

APPARATUS AND METHOD

The present invention relates to an apparatus and method particularly but not
5 exclusively for use in the moon pool area of an offshore vessel used to install and
support a riser system used to produce hydrocarbons from a subsea well to a
floating production facility or vessel on the sea surface and more particularly the
invention relates to seeking to improve safety by allowing the possibility of halting
and diverting the flow of hydrocarbon product to or below the drill floor and also
10 providing the possibility of remote disconnection of the top level equipment on the
drill floor from the riser system below and therefore allowing the possibility of work to
be safely carried out on the top level equipment and/or the upper end of the riser
system on the drill floor without the heave hazard associated with sea and vessel
movement relative to the riser system.

15 Conventionally, hydrocarbons are produced from a subsea well through a wellhead.
A primary flow control system in the form of a christmas tree is located at the
wellhead and which controls the flow of hydrocarbon product from the subsea well
through the wellhead and through the christmas tree into a riser system. The riser
20 system consists of a sufficient length of flexible riser in the form of a flexible flow line
or pipeline and which connects the christmas tree to a floating production facility or
vessel located on the sea surface such that the riser system delivers the
hydrocarbon product to the floating facility or vessel. The riser system is typically
installed by a drill ship having a moon pool located in its centre where all the
25 equipment that is required when installing a riser system such as a lower riser
package (LRP) and an emergency disconnect package (EDP) and the flexible riser
itself can be lowered from the drill ship through the moon pool into the sea and down
to the christmas tree.

30 Conventionally, work on the upper end of the riser system such as connecting in or
swapping out required top level equipment is normally carried out with the drill ship
moving relative to the sea bed/riser system because of the sea swell and this causes
significant safety and operational problems when installing/changing such top level
equipment and therefore sea conditions have to be calm to proceed with any degree
35 of safety.

It would therefore be desirable to be able to safely work on the upper end of the riser system in conditions with some sea swell.

5 According to a first aspect of the present invention there is provided a valved tree member for inclusion in a riser system and suitable for use in the region of a moon pool on a floating vessel, the valved tree member comprising:-

one or more valve members adapted to selectively permit and prevent flow of fluid there through, and

10 one or more moveable stab members adapted to respectively selectively provide a sealed fluid communication path between a throughbore of the riser system and the one or more valve members.

Preferably, the valved tree member comprises a body member upon which the said
 15 one or more valves are mounted and typically, the one or more valve members mounted thereon comprise a longitudinal axis arranged substantially perpendicularly to a longitudinal axis of the riser system at the point at which the valved tree member is included in the riser system. Typically, the said one or more valve members are connected to the body member by a tubular coupling having a throughbore and more
 20 preferably, the said moveable stab member is located within the throughbore of the tubular coupling. Preferably, the said moveable stab member is arranged to selectively engage with a port provided in the riser system. More preferably, the port is included at a suitable location in the riser system and comprises at least an aperture through a sidewall of the riser system. Typically, the said moveable stab
 25 member is arranged to selectively sealingly engage with the port provided in the riser system. Typically, the said moveable stab member is arranged to selectively move radially inwards toward the longitudinal axis of the riser system in a direction substantially perpendicular to the longitudinal axis of the riser system to sealingly engage with the port having an aperture formed through the sidewall of the riser
 30 system such that fluid in the throughbore of the riser system may flow in a sealed manner from the throughbore of the riser system through the moveable stab member and into the said one or more valves mounted on the valved tree member.

Preferably, a flow diverter member is included in the riser system, the flow diverter
 35 member comprising a substantially vertical tubular member having a longitudinal axis

substantially parallel with and more preferably substantially co-incident with the longitudinal axis of the riser system at the point at which the flow diverter member is included in the riser system and more preferably the flow diverter member further comprises a cross tubular member which is more preferably arranged with its longitudinal axis to be substantially perpendicular to the longitudinal axis of the substantially vertical tubular member. Preferably, the cross tubular member provides said port or aperture at each end thereof. Typically, the flow diverter member comprises three or more (and more preferably only four) fluid entry/exit points where two are provided by each end of the substantially vertical tubular member and two are provided by each end of the cross tubular member and typically, the respective throughbores of the cross tubular member and the substantially vertical tubular member intersect one another.

Preferably, the valved tree member is selectively coupled to a housing member provided on the floating vessel and more preferably, the valved tree member comprises a selective locking system to selectively lock the valved tree member to the said housing member of the floating vessel. Typically, the valved tree member will be locked to the said housing member when the riser system is being run into the body of water on which the vessel is floating, the riser system being run in through a throughbore of the valved tree member and through the moon pool of the floating vessel.

Preferably, once the one or more valves of the valved tree member are in sealed fluid communication with the throughbore of the riser system, the selective locking system may be unlocked to release the valved tree member from engagement with the housing member and one or more tension supporting members are provided to support the weight of the valved tree member. Preferably, the said one or more tension supporting members permit relative movement, typically relative vertical movement, to occur between the valved member (which is now secured to the riser system) and the floating vessel such that the one or more tension supporting members also bear at least a portion of the weight of the riser system and thereby compensate for relative heave between the riser system and the floating vessel.

According to a second aspect of the present invention there is provided a telescoping device for inclusion in a riser system, the telescoping device comprising:-

an inner member telescopingly provided in an outer member;
the inner member being moveable between three configurations in which:-

i) the inner member is locked to the outer member in a substantially closed configuration such that a substantial proportion of the inner member is located within the outer member such that the telescoping device is relatively short;

ii) the inner member is locked to the outer member in a substantially open configuration such that a substantial proportion of the inner member is located outwith of the outer member such that the telescoping device is relatively long; and

iii) the inner member is substantially free to move with respect to the outer member such that the inner member can telescope in and out of the outer member;

characterised in that the inner member is adapted to be sealed to the outer member when in at least one of configurations i) and ii) but is arranged to be clear of at least a portion of the outer member when in configuration iii).

