United States Patent [19]

Slack

[11] **3,782,458**

[45] **Jan. 1, 1974**

[54] **UPRIGHT, SWIVELABLE BUOYED CONDUIT FOR OFFSHORE SYSTEM**

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[22] Filed: **Aug. 4, 1971**

[21] Appl. No.: **169,036**

[52] **U.S. Cl.** **166/.5,** 141/387, 169/2

[51] **Int. Cl.** **E21b 33/035**

[58] **Field of Search** ..... 166/.5, .6; 175/5, 175/7; 141/387, 229, 284; 169/2; 114/.5 D; 9/8.5, 8 P; 61/46

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[57] **ABSTRACT**

The basic device of the invention includes a submerged, bottom supported ball joint having a conduit extending upwardly therefrom, a body of flotation material secured on the conduit above the center of gravity thereof so that the conduit is buoyed in a generally vertical condition and emergent means at the upper end of the conduit for accomplishing the desired use of the device. This latter means may include means for connecting another conduit thereto, valving and control means, visual indicators and the like. The means which anchor the device to the bottom may be a partly or fully completed petroleum well wellhead, or a portion thereof, an anchor pipe or similar means.

26 Claims, 4 Drawing Figures

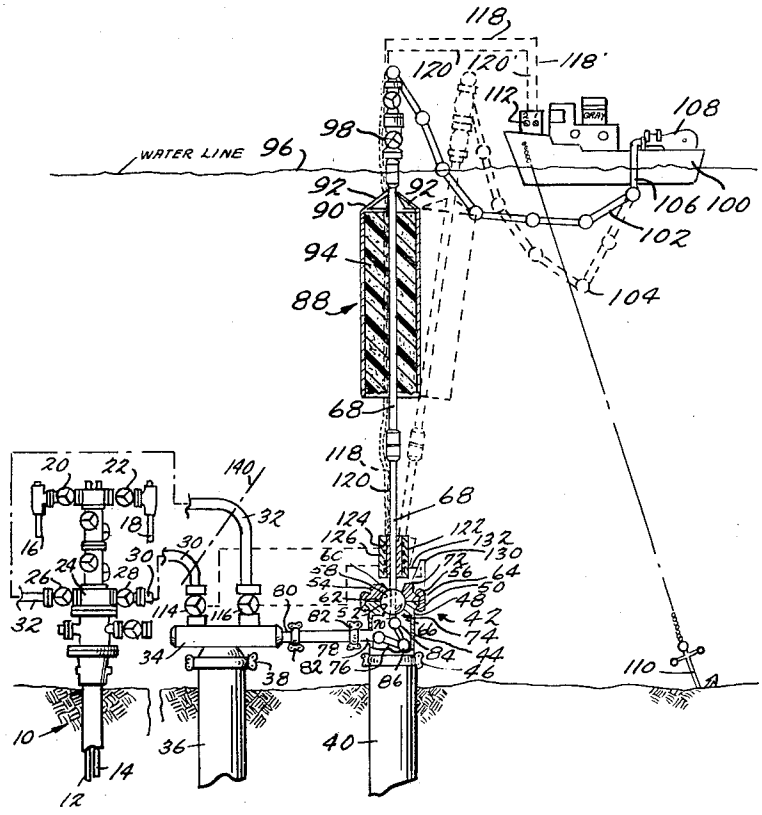
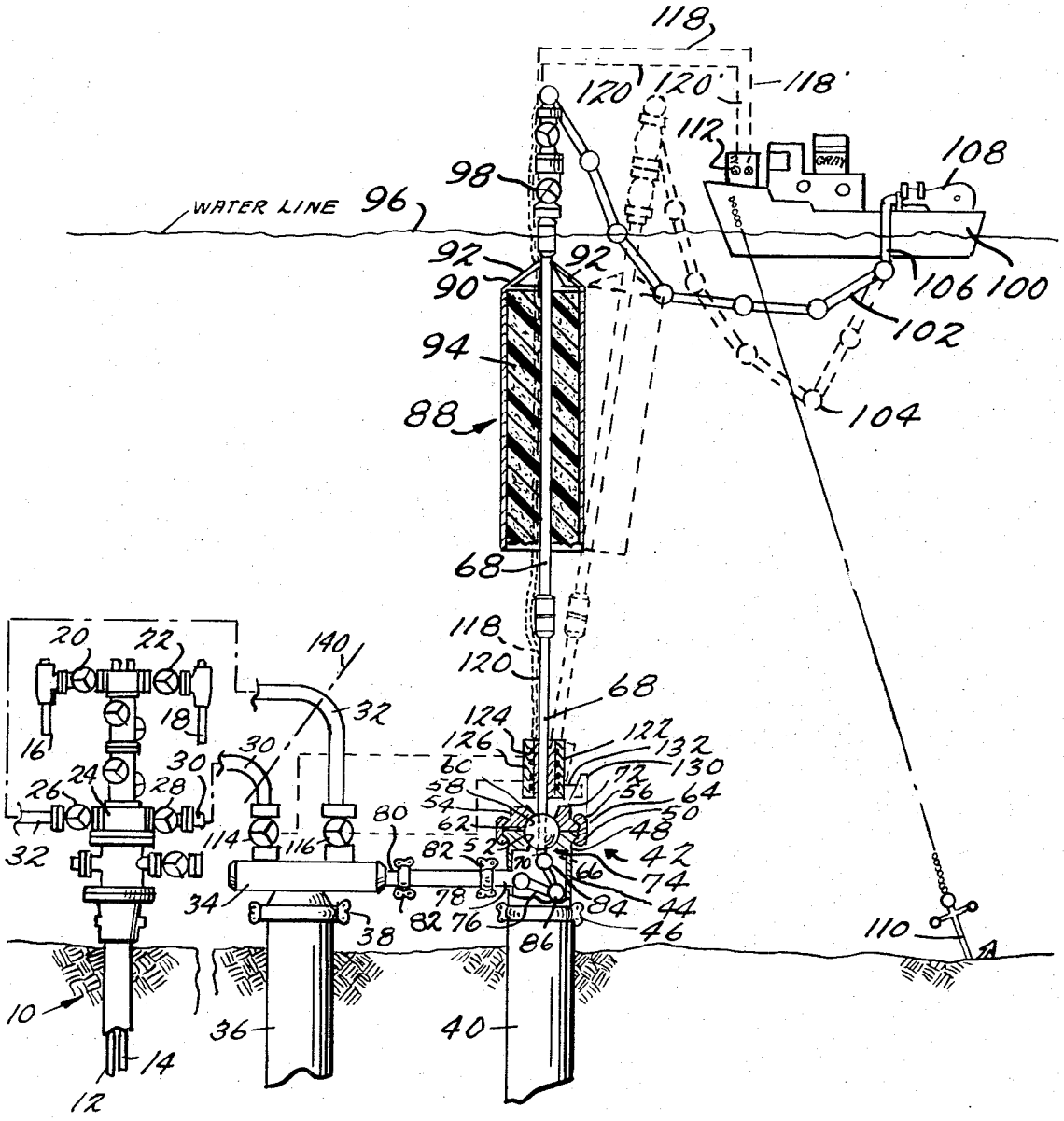


