each skirt, the bottom of each skirt, and/or at one or more places along the length of each skirt. Thus, the frame may rigidly secure the skirt to the longitudinal supports, or may allow the skirt to sway relative to the supports.

[0031] The frame may be welded directly to the interior longitudinal supports and/or may be secured thereto using J-Lay collars, or similar structure. Thus, the frames and skirts may hang, or be suspended, from the top, or bottom, of a flange near a connection of the interior longitudinal supports. Where the frames hand from the supports, a bottom most ring is preferable made weighted,
such as by being made of steel, to weight down the skirt and ensure each skirt seals with a lower skirt.

[0032] Because the system may use multiple skirts mounted on each of multiple supports, the system may include between two and thirty skirts, between five and twenty skirts, between five and thirty skirts, between ten and twenty skirts, or between ten and thirty skirts, such as ten, fifteen, twenty, or thirty skirts. In one embodiment, the system utilizes nineteen skirts suspended on four supports.

[0033] At the top of the upper most skirt, the system preferably includes a dome, or collection structure with a hose attachment collar. The dome may be constructed of steel, aluminum, an aluminum alloy, or even a composite material, such as fiberglass, carbon fiber, or plastic material. The dome may also be supported by a frame, if needed. The hose connects the dome with a collection ship, the rig, drillship or other installing vessel in order to direct the oil collected by the system to the surface in a controlled manner. Similar to the skirts, the dome, or its frame, may be welded to the support and or may be secured to a flange or J-lay collar.

[0034] The flexible segmented nature of the skirts allow them to be installed on the support after it has been threaded, or welded, to a lower support and/or a J-lay collar between adjacent supports. In any case, the supports preferably carry the weight of the skirts. Also, a bottom rigid frame may provide a tensioning mechanism for the skirts and/or a base for a packer and/or Chevron type seal. The seal system will allow each skirt to use the surface of a lower support top ring as bearing surface to reduce or eliminate the amount of water intake from outside.

[0035] The system also preferably includes a funnel structure at the bottom of the lower most skirt to collect the oil. The lower, larger outer diameter of the funnel may be between five and twenty feet across, such as six feet, eight feet, ten feet, twelve feet, sixteen feet, eighteen feet, twenty feet, or even twenty-five feet in diameter. In some embodiments, the larger outer diameter of the funnel may be significantly larger, such as between thirty and forty feet across.

[0036] If the above described components of the system, as constructed are heavier than the surrounding seawater, the system may include one or more
air cans, or floats to suspend the system. For example, as described, the supports, skirts, frame, and/or dome may be constructed of steel, which would tend to sink. The air cans are preferably sized and configured to prevent this. Thus, there may be between two and ten air cans, such as four, six, or eight. The system may be configured with two or three times as many air cans as needed to provide a level of redundancy.

[0037] The system is preferably secured to the seabed using two or more suction piles around the spill location, or source. The funnel, lower most support, and/or lower most skirt and/or frame may be secured to the suction piles with one or more lengths of wire, cable, chain, rope, or the like. The length of the wire between the suction piles and the above assembly can be modified to raise and lower the funnel and/or move the assembly to the side in the event direct intervention to the spill source is needed. If a cap can be installed on the spill source; then flow from the cap can be channeled into the above system, or directly to the hose and surface vessel. The system thus advantageously allows access to the well, or spill source. The system may also be configured to handle above and underground blow outs and can be placed anywhere oil is leaking.

[0038] With the surface vessel drawing collected oil and/or water from the dome at the top of the system, and/or through the interior longitudinal support, a pressure differential is created, thereby drawing the leaking oil into the system. In other words, the system collects oil via a pressure differential from the vessel taking the oil from top of the dome. The density difference between oil and water is also advantageously utilized to draw oil up into the system. The surface vessel may also inject a liquid or gas, such as air, through the interior longitudinal supports to be vented through holes in the interior longitudinal supports at selected depths along the system to reduce the density of the liquid within the system, thereby assisting and/or facilitating drawing the oil and/or other liquids into and through the system. In the event the surface vessel needs to disconnect the hose, the system will vent through the hose from the top and the funnel from the bottom so the system does not necessarily experience any pressure build up. When the hose is disconnected it may drop and hang beside the skirts of the system.
FIG. 2 and 3 illustrate another construction for the skirts. While this construction for the skirts may be similar to that discussed above, rather than being constructed of a flexible fabric, the skirts may be rigid. For example, the skirts may be constructed from steel, a lightweight rigid composite, and/or alloy pipe. This pipe may be threaded at each end, thereby allowing joints to be made for the skirts much like the interior longitudinal supports and/or commonly available drill pipe. Joints between rigid skirts may or may not include the press fit and/or expanding seal discussed above. In this embodiment, the skirts are expected to be generally cylindrical, with an expanded end. For example, the skirts may have an expanded lower end that slips over, or threads onto, an upper end of a lower skirt. Alternatively, the skirts may be generally cylindrical, with a reduced diameter end. For example, the skirts may have an reduced diameter upper end that slips within, or threads into, lower end of an upper skirt. Of course, the opposite construction is possible as well, such that the skirts have an expanded upper end and/or a reduced diameter lower end. While the expanded end and/or reduced diameter end may be integral to the skirts, such expanded ends and/or reduced diameter ends may be formed with one or more sleeves or collars secured to an exterior or interior of the skirts.