Preferably, the telescoping device comprises a seal member provided on one of the inner and outer members wherein the seal acts against the other of the inner and outer members to thereby provide a seal therebetween when the telescoping device is in at least one of the configurations i) and ii). Preferably, the seal member is provided on one of the inner and outer members in such a manner that the seal is clear of the at least a portion of the other of the inner and outer members to thereby not make contact with and thereby not provide a seal with the other of the inner and outer members when the telescoping device is in configuration iii).

Preferably, the telescoping device comprises a selective locking system to selectively lock the inner member to the said outer member. Typically, the locking system comprises a dog member provided on one of the inner and outer members and which is preferably moveable toward and away from the other of the inner and outer members to make contact with the other of the inner and outer members to prevent relative movement occurring therebetween.

Preferably, the dog member is provided on the outer member and is preferably selectively moveable toward and away from the inner member to make contact with an outer portion of the inner member to prevent relative movement occurring therebetween. Typically, the outer portion of the inner member comprises a

formation formed at least part way around the outer circumference of the inner member. Preferably, the inner member comprises two said formations at or toward each end of the inner member.

5 Typically, one of the inner and outer members is provided with a varied inner or outer circumference such that the seal is prevented from acting against the other of the inner and outer members when the seal is at a location in between the said two formations such that the seal does not act when the telescoping device is in configuration iii).

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Typically, the seal is mounted on a portion secured to the outer member and acts against an inner bore of the inner member. Typically, the seal is located within the bore of the inner member and acts against the inner surface of the bore of the inner member. Typically, the seal is secured within a recess provided on an outer surface of the said portion secured to the outer member and acts against the inner surface of the bore of the inner member to provide a seal therebetween when the telescoping device is in one of configurations i) or ii).

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Preferably, the dog member is moved radially towards or away from the said respective formation by an actuating mechanism which preferably comprises at least one angled or tapered surface provided on the dog member and against which the actuating mechanism acts upon in a direction substantially parallel to the longitudinal axis of the riser system and which results in movement of the dog member in a direction substantially perpendicular to the longitudinal axis of the riser system.

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Preferably, the riser system is provided with one or more in-line valves which may be selectively opened or closed to respectively permit or prevent flow of fluid through the throughbore of the riser system. Preferably, at least one of said in-line valves is located below the valved tree member when the one or more valves of the valved tree member are in sealed fluid communication with the throughbore of the riser system and more preferably, at least one and typically two in-line valves are located between the valved tree member and the telescoping device. Typically, the telescoping device is located vertically above the two inline valves which in turn are located vertically above the flow diverter member and which in turn is located vertically above at least one in-line valve.

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According to a third aspect of the present invention there is provided a riser completion system comprising:-

5 a riser system comprising a lower in-line valve, a flow diverter member located above the lower inline valve and at least one upper in-line valve located above the flow diverter member and a telescoping device located above the said upper in-line valve to permit compensation for heave; and

10 a valved tree member suitable for use in the region of a moon pool on a floating vessel, the valved tree member comprising:-

one or more valve members adapted to selectively permit and prevent flow of fluid therethrough, and

15 one or more moveable stab members adapted to respectively selectively seal with at least one portion of the flow diverter member to thereby provide a sealed fluid communication path between a throughbore of the riser system and the one or more valve members.

Typically, the flow diverter member comprises:-

20 a substantially vertical tubular member comprising a throughbore having a longitudinal axis substantially co-incident with the longitudinal axis of the riser system at the point at which the flow diverter member is included in the riser system; and

a cross tubular member having a throughbore arranged with its longitudinal axis substantially perpendicular to the longitudinal axis of the substantially vertical tubular member;

25 wherein, a lower end of the substantially vertical tubular member is coupled to a lower portion of the riser system such that, in use, fluid passing through the lower portion of the riser system is arranged to enter the throughbore of the lower end of the substantially vertical tubular member in a fluid tight manner;

30 an upper end of the substantially vertical tubular member is coupled to an upper portion of the riser system such that, in use, fluid passing through the upper end of the substantially vertical tubular member is arranged to enter the upper portion of the riser system in a fluid tight manner;

35 and wherein the throughbore of the cross tubular member is in fluid communication with the throughbore of the substantially vertical tubular member such that, in use, fluid produced from the lower portion of the riser system is

permitted to flow through the end(s) of the cross tubular member and/or the upper end of the substantially vertical tubular member depending upon the configuration of valves attached thereto.

5 According to the present invention there is further provided a method of completing a riser installation comprising the steps of:-

i) lowering a riser system from a vessel at the surface of a body of water to or in close proximity to the surface at the bottom of the body of water;

10 ii) connecting a lower inline valve toward an upper end of the riser system;

iii) connecting a flow diverter member above the said lower inline valve in the riser system;

iv) connecting at least one upper inline valve above the said flow diverter member in the riser system;

15 v) connecting a telescoping member above the said upper inline valve in the riser system;

vi) connecting the lower end of the riser system to wellhead equipment provided at the head of a well;

20 vii) providing a valved tree member suitable for use in the region of a moon pool on the vessel, the valved tree member comprising one or more valve members adapted to selectively permit and prevent flow of fluid therethrough, and one or more moveable stab members wherein the riser system is run into the sea through a throughbore of the valved tree member;

25 viii) aligning the T-piece with the valved tree member and coupling the flow diverter member and moving the said one or more stab members to respectively seal with at least one portion of the flow diverter member to thereby provide a sealed fluid communication path between a throughbore of the riser system and the one or more valve members;

30 wherein the flow of fluid produced from the upper end of the riser system is capable of being selectively diverted from flowing up through the upper end of the riser system and instead is capable of being selectively diverted through the said one or more stab members and through the said one or more valves of the valved tree member.