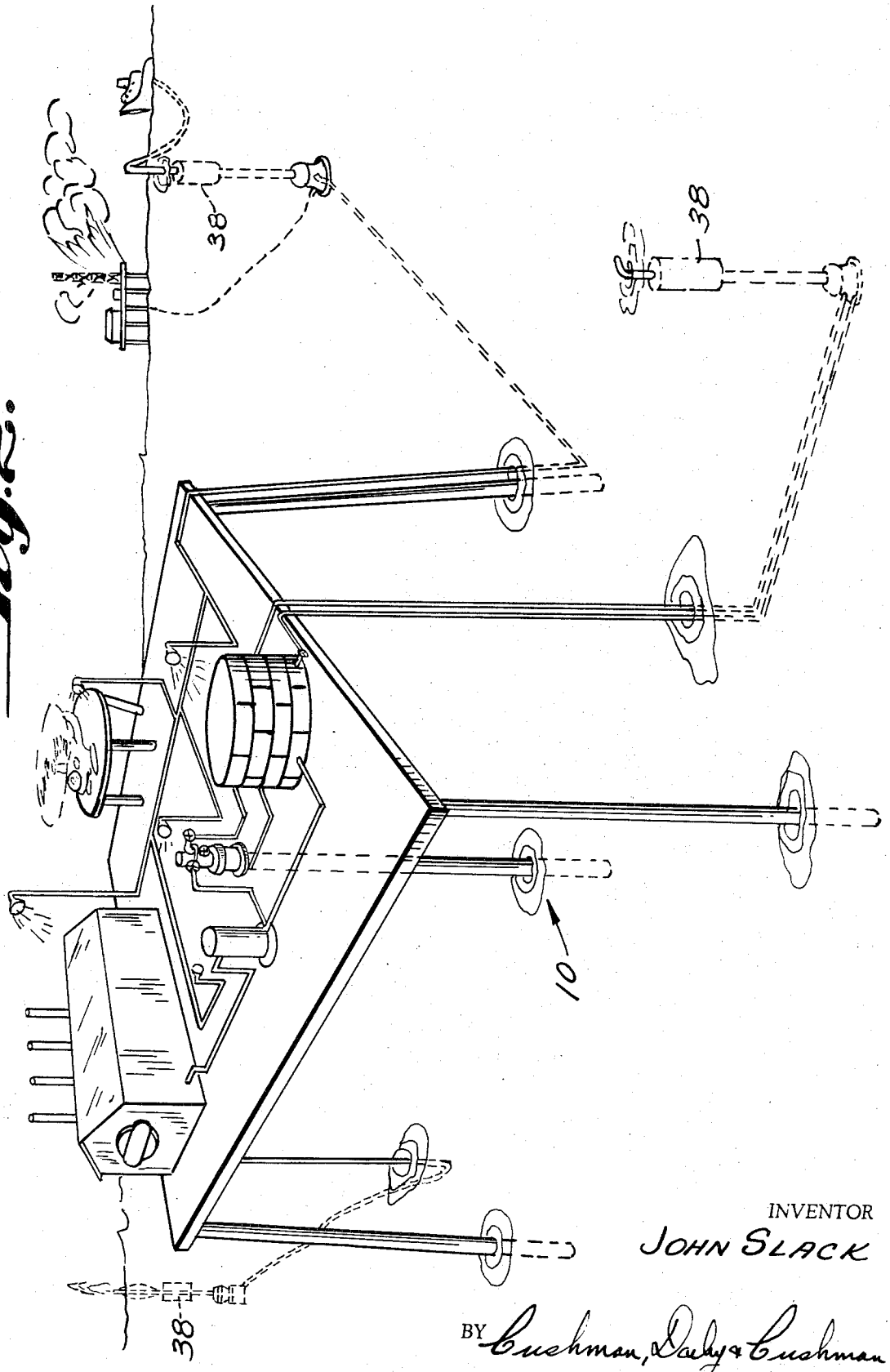
Fig. 1.