In the embodiment shown in FIG. 2 and 3, the skirts are expected to be approximately forty feet in length and approximately twenty feet in diameter, but may fall within some range. For example, the skirts may be between five and ten feet, between five and fifteen feet, between five and twenty feet, between ten and fifteen feet, between ten and twenty feet, between ten and thirty feet, between fifteen and twenty feet, or between fifteen and thirty feet in diameter. The skirts for this embodiment, may or may not utilize the frame discussed above, and/or may be secured directly to the interior longitudinal supports using J-Lay collars, or similar structure. Thus, the skirts may be longer continuous rigid segments, such as with one large skirt to each interior longitudinal support, as opposed to the multiple smaller flexible skirts to each interior longitudinal support described above. Of course, depending on the application, any combination of these features may be utilized.

The skirts made be pre-assembled upon the interior longitudinal supports awaiting installation above the spill. For example, where the skirts are
rigid, one interior longitudinal support, or skirt, may be pushed, pressed, raised, or lowered toward another until the joint between the two adjacent interior longitudinal supports is made and then the expanded end of one skirt may be slid, or threaded, over the other skirt. The seal between the two skirts may then be activated, pneumatically and/or hydraulically, through a port in the expanded end of the skirt. Flexibility in the frame and/or other components mounting the skirts to the interior longitudinal supports may allow access to the joint between the two adjacent interior longitudinal supports before the seal between the two adjacent skirts has been achieved. This process may be repeated until the system, of the desired size, length, or depth, is assembled over the spill.

[0042] Other and further embodiments utilizing one or more aspects of the inventions described above can be devised without departing from the spirit of Applicant's invention. For example, one or more of the interior longitudinal supports may be hollow and/or may have holes between the exterior and any interior spaces. In this case, and especially where the surface vessel draws collected oil and/or water through the interior longitudinal support, the holes may be located in order to draw oil and/or water at a selected depth, or height within the system. Alternatively, as discussed above, these holes may be utilized to inject liquid or gas between the interior longitudinal supports and the skirts selected depths, or heights within the system. This will allow the system to control the density difference along the water column, and/or prevent the oil and/or water to density from getting concentrated and/or eliminated. More specifically, as different hollow regions take oil from the confined space within the skirts, the system may also allow water to come in a gap between the skirts and maintain certain level of density difference throughout the column. Taking oil from the confined space within the skirts may allow the system to control a speed at which the spilled oil rises toward the surface. Additionally, or alternatively, as discussed above, the system may inject liquid or gas into the confined space within the skirts, to further control the density and/or the speed at which the spilled oil rises toward the surface.

[0043] Finally, this arrangement could be used for power generation, such as by using density difference in the ocean due to temperature difference between deep and shallow water and/or the density difference generated by oil in the water
column as described above, with a turbine or turbines at different locations. These turbines could also be used to control the flow of oil and/or water within the system.

[0044] The various methods and embodiments of the present invention can be included in combination with each other to produce variations of the disclosed methods and embodiments. For example, multiple strings of skirts may be used with one funnel and/or multiple systems may be used in close proximity to cover a large area spill. Discussion of singular elements can include plural elements and vice-versa. Further, the order of steps can occur in a variety of sequences unless otherwise specifically limited. The various steps described herein can be combined with other steps, interlineated with the stated steps, and/or split into multiple steps. Similarly, elements have been described functionally and can be embodied as separate components or can be combined into components having multiple functions.

[0045] The inventions have been described in the context of preferred and other embodiments and not every embodiment of the invention has been described. Obvious modifications and alterations to the described embodiments are available to those of ordinary skill in the art. The disclosed and undisclosed embodiments are not intended to limit or restrict the scope or applicability of the invention conceived of by the Applicants, but rather, in conformity with the patent laws, Applicants intend to fully protect all such modifications and improvements that come within the scope or range of equivalent of the following claims.
CLAIMS:

1. A subsea spill containment system comprising:
   a funnel structure positioned over a subsea leak;
   a plurality of interconnected skirts serially joined above the funnel;
   a collection dome above the skirts; and
   a hose connected to the dome.