In the description that follows, like parts are marked throughout the specification and drawings with the same reference numerals, respectively. The drawings are not necessarily to scale. Certain features of the invention may be shown exaggerated in scale or in somewhat schematic form, and some details of conventional elements may not be shown in the interest of clarity and conciseness. The present invention is susceptible to embodiments of different forms. There are shown in the drawings, and herein will be described in detail, specific embodiments of the present invention with the understanding that the present disclosure is to be considered an exemplification of the principles of the invention, and is not intended to limit the invention to that illustrated and described herein. It is to be fully recognized that the different teachings of the embodiments discussed below may be employed separately or in any suitable combination to produce the desired results.

The following definitions will be followed in the specification. As used herein, the term "riser" refers to a riser string coupled to a wellhead at the head of a wellbore or borehole being provided or drilled in a manner known to those skilled in the art. Reference to up or down will be made for purposes of description with the terms "above", "up", "upward", "upper", or "upstream" meaning away from the bottom of the body of water along the longitudinal axis of the riser toward the surface of the body of water and "below", "down", "downward", "lower", or "downstream" meaning toward the bottom of the body of water along the longitudinal axis of the riser and away from the surface and deeper into the body of water toward the wellhead.

The various aspects of the present invention can be practiced alone or in combination with one or more of the other aspects, as will be appreciated by those skilled in the relevant arts. The various aspects of the invention can optionally be provided in combination with one or more of the optional features of the other aspects of the invention. Also, optional features described in relation to one embodiment can typically be combined alone or together with other features in different embodiments of the invention. Additionally, any feature disclosed in the specification can be combined alone or collectively with other features in the specification to form an invention.

Various embodiments and aspects of the invention will now be described in detail with reference to the accompanying figures. Still other aspects, features, and

advantages of the present invention are readily apparent from the entire description thereof, including the figures, which illustrates a number of exemplary embodiments and aspects and implementations. The invention is also capable of other and different embodiments and aspects, and its several details can be modified in various respects, all without departing from the spirit and scope of the present invention.

Any discussion of documents, acts, materials, devices, articles and the like is included in the specification solely for the purpose of providing a context for the present invention. It is not suggested or represented that any or all of these matters formed part of the prior art base or were common general knowledge in the field relevant to the present invention.

Accordingly, the drawings and descriptions are to be regarded as illustrative in nature, and not as restrictive. Furthermore, the terminology and phraseology used herein is solely used for descriptive purposes and should not be construed as limiting in scope. Language such as "including", "comprising", "having", "containing" or "involving" and variations thereof, is intended to be broad and encompass the subject matter listed thereafter, equivalents, and additional subject matter not recited, and is not intended to exclude other additives, components, integers or steps. In this disclosure, whenever a composition, an element or a group of elements is preceded with the transitional phrase "comprising", it is understood that we also contemplate the same composition, element or group of elements with transitional phrases "consisting essentially of", "consisting", "selected from the group of consisting of", "including", or "is" preceding the recitation of the composition, element or group of elements and vice versa. In this disclosure, the words "typically" or "optionally" are to be understood as being intended to indicate optional or non-essential features of the invention which are present in certain examples but which can be omitted in others without departing from the scope of the invention.

All numerical values in this disclosure are understood as being modified by "about". All singular forms of elements, or any other components described herein including (without limitations) components of the riser system are understood to include plural forms thereof and vice versa.

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

Fig. 1A is a schematic overview (not to scale) of the initial stage of the installation of a riser system from a drill ship, utilising a moon pool surface tree in accordance with a first aspect of the present invention;

Fig. 1B is a more detailed view of a portion of Fig. 1A, where Fig. 1B shows the christmas tree sitting on the mud line or subsea surface (bottom of the sea);

Fig. 2A shows a next stage of the installation of the riser system, where the EDP and LRP have been connected to the lower end of the riser system and have been lowered into the sea through the moon pool of the drill ship;

Fig. 2B is a more detailed close up view of the LRP, EDP and lower portion of the riser system;

Fig. 2C is a close up more detailed view of one of the screw threaded connections that makes up the separate lengths of flexible riser tubular or flow line into the connected flexible riser system;

Fig. 3A is a schematic side view of the next stage of installation of the riser system in accordance with various aspects of the present invention where the riser system has continued to be lowered into the sea down toward the christmas tree and Fig. 3A also shows a telescopic joint in accordance with a second aspect of the present invention at the upper end of the riser system;

Fig. 3B shows a more detailed schematic side view of the upper end of the riser system (with the lower end of the riser system having been omitted for clarity) being lowered through the drill floor and through a diverter housing of the riser system, where the moon pool surface tree is shown as still being coupled to the diverter housing;

Fig. 3C is a much more detailed and closer schematic side view of detail A of Fig. 3B showing a set of dogs used to couple an active support ring of the moon pool surface tree to the diverter housing;

Fig. 4A is a close up schematic side view of the telescopic joint and a series of in-line valves connected thereto being lowered through the diverter housing and also shows that the active support ring of the moon pool surface tree has been disconnected from the diverter housing, where the moon pool surface tree is supported by wire tensioners from the drill floor;

Fig. 4B is a closer up more detailed schematic side view of detail A of Fig. 4A showing the dogs that were used to connect the active support ring to the diverter

housing having been retracted to allow for the disconnection of the active support ring from the diverter housing;

Fig. 5A shows a schematic side view (not to scale) of the next stage of the installation of the riser system in accordance with various aspects of the present invention, where the LRP and the EDP have been lowered into connection with the christmas tree and therefore the drill ship must be able to heave with respect to the riser system;