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Fig. 2.



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Fig. 3.

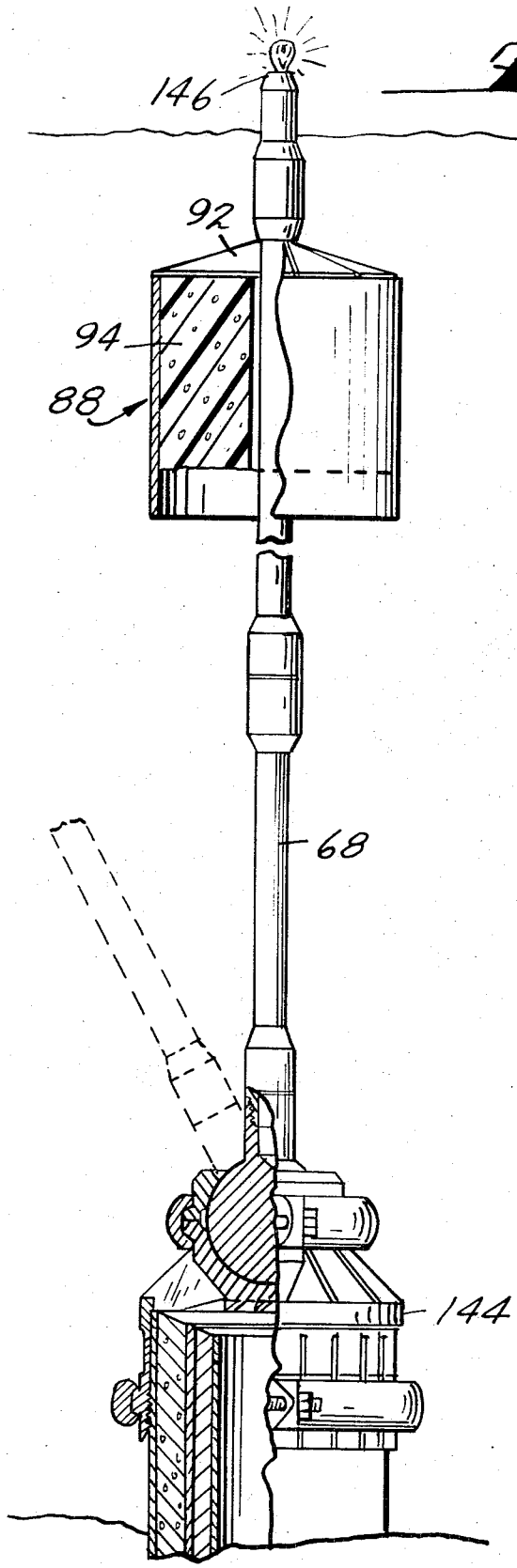
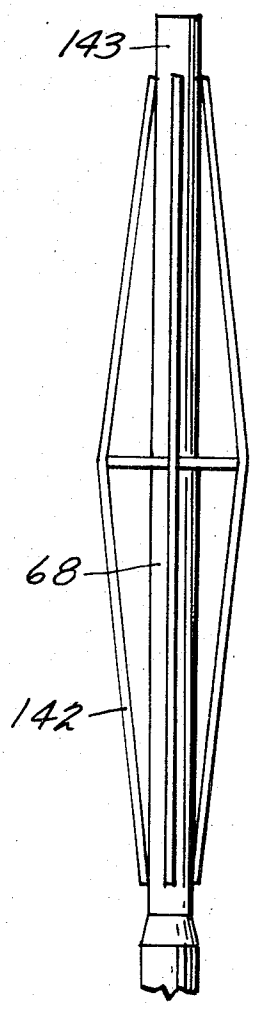


Fig. 4.



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UPRIGHT, SWIVELABLE BUOYED CONDUIT FOR OFFSHORE SYSTEM

BACKGROUND OF THE INVENTION

There are a number of occasions when it is necessary or desirable to have access to or mark for identification a petroleum well, oil or chemical storage facility, piping system, or the like, which is on shore or offshore and which is platform-supported or submerged, from an offshore location. Equipment useful in such instances has tended to be especially configured to adapt it for one, but not all, of these uses. The specialization of design has tended to limit marketability so the price of such equipment has heretofore not been able to benefit from large scale production. This has, itself, tended to limit marketability of such devices.

SUMMARY OF THE INVENTION

The invention provides an upright, swivelable, water-buoyed conduit for connection to one or more of: the production string(s) of one or more petroleum wells through wellheads which are fully or partly submerged or mounted on a production platform, other parts of wellheads during a drilling, completion, production, servicing emergency or workover phases of use of the wells, for introducing or withdrawing fluids from the well, including drilling, mud, water, cement, petroleum, fire-fighting chemicals, well stimulating chemicals, and the like; a petroleum or other storage facility, a fire protection sprinkler system or the like, or to mark a navigational hazard or submerged, bottom supported structure in order to comply with applicable rules and regulations or to permit reestablishment of contact or communication with the submerged, bottom supported structure. Use may be made of the device for on-loading or off-loading of fluids by a water-borne vessel, for instance, for periodically collecting into a tanker the crude oil produced from one or more offshore petroleum wells and temporarily stored in a storage tank which is submerged or located upon a production platform. Use may also be made of the device for putting the crude oil ashore at a jetty from a tanker which cannot enter a harbor, e.g. due to its draft.

The basic device of the invention includes a submerged, bottom supported ball joint having a conduit extending upwardly therefrom, a body of flotation material secured on the conduit above the center of gravity thereof so that the conduit is buoyed in a generally vertical condition and emergent means at the upper end of the conduit for accomplishing the desired use of the device. This latter means may include means for connecting another conduit thereto, valving and control means, visual indicators and the like. The means which anchor the device to the bottom may be a partly or fully completed petroleum well wellhead, or a portion thereof, an anchor pipe or similar means.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevation view of an offshore system equipped with an upright, swivelable buoyed conduit in accordance with the principles of the present invention;

FIG. 2 is an elevation view of a more complex offshore system equipped with the apparatus of the invention;

FIG. 3 is an elevation view, with parts broken away and sectioned, of an alternate use of apparatus of the invention as a navigation hazard marker for a temporarily abandoned well; and

FIG. 4 is an elevation view of another modification of the apparatus, useful for flaring gas from an offshore system.