2. The system as set forth in claim 1, wherein the skirts are supported by one
   or more central internal longitudinal supports.

3. The system as set forth in claim 2, wherein the supports are metal pipes at
   least twenty feet in length.

4. The system as set forth in claim 2, wherein the supports are solid rods at
   least twenty feet in length.

5. The system as set forth in claim 2, wherein there are at least four skirts
   secured to each support.

6. The system as set forth in claim 1, wherein an upper most one of the skirts
   is sealed to the dome.

7. The system as set forth in claim 1, wherein a lower one of the skirts seals
   to an upper one of the skirts.

8. The system as set forth in claim 1, wherein a lower most one of the skirts
   seals to the funnel.

9. The system as set forth in claim 1, further including at least two anchor
   points secured to a seabed around the leak and cables connecting the anchor
   points to the funnel, the skirts, a frame or other support of the system to hold the
   funnel over the leak.
10. The system as set forth in claim 1, wherein the cables are configured to be manipulated to move the funnel relative to the leak.

11. A method for containing a subsea spill, the method comprising the steps of:
positioning a funnel above a subsea leak;
positioning a first skirt above the funnel;
positioning a second skirt above the first skirt;
positioning a collection dome above the skirts;
connecting a hose to the dome; and
drawing oil from the dome through the hose.

12. The method as set forth in claim 1, further comprising supporting the skirts with one or more central internal longitudinal supports.

13. The method as set forth in claim 12, wherein the supports are metal pipes at least twenty feet in length.

14. The method as set forth in claim 12, wherein the supports are solid rods at least twenty feet in length.

15. The method as set forth in claim 12, wherein there are at least four skirts secured to each support.

16. The method as set forth in claim 11, further comprising sealing the second skirt to the dome.

17. The method as set forth in claim 11, further comprising sealing the first skirt to the second skirt.

18. The method as set forth in claim 11, further comprising sealing the first skirt to the funnel.
19. The method as set forth in claim 11, further comprising setting at least two anchor points into a seabed around the leak and securing the funnel, the skirts, a frame or other support with cables connected to the anchor points, thereby holding the funnel over the leak.

20. The method as set forth in claim 11, further comprising manipulating the cables to move the funnel relative to the leak.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

E21B 43/01(2006.01); E02B 15/04(2006.01); B63B 35/44(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)

E21B 43/01; E02B 15/04

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: leak, spill, dome, shroud, funnel, cone, fissure, prevent, contain, remediate, capture, draw, oil, source, collect, thread, skirt, pipe, modular

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<th>Relevant to claim No.</th>
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<td>A</td>
<td>WO 93-11305 A1 (SETERNES, HANS) 10 June 1993 See abstract, pages 3,4, claim 1 and figures 1,4a</td>
<td>1-20</td>
</tr>
<tr>
<td>A</td>
<td>US3666100 A (THADDEUS A. MADEJ) 30 May 1972 See abstract, columns 1,2, claim 1 and figure 1</td>
<td>1-20</td>
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<tr>
<td>A</td>
<td>US3658181 A (THOMAS O. BLAIR) 25 April 1972 See abstract, columns 1,2, claim 1 and figure 1</td>
<td>1-20</td>
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<tr>
<td>A</td>
<td>US3548605 A (PETER L. PAULL et al.) 22 December 1970 See abstract, columns 2,3, claim 1 and figures 1,2</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 citation or other special reason (as specified)
  "O" document referring to an oral disclosure, use, exhibition or other means
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  "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
19 DECEMBER 2011 (19.12.2011)

Date of mailing of the international search report
19 DECEMBER 2011 (19.12.2011)

Name and mailing address of the ISA/KR
Korean Intellectual Property Office
Government Complex-Daejeon, 189 Cheongsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea
Facsimile No. 82-42-472-7140

Authorized officer
BAHNG, Seung Hoon
Telephone No. 82-42-481-8444

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<tbody>
<tr>
<td>wo 93-1 1305 A1</td>
<td>10.06.1993</td>
<td>AU 2958392 A</td>
<td>28.06.1993</td>
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<tr>
<td></td>
<td></td>
<td>N0914738D0</td>
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<td>30.05.1972</td>
<td>None</td>
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<td>25.04.1972</td>
<td>None</td>
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<tr>
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