Fig. 5B is a schematic but closer up and more detailed side view of a portion of the upper section of the riser system of Fig. 5A;

Fig. 5C is a more detailed closer up schematic side view of the upper end of the riser system being shown in cross-section, where a combined landing ring and flow diverter piece is included in the riser system in accordance with a third aspect of the present invention and has been located within the moon pool surface tree and has landed out therein such that the weight of the riser system is transferred to the moon pool surface tree and therefore to the drill ship via the tensioning wires which can compensate for the heave of the drill ship relative to the riser system;

Fig. 5D shows a much more detailed close up sectional side view of the detail area "A" of Fig. 5C and therefore shows the combined landing ring and flow diverter piece having landed out on the load shoulder of the moon pool surface tree;

Fig. 5E shows a cross-sectional perspective view of the moon pool surface tree with its active support ring and where the combined landing ring and flow diverter piece of the riser system has landed out on the load shoulder of the moon pool surface tree;

Fig. 5F is another version of the cross-sectional perspective view of the moon pool surface tree of Fig. 5E;

Fig. 6A is a schematic side view (not to scale) of the next stage of the installation of the riser system in accordance with various aspects of the present invention, where the upper most riser package equipment can be safely coupled and un-coupled to the upper end of the universal connection of the telescopic joint in a safe manner because the telescopic joint can telescope in and out of the other lower half of the telescopic joint and therefore the upper end of the telescopic joint can remain stationery with respect to the drill ship and therefore provides for safer connection to the upper most riser package equipment such as the coiled tubing unit, lubricator or surface tree, whilst the hydrocarbon product can be diverted through the moon pool surface tree and out through either or both side ball valves, in accordance

with various aspects of the present invention, once valve stabs have been moved into and locked with respect to the inner bore of the side apertures of the combined landing ring and flow diverter piece (as shown in Fig. 6F);

Fig. 6B shows the moon pool surface tree with the telescopic joint of Fig. 6A coupled in the riser string in a fully stroked in/running in configuration;

Fig. 6C is a cross-sectional schematic view of the moon pool surface tree of Fig. 6A but now in an operating configuration where it is diverting hydrocarbon production to the side valves attached thereto and is therefore shown in an operating configuration;

Fig. 6D is a cross-sectional schematic view showing the moon pool surface tree in more detail in the configuration shown in Fig. 6C;

Fig. 6E is a more detailed cross-sectional schematic view of the moon pool surface tree in the same configuration as Fig. 6D;

Fig. 6F is a more detailed and closer up schematic cross-sectional view of the detail area "A" of Fig. 6C;

Fig. 6G is a closer up more detailed cross-sectional schematic view of the telescopic joint when in the running in configuration shown in Fig. 6C;

Fig. 6H is a closer up more detailed view of the detail area "A" of Fig. 6G of the telescopic joint when in the running in configuration, where Fig. 6H shows the dogs of the telescopic joint in the locked configuration thereby locking the telescopic joint in the configuration shown in Fig. 6G;

Fig. 7A shows the telescopic joint of Fig. 6G as having been unlocked and being free to stroke;

Fig. 7B is a closer up more detailed view of detail area "A" of the telescopic joint of Fig. 7A, where Fig. 7B shows the locking dogs in the unlocked configuration;

Fig. 8A is a perspective view of the moon pool surface tree with the telescopic joint of Fig. 6A attached to the upper end of the section of the riser system string that passes through the moon pool surface tree, where the telescopic joint is now shown in the stroked out configuration or open configuration or operating configuration;

Fig. 8B shows a cross-sectional schematic view of the telescopic joint when in the configuration shown in Fig. 8A;

Fig. 8C is a cross-sectional schematic view of detail area "A" showing the locking dogs in the locked configuration therefore locking the telescopic joint in the open configuration;

Fig. 9A is a perspective side view of the moon pool surface tree of Fig. 6A and in particular showing hydraulic stabs for valve/connector supply; and

Fig. 9B shows a perspective view from below of the moon pool surface tree showing the hydraulic stabs of Fig. 9A being presented into alignment with their
 5 respective aperture formed in the moon pool surface tree.

Fig. 1 shows a riser installation system 10 which is typically located on a sea going vessel 8 (not shown) such as a drill ship or floating production facility or other suitably arranged sea going vessel 8 (only partially shown in the Figures) where the
 10 vessel 8 comprises a drill floor 12 and a moon pool 14 located immediately below the drill floor 12, where the moon pool 14 comprises an opening in the bottom of the sea going vessel and through which a riser system 35 and other equipment to be installed on the sea bed in the general location below the sea going vessel 8 can be lowered through.

As can be seen in Fig. 1A and in more detail in Fig. 1B, a christmas tree 20 has already been lowered from the sea going vessel 8 (or from another sea going vessel not shown)) through the moon pool 14 and into the water at the water line 16 and further lowered all the way to the sea bed surface or the mud line 18 which may be
 20 many thousands of feet and in Fig. 1 the distance between mud line 18 and the drill floor 12 in the example shown is in the region of 10,000 feet.

Fig. 1A also shows the first stage or start of the installation of the riser system 35, where the riser system 35 also comprises further safety equipment in the form of an
 25 emergency disconnect package and a lower riser package 22, 24 and which are sitting on a moon pool trolley 26, awaiting to be picked up such that the moon pool trolley 26 can be removed thereby opening the moon pool 14 such that the EDP 22 and the LRP 24 can be lowered through the moon pool 14 into the water line 16 and down to the subsea installation location on top of the christmas tree 20, where the
 30 lower end of the LRP 24 will be securely connected to the tree cap 28 located at the upper end of the christmas tree 20.