DETAILED DISCUSSION OF THE PRESENTLY PREFERRED EMBODIMENTS OF THE INVENTION

In FIG. 1 there is shown an offshore underwater wellhead **10.** In the instance depicted, the well includes two side-by-side tubing strings **12, 14** which extend down to different levels to permit production from different petroleum-bearing zones. Accordingly, the wellhead is equipped with piping **16,18** for carrying off the output of the two strings separately and valves **20,22** which remain open to permit production from the well and which may be closed to shut off production from the well. The valves **20,22** would, in many instances, be provided with remotely actuable, fail-closed operators which are commerically available from, i.a., Harold Brown Company or U.S.I. (see the *Composite Catalog of Oil Field Equipment and Services*, 1970–1971 Edition, Gulf Publishing Company, Houston, Texas, U.S.A.)

The well may further be provided with down-hole tubing safety valves (see i.a., Otis Engineering Corp. listing in the *Composite Catalog*) and/or with tubing safety valves located in the tubing head bonnet, below the valves **20, 22.**

In the instance depicted, the wellhead is provided with a tee-bonnet **24** (see Type D, page 2,251 of the *Composite Catalog*). The two respective outlets of the tee are shown equipped with normally closed valves **26,28** connected to respective kill lines **30, 32.**

The principles of the invention will be further hereinafter discussed with reference to the drawings wherein preferred embodiments are shown. The specifics illustrated in the drawings are intended to exemplify, rather than limit, aspects of the invention as defined in the claims.

In the event that it is desired to pump fluid into the well through either the line **30** or the line **32,** or both, the respective valve(s) **20,22** would be closed and the respective valve(s) **26,28** opened.

(It should be stated here that an underwater wellhead is illustrated only for the purpose of providing a complete discussion of a presently contemplated best mode of the invention. The apparatus of the invention may also be used with offshore wellheads located on a platform at the surface or with offshore wellheads which are "stretched" so as to have tubing and/or casing string suspension at or near the mud line, but control elements of the wellhead christmas tree up on a production platform at the surface. These differences will be easily appreciated by those skilled in offshore well completion and will not effect the principles of the equipment to the right of the breaks illustrated in the pipes **16, 18** in FIG. **1.**)

The valves **26,28** may be ones which are remotely actuable and/or ones which fail open. For instance, where they are to be used solely in case of a fire, they may be constituted by thermal activated safety relief valves such as are illustrated at **60** in the U.S. Pat. of Slack, No. 3,450,202, issued June 17, 1969. Or, the valves **26,28** may be ones which open upon the application of pressure through the lines **30,32,** e.g. check valves such

as are illustrated in the U.S. Patent of Latham et al., No. 3,509,908, issued May 5, 1970, or in the U.S. Patent application of Boitnott, Ser. No. 869,160 filed Oct. 24, 1969.

In FIG. **1**, the lines **30,32** proceed to a manifold **34**, which, in the instance depicted, is mounted at the ocean floor by driving a pipe **36** into the ocean bottom and securing the manifold **34** to the upper end of the pipe, for instance using a clamp **38** (see pages 2,255–2,260 of the *Composite Catalog*). Several suitable manifolds **34** are commercially available (e.g. see page 2,445 and page 2,944, FIG. 24, of the *Composite Catalog*).

Adjacent the pipe **36**, another pipe **40** is similarly driven into the ocean floor to provide support and securement for the upright, swivelable buoyed conduit device **42**.

That device is shown in FIG. **1**, including an axially short segment of conduit **44** clamped to the upper end of the pipe **40** with a clamp **46**, substantially like the clamp **38**. At its upper end, the conduit segment **44** mounts a ball seat lower member **48** which is an annular element having a clamp receiving circumferential wedging surface **50** bounding its outer periphery and an internal, upwardly and inwardly facing, spherically curved, annular seat surface **52**. The device further includes a ball seat upper member **54** which is an annular element having a clamp receiving circumferential wedging surface **56** bounding its outer periphery and an internal, downwardly and inwardly facing, spherically curved, annular seat surface **58**.