The riser system 35 further comprises a riser string 32 and a riser running tool 30, where the upper end of the EDP 22 is picked up by running the riser running tool 30
 35 being provided at the lower end of the string 32 of flexible riser pipe 32T connected

end 32P to end 32B by suitable connections such as a Merlin™ connection offered by Oil States Industries (UK) Limited of Aberdeen, UK (only a very short portion of the riser string 32 is shown in Fig. 1A). The riser running tool 30 comprises a swivel joint 34 at its lower end being further connected to a weak link 36 and further being coupled to a flex joint 38, where the swivel joint 34 permits rotation of its lower end relative to its upper end and where the weak link 36 can be sheared apart if needs be to separate the riser string 32 from the tools located below the weak link 36 and where the flex joint 38 permits some flexing to allow a degree of movement to occur between the riser string 32 and the EDP 22 as and when necessary. The riser running tool 30 is lowered through the drill floor 12 through an automated Merlin™ connector make up tool 40 and which tool 40 will be used to connect further lengths of the riser pipe 32T together and is further run through a diverter housing 42 and a moon pool surface tree 50 in accordance with the present invention, where the moon pool surface tree 50 is, when in the configuration shown in Fig. 1A, securely coupled to the diverter housing 42.

The next stage of installation of the riser system 35 as can be seen in Fig. 2A, where the riser running tool 30 has, along with the flex joint 38, the weak link 36 and the swivel joint 34, been lowered (on the lower end of the riser string 32) through firstly the make up tool 40 and therefore through the drill floor 12 and then through the diverter housing 42 and through a bore 51 (shown in Fig. 3B) provided in the moon pool surface tree 50 until the flex joint 38 is securely coupled to the EDP 22 and thus the LRP 24 and the riser string 32 is then lifted up such that the moon pool trolley 26 can then be removed and the riser string 32 can then be lowered with the rest of the equipment 30, 22, 24 now coupled thereto through the moon pool 14 and into the water through the water line 16. As can further be seen in Fig. 2A, a pair of umbilical lines 52A, 52B have a lower end which is coupled to the upper end of the EDP 22 where the umbilicals 52A, 52B can be payed out from a respective reel 54A, 54B via a respective sheave 56A, 56B and can be clamped to the outer surface of the riser string 32 at spaced apart locations by means of an umbilical clamp 58, where the umbilicals 52A, 52B can be used to supply power and/or data via an electrical line and/or can supply fluid such as hydraulic fluid via a hydraulic umbilical 52A, 52B.

As can be seen in Figs. 2B and 2C, the riser string 32 is made up of distinct lengths of flexible riser tubing or pipe 32T having a pin end 32P provided at an upper end

thereof and a box end 32B provided at a lower end thereof where the lower end 32B is coupled to a pin end 32P of the next flexible tubing 32T and a preferred pin 32P and box 32B comprise the Merlin™ connector offered by Oil States Industries (UK) Limited of Aberdeen, United Kingdom.

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Additional lengths of flexible riser tubing 32T continue to be made up by the make up tool 40 into the riser string 32 at the upper end thereof such that the LRP 24 and EDP 22 continue to be lowered on the riser string 32 down toward the christmas tree 20 as shown in Fig. 3A until such a time that the LRP 24 is located just above the christmas tree 20 as shown in Fig. 3A. At this point, an upper riser package 48 (shown in Fig. 3B) is coupled to the upper end of the riser string 32, where the upper riser package 48 comprises a telescopic joint 60 in accordance with the second aspect of the present invention at its upper most end, the details of which will be discussed subsequently, where the lower end of the telescopic joint 60 is coupled to the upper end of an upper in-line ball valve 62 and which in turn is coupled via its lower end to the upper end of a middle in-line ball valve 64 and which in turn is coupled via its lower end to the upper end of a combined landing ring and flow diverter piece 66 and which in turn is coupled at its lower end to the upper end of a lower in-line ball valve 68 and which in turn is coupled at its lower end to the upper end of the riser string 32. It should be noted that the riser string 32 is omitted from Fig. 3B for clarity purposes.

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The combined landing ring and flow diverter piece 66 preferably comprises a vertically arranged main body in the form of a tubular or pipe 66 having an upper 66U and a lower 66L half connected into the riser string 32 and forming part of it and having its longitudinal throughbore 33, where the upper half 66U and lower half 66L are formed integral with or are securely and sealingly coupled to a landing ring 65 and which has a lower shoulder 72 formed or provided around its outer lower most circumference (the use of which will be detailed subsequently) and which also comprises a horizontally arranged throughbore 67 which perpendicularly intersects the main vertically arranged longitudinal throughbore 33 and through which produced fluids from the subsea well can be diverted through into stabs 76A, 76B when connected thereto (as will be described subsequently). A key (not shown) and groove (not shown) are provided to ensure the correct rotational alignment occurs between the combined landing ring and flow diverter 66 and more particularly

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between the throughbore 67 and the stabs 76A, 76B during seating of the landing ring 66 against an upwardly directed shoulder 74 (as will be described in more detail subsequently). The skilled reader will understand that the annular ring shaped landing ring 65 with a horizontally arranged cross intersecting throughbore 67 could be replaced by a pair of laterally arranged tubular output ports which provide the same horizontally arranged cross intersecting throughbore 67 but the annular ring shaped landing ring 65 has the advantage of spreading the seating load 360° around its whole circumference due to the seating contact between the respective shoulders 72 and 74 as will be described in more detail subsequently.

As can be seen in Figs 3A and 3B, the moon pool surface tree 50 is at this point still securely coupled to the diverter housing 42 via an Active Support Ring (ASR) 44 (an example of which is offered by Oil States Industries (UK) Limited of Aberdeen, United Kingdom). The ASR 44 dynamically compensates for any torsional movement between the vessel 8 and the riser system 35 via geared motorised connection between an ASR outer ring 44O (see Figs. 3C and 5E) (which is fixed to the vessel 8) and an ASR main body 44B (which will be fixed to the riser system 35 as will be described subsequently). A lower set of dogs 52L project radially inwardly from the ASR outer ring 44O into a recess provided around the outer surface of an ASR bearing surface 44S (see Fig. 5E) (and where the moon pool surface tree 50 is secured to the ASR main body 44B and where motors provided on the ASR main body 44B can rotate the ASR main body 44B with respect to the ASR bearing surface 44S to compensate for torsion therebetween) and an upper set of dogs 52U project radially inwardly from the ASR outer ring 44O into a recess provided around the lower end of the diverter housing 42 such that when both sets of dogs 52L, 52U project radially inwardly into their respective recess, the moon pool surface tree 50 is secured to the diverter housing 42.

However, just prior to the moment when the upper riser package 48 starts passing through the bore 51 of the moon pool surface tree 50, the upper set of dogs 52U are retracted from their recess in the diverter housing 42 such that the upper dogs 52U are released from the diverter housing 42 and therefore the moon pool surface tree 50 is disconnected from the diverter housing 42. Instead, the weight of the ASR 44 and thus the moon pool surface tree 50 is taken up by at least two and preferably at least three (not shown) tension wires 82A, 82B which are payed out from respective

tension wire reels 84A, 84B secured to the vessel 8 and this stage of the riser installation method is shown in Fig. 4A.

The weight of the moon pool surface tree 50 is thus taken up by the ASR 44 and thus the tension wire reels 84A, 84B and the moon pool surface tree 50 and ASR 44 are lowered a short distance away from the lower end of the diverter housing 42. The upper riser package 48 is then lowered through the diverter housing 42 and through the bore 51 of the moon pool surface tree 50 until a lower shoulder 72 of the combined landing ring/flow diverter piece 66 makes contact with and therefore butts against an upwardly directed shoulder 74 provided around the inner bore 51 of the moon pool surface tree 50 such that at least a proportion of and possibly up to the whole weight of the riser string is taken on the upwardly directed load shoulder 74 and therefore by the tension wires 82A, 82B and the tension wire reel 84A, 84B and at this point the riser string is in the running in configuration shown in Figs. 5A, 5B, 5C, 5D, 5E and 5F and this configuration can be regarded as the last stage of the running in of the riser string 32.

The LRP 24 is secured to the tree cap 28 and then the combined landing ring/flow diverter piece 66 and thus the rest of the upper riser package 48 and the riser string 32 indeed the whole riser system 35 can be secured to the moon pool surface tree 50 by actuating stabs 76A, 76B located within laterally arranged flanged pipes 90A, 90B mounted horizontally on each side of the moon pool surface tree 50 such that the throughbores of the flanged pipes 90A, 90B are horizontally aligned with one another and are arranged perpendicularly to the longitudinal and vertically arranged throughbore 51 of the moon pool surface tree 50. The stabs 76A, 76B are arranged such that they can be actuated to move radially inwardly (with respect to the longitudinal vertically arranged throughbore 51) from being wholly located within the throughbore of the flanged pipes 90A, 90B to respectively project at least partially into the horizontally arranged throughbore 67 of the laterally projecting side ports 69A, 69B of the combined landing ring/flow diverter piece 66. The radially inner most ends of the stabs 76A, 76B are provided with suitable seals such as O-ring seals 78A, 78B around their outer circumference such that the respective throughbore 76AT; 76BT of the stabs 76A, 76B is sealed by the seals 78A, 78B with respect to the throughbore 67 of the combined landing ring/flow diverter piece 66. Accordingly, the stabs 76A, 76B have a dual function of not only physically locking

the combined landing ring/flow diverter piece 66 and thus the riser string 32 to the moon pool surface tree 50 but also provide a seal between:-

i) the inner throughbore 51 of the moon pool surface tree 50 (and indeed the outer environment); and

5 ii) the inner throughbore 33 of the riser string 32

such that the respective throughbore 76AT; 76BT of the stabs 76A, 76B is in sealed fluid communication with the throughbore 67 of the combined landing ring/flow diverter piece 66 and thus is in sealed fluid communication with the throughbore 33 of the riser string 33. The riser string 32 and moon pool surface tree 10 50 are now in the operating position as shown in Fig. 6A through Fig. 6F.

At this point the operator now has the option of diverting fluid located in or flowing through the throughbore 33 of the riser string 32 located below the middle ball valve 64 out of the throughbore 33, through the throughbore 76B and through the lateral 15 ball valves 70A, 70B located on the moon pool surface tree 50 and out of lateral exit ports 71A, 71B into e.g. conduits or hoses (not shown) and onto further pressurised fluid containment equipment (not shown) which may be located below the drill floor 12 by ensuring that upper ball valve 62 and middle ball valve 64 are closed such that fluid cannot flow through the throughbore 33 up through the middle ball valve 64 or 20 upper ball valve 62. It should be noted that only one upper or middle ball valve 62, 64 is required but two are provided to ensure that there is redundancy in case one is stuck or malfunctions and cannot close. Accordingly, the operator can conduct a well test via the lateral ball valves 70A, 70B of the moonpool surface tree 50.

25 Consequently, the moon pool surface tree 50 provides the great advantage that, in combination with the combined landing ring/flow diverter piece 66, and the valves 62, 64, 68 run therewith, the potentially highly pressurised fluid such as produced hydrocarbons located within the throughbore 33 below the moon pool surface tree 50 can be safely controlled, thus allowing the operator to perform a well test or conduct 30 work on the riser system 35 and/or riser string 32 located above the moon pool surface tree 50 and more particularly located above the upper ball valve 62. For example, the final required equipment 100, 102, 104 can be safely installed to the upper end of the universal connection 61 provided at the uppermost end of the telescopic joint 60 in a safe manner because the pressurised fluid located within the

throughbore 33 is all located below the closed upper 62 and middle 64 ball valves and is being safely diverted to said other pressurised fluid containment equipment.