The seats **52** and **58** are configured to receive a ball **60** between them with the respective end surfaces **62** of the parts **48,54** in engagement. The ball joint **48,60,54** is held together by a circumferential clamp **64** which is like the clamps **38,46**. This ball joint is perferred for use in the instance depicted. Alternative designs could be employed, for instance one of the controlled deflection ball joints of the U.S. Patent of Nolan, Jr. et al., No. 3,523,578 issued Aug. 11, 1970, could be substituted in some instances and the Hydraloc (T.M.) ball joint connector of the U.S. Patent of Harwell, Jr., No. 3,450,421 issued June 17, 1969, could be used, either as depicted, or inverted.

It should now be noticed that the ball **60** has a generally vertical bore or passageway **66** formed diametrically therethrough. A pipe **68** has its lower end secured in the upper end of the bore **66** and a pipe **70** has its upper end secured in the lower end of the bore **66**. The openings **72,74** centrally of the seats **52,58** receive the pipes **68,70** freely therethrough with sufficient clearance to permit the ball **60** to cock, e.g. 30° from a central datum position wherein the pipes **68,70** and the bore **66** are vertical.

The lower end of the pipe **70** is secured to one end of a swivelable, flexible conduit **76**. The opposite end of the conduit **76** is connected to a short segment of pipe **78** securely mounted in the sidewall of the conduit segment **44** so that its inner end lies within the bore of the conduit **44**, and its outer end lies outside the conduit **44**. The outer end of the pipe **78** is secured to the outlet **80** of the manifold **34**, e.g. by clamps **82**.

As depicted, the flexible, swivelable conduit **76** may be constituted by a Chiksan Style **50** low pressure swivel joint **84** connected to three Chiksan Style 30 low pressure swivel joints **86** in tandem (see the Chiksan listing in the *Composite Catalog*). Other materials, for instance a flexible hose with a rotatable coupling at at least one end could be used in place of the Chiksan joints.

In the instance illustrated, the pipe **68** consists of at least one, and usually several, joints of drill pipe, e.g. 6⅝ inch A.P.I. full hole tool joints.

Near the upper end of the string of pipe **68**, a flotation canister **88** surrounds and is secured upon the pipe **68**. As shown, the flotation canister **88** includes a cylindrical sidewall, e.g. of ½ inch thick steel plate welded at its upper end to the outer periphery of an annular upper end wall **90**, topped by triangular ribs **92**. The inner periphery of the end wall **90** and the inner sides of the ribs **92** are welded to the pipe **68** to hold the canister **88** in place. The canister is filled with a flotation material **94** which provides, e.g. 125 pounds positive flotation per one foot of length. A typical flotation material is closed cell polyurethane foam having a density of two pounds per cubic foot. A typical canister **88** will provide about 600 pounds of positive buoyancy. The canister **88** is, of course, positioned above the center of gravity of the string of pipe **68**, including structures supported on the upper end of the string of pipe **68**. What is important is that the pipe **68** be buoyed so that it remains generally upright, with the equipment mounted on its upper end above or accessible from the water line. Of course, a telescoping slip joint may be provided intermediate the ends of the string of pipe **68** so that, e.g. in rough seas, the equipment will remain accessible. As an alternative for many instances, the pipe **68** may extend sufficiently upwardly that, even in swells likely to be expected, the equipment on the upper end will remain above or accessible from the water line. By "accessible" it is recognized that connections may be made with the equipment, even though the equipment may be submerged a few feet below the water line.

The upper end of the string of pipe **68** emerges above the water line **96** and is provided with appropriate valving **98**. The valving **98** and emergent end of the pipe **68** may be considered as the equivalent of a floating fire hydrant for a rapid understanding of much of what is depicted in FIG. **1**.

In the event it becomes necessary for a fluid, e.g. mud, fire fighting foam, water, well-stimulating chemicals, etc. to be pumped into the well, a vessel **100** pulls up to the valving **98** and connects thereonto, e.g. using a flexible conduit and rotatable connection assembly **102**. This may include more Chiksan joints **104** connected to a floating flexible hose **106** connected to a high pressure pump **108** and fluid mixing and supply means on board the vessel, on an auxiliary barge, etc. While the vessel is pumping fluid through the apparatus of the invention, it may be anchored as at **110** or dynamically positioned as is known in the art.