However, to further increase the safety of connecting that final safety equipment
5 such as a surface tree 100, lubricator 102 and/or coiled tubing unit 104, the telescopic joint 60 is adapted to be able to stroke out from the fully stroked in (also referred to as the running in configuration) configuration shown in Fig. 6B and Fig. 6C and particularly in Fig. 6G to a free to stroke configuration shown in Fig. 7A to allow the universal joint 61 at its upper end to remain static with respect to the drill
10 floor 12 in order to compensate for the heave of the vessel 8 relative to the riser system 35 and onto a fully open configuration as shown in Fig. 8B, as will now be described in detail.

The telescopic joint 60 in accordance with the second aspect of the present invention
15 comprises an outer barrel 110 which is secured at its lower end 110L to the upper end of the upper ball valve 62 such that the throughbore 109 of the telescopic joint 60 is in sealed fluid communication with the throughbore 33 of the riser string 32 and the rest of the riser system 35 (assuming that the upper 62 and middle 64 in-line ball joints are open). The inner bore 109 comprises a protruding tubular end 111 which
20 projects upwardly and to which is secured (by means of a suitable fixing means such as welding or a sealed screw thread or other suitable fixing means) to the lower end of an internal sealing tube 115 at its lower end 115L. It should be noted that the internal sealing tube 115 is preferably a separate component from the rest of the outer barrel 110 to aid manufacture and installation and also to aid repair but it could
25 be that the internal sealing tube 115 is a one piece unit integral with the outer barrel 110. The outer diameter of the internal sealing tube 115 forms an annulus 116 with the inner bore of the rest of the outer barrel 110 and an inner barrel 120 is located in that annulus 116 (when in the fully stroked in configuration as shown in Fig. 6B) where the inner barrel 120 comprises the universal joint 61 at its upper end and the
30 inner barrel 120 is arranged to telescope in and out in a stroking manner within the outer barrel 110 when it is permitted to do so as will now be described.

The inner barrel 120 is provided with a formation in the form of an upper dog ring
126U provided towards its upper end on its outer surface and is further provided with
35 a lower dog ring 126L provided toward or at its lower end again on its outer surface.

Two or more concentrically spaced apart dogs 124 are provided around the outer circumference of the inner barrel 120 and are located in a suitably sized recess within the outer barrel 110 where the dogs 124 can be forced radially inwardly toward the outer surface of the inner barrel 120 by means of a cam ring 128 which
5 can be forced (when actuated to do so by actuating cylinders 130) in a downwards direction to act on a tapered outer face 124T of the dogs 124 to force the dogs 124 radially inwardly against the outer surface of the inner barrel 120 and in particular to trap the upper dog ring 126U or lower dog ring 126L as appropriate within a recess 124R formed on the inner surface of the dogs 124.

10 Consequently, when the respective dog ring 126U, 126L is trapped within the recess 124R, the inner barrel 120 is locked with respect to the outer barrel 110. Moreover, when the upper dog ring 126U is trapped within the recess 124R (as shown in Fig. 6G and Fig. 6H), the telescopic joint 60 is in the fully stroked in or closed position as
15 shown in Fig. 6G. In this position, seals 117 provided on the outer surface concentrically around the upper end of the internal sealing tube 115 are typically slightly spaced apart from the inner bore at the upper end of the inner barrel 120 such that there is no seal against the inner bore at the upper end of the inner barrel 120 when in the fully stroked in or closed position as shown in Fig. 69 because there
20 won't be any produced hydrocarbons flowing through the throughbore 109 when in that configuration.

When the operator decides to allow the inner barrel 120 to stroke out of the inner barrel 110, he actuates the cylinders 130 to move the cam ring 128 upwards which in
25 turn permits the dogs 124 to relax or move radially outwardly away from the upper dog ring 126U such that the inner barrel 120 can now move upwards with respect to the outer barrel 110 as shown in Fig. 7A.

Importantly, the inner bore of the inner barrel 120 is provided with a slightly enlarged
30 inner bore 121 along its upper and its middle section such that the slightly enlarged inner bore 121 clears the pair of seals 117 such that the slightly enlarged inner bore 121 is not sealed with respect to the outer surface of the internal sealing tube 115 and in use, this has the advantage that the seals 117 will not be worn away by the telescoping action of the inner barrel 120 moving with respect to the internal sealing
35 tube 115 and the outer barrel 110. Because of this feature, the operator will ensure

that when the inner barrel 120 is in the closed or fully stroked in configuration shown in Fig. 69 or when in the free to stroke configuration as shown in Fig. 7A, the upper 62 and/or middle 64 ball valves are in the closed position such that no fluid can flow through the throughbore 33 of the riser system 35 above the upper ball valve 62.

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The telescopic joint 60 is shown in the fully stroked out or fully open position in Fig. 8A and Fig. 8B and is thus in the operating position where the seals are now in sealed abutment against the lower end of the inner bore of the inner barrel 120 and as shown most clearly in Fig. 8C the recess 124R traps the lower dog ring 126L due to the dogs 124 being forced radially inwardly by the cam ring 128. Thus, the operator can safely produce hydrocarbons up the throughbore 33 of the riser system 35 and up throughbore 109 of the telescopic joint 60 by opening up the upper 62 and middle 64 ball valves and ensuring lower ball valve 68 is open and also ensuring lateral ball valves 70A, 70B are closed. Compensation for heave of the vessel 8 relative to the riser system 35 whilst the telescopic joint 60 is locked in the fully stroked out position of Fig. 8A (or whilst locked in the fully stroked in position of Fig. 6G) is provided for by an additional compensation system (not shown) located above the drill floor 12 at the upper most end of the riser system 35.

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Fig. 9A shows two hydraulic valve stabs 140 being provided through the side wall of the moon pool surface tree 50.

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The hydraulic valve stabs 140 provide a suitable connection such as to supply electrical power or supply of pneumatic or hydraulic fluid to the various ball valves 62, 64, 68, 70 and also provide for hydraulic connection for operation of the actuating cylinders 130 such that electric power and/or hydraulic fluid can be delivered to the various valves 62, 64, 68, 70 and also the actuating cylinder 130 to operate the respective valves 62, 64, 68, 70 and/or the telescopic joint locking/unlocking system and therefore all power and/or hydraulic supplies to the various valves 62, 64, 68, 70 and the actuating cylinder 130 can be connected up before the equipment is run and this eliminates the need for man-riding during set up thereby greatly improving safety. Only two hydraulic valve stabs 140 are shown in Fig. 9A where the other two are located around the other side of the moon pool surface tree 50. The four stabs 140 can provide eight hydraulic lines. All four hydraulic stabs 130 can be seen in

Fig. 9H. The skilled reader will understand that fewer or more stabs 140 can be provided through the sidewall of the moon pool surface tree 5 as required.

5 Accordingly, embodiments of the present invention described herein provide the ability to remotely operate the various valves 62, 64, 68, 70 and/or the actuating cylinder 130 (the remote operation possibly being conducted a relatively short or a relatively long distance away from the relevant equipment 62, 64, 68, 70, 130 either on or off the vessel 8) and also provide the advantage of permitting remote disconnection of the equipment on the drill floor 12 to the riser system 35 and also
10 provide the great advantage of allowing for the halting or the diversion of production flow to relevant equipment on or below the drill floor 12.

These advantages individually or combine to permit work to be safely carried out on the top level equipment 100, 102, 104 on the drill floor without the hazards
15 associated with sea movement.

Consequently, the various embodiments described herein provide numerous significant safety and operational advantages over conventional riser systems.

20 Modifications or improvements may be made to the embodiments described herein without departing from the scope of the invention.

1. A telescoping device for inclusion in a riser system, the telescoping device comprising:-

an inner member telescopingly provided in an outer member;

the inner member being moveable between three configurations in which:-

5 i) the inner member is locked to the outer member in a substantially closed configuration such that a substantial proportion of the inner member is located within the outer member such that the telescoping device is relatively short;

10 ii) the inner member is locked to the outer member in a substantially open configuration such that a substantial proportion of the inner member is located outwith of the outer member such that the telescoping device is relatively long; and

iii) the inner member is substantially free to move with respect to the outer member such that the inner member can telescope in and out of the outer member;

15 characterised in that the inner member is adapted to be sealed to the outer member when in at least one of configurations i) and ii) but the seals are arranged to be clear of at least a portion of the outer member when in configuration iii).

2. A telescoping device as claimed in claim 1, wherein the telescoping device comprises a seal member provided on one of the inner and outer members wherein
20 the seal acts against the other of the inner and outer members to thereby provide a seal there between when the telescoping device is in at least one of the configurations i) and ii).

3. A telescoping device as claimed in claim 2, wherein the seal member is
25 provided on one of the inner and outer members in such a manner that the seal is clear of the at least a portion of the other of the inner and outer members to thereby not make contact with and thereby not provide a seal with the other of the inner and outer members when the telescoping device is in configuration iii).

30 4. A telescoping device as claimed in claim 2 or claim 3, wherein the telescoping device comprises a selective locking system to selectively lock the inner member to the said outer member.

5. A telescoping device as claimed in claim 4, wherein the locking system
35 comprises a dog member provided on one of the inner and outer members, the dog

being moveable toward and away from the other of the inner and outer members to make contact with the other of the inner and outer members to prevent relative movement occurring therebetween.

- 5 6. A telescoping device as claimed in claim 5, wherein the dog member is provided on the outer member and is selectively moveable toward and away from the inner member to make contact with an outer portion of the inner member to prevent relative movement occurring therebetween.
- 10 7. A telescoping device as claimed in claim 5 or claim 6, wherein the outer portion of the inner member comprises a formation formed at least part way around the outer circumference of the inner member.
- 15 8. A telescoping device as claimed in claim 7, wherein the inner member comprises two said formations at or toward each end of the inner member.
- 20 9. A telescoping device as claimed in claim 8, wherein one of the inner and outer members is provided with a varied inner or outer circumference such that the seal is prevented from acting against the other of the inner and outer members when the seal is at a location in between the two formations such that the seal does not act when the telescoping device is in configuration iii).
- 25 10. A telescoping device as claimed in any one of claims 7 to 9, wherein the dog member is moved radially towards or away from the respective formation by an actuating mechanism.
- 30 11. A telescoping device as claimed in claim 10, wherein the actuating mechanism comprises at least one angled or tapered surface provided on the dog member and against which the actuating mechanism acts upon in a direction substantially parallel to a longitudinal axis of the riser system and which results in movement of the dog member in a direction substantially perpendicular to the longitudinal axis of the riser system.

12. A telescoping device as claimed in any one of claims 2 to 11, wherein the seal is mounted on a portion secured to the outer member and acts against an inner bore of the inner member.

5 13. A telescoping device as claimed in claim 12, wherein the seal is located within the bore of the inner member and acts against the inner surface of the bore of the inner member.

10 14. A telescoping device as claimed in claim 13, wherein the seal is secured within a recess provided on an outer surface of the said portion secured to the outer member and acts against the inner surface of the bore of the inner member to provide a seal therebetween when the telescoping device is in one of configurations i) or ii).

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