A remote valve operator console **122** is shown provided on the vessel for operating the line valves **114,116** ahead of the manifold **34** to control which if the pipe lines entering the manifold is communicated to the buoyed conduit **68**. Control lines **118,120** for remotely operating the valves **114,116** are shown extending from the valves **114,116** to a swivel communtator **122** at the base of the pipe **68**, just above the ball, out of the commutator **122** and up along side the pipe **68** to connectors **124** among the equipment at the emergent upper end of the pipe **68** and from there to the

console **112** through line portions **118',120'** carried on board the vessel.

In a typical use of the system, e.g. to pump mud down one tubing string of a wild well, the vessel reports to the scene, connects with the equipment at the upper end of the buoyed conduit **68**, opens the proper valve from the console and begins pumping mud from on board the vessel down through the buoyed conduit, the ball joint, the flexible conduit below the ball joint, through the manifold to the proper pipeline, back through the christmas tree bonnet tee outlet and check valve serving the specified tubing string and down into the well.

The communtator **122** is needed in the instance depicted to keep the remote valve control lines from parting should the ball and pipeline **68** rotate about the longitudinal axis of the pipeline **68.** As shown, the commutator **122** includes a radially inner tubular sleeve (or rotor) **124** to which the valve control lines from the manifold valves are directly connected and a radially outer tubular sleeve (or stator) **126** from which the valve control lines running up the side of the buoyed conduit **68** emanate. The facing surfaces of the rotor and stator are grooved and channeled to isolate the control line conduits from one another but keep the two portions of each same control line in sealed communication with one another regardless of the relative angular disposition of the rotor and stator. The stator is maintained in fixed angular relation by guide fins **130** mounted on the ball seat upper member **54** which flank a guide fin **132** mounted on the stator. This arrangement permits cocking of the ball, buoyed conduit and commutator with respect to the ball seat, and angular rotation of the ball, buoyed conduit and commutator rotor with respect to the ball seat, but prevents angular rotation of the stator.

In the context of the arrangement shown in FIG. **1,** it should be apparent that another buoyed conduit device could be similarly connected through a manifold to the piping **16,18** to permit production from the well into a floating storage facility, or the piping **16,18** could lead through conventional intermediate equipment to crude oil storage tanks to which another buoyed conduit device (replicating everything to the right of the plane **140**) could be connected for periodically transferring the crude oil from storage to a tanker. In such an instance, the buoyed conduit would be connected to the suction side of the aboard-vessel pump.

It would also be within the purview of the invention to omit the manifold and maintain two or more individual flow lines into respective plural passages through the ball and up through the flotation canister to the emergent upper end of the device. This would permit concurrent operations of similar or dissimilar nature through the individual flow lines. In such instance, the buoyed conduit **68** may comprise side-by-side conduits bundled together or coaxial conduits.

FIG. **2** further illustrates the versatility and usefulness of the buoyed conduit device of the present invention. The piping is shown somewhat schematically for ease of illustration without detracting from the information one skilled in the art can absorb from the drawings and this specification.

One buoyed conduit device **38** is shown being served by a pump boat to power the safety water sprinkler system on a production platform in the foreground and to pump mud into a burning well at a platform in the background. Another buoyed conduit device **38** is shown in the foreground ready to permit periodic removal of petroleum from the storage tank on the foreground platform into a tanker and to permit fluid to be pumped into the well through the wellhead on the foreground platform. A third buoyed conduit device **38** is located in the left background for flaring gas from the foreground platform well (see also FIG. **4**).

In FIG. **4,** a modification is shown, wherein the upper end of the buoyed conduit **68,** instead of being provided with valving and connection means, is provided with bracing **142** and an open upper end **143** to allow gas issuing from a well to be flared after it has been separated from the crude oil, in instances where it is uneconomical to collect and compress the gas or to accommodate instances where, temporarily, the gas cannot be collected, for instance due to compressor breakdown.

In FIG. **3,** the buoyed conduit device **38** is shown mounted on the temporary abandonment cap **144** of a temporarily abandoned well and is topped by a navigation aid such as a signal light **146.** (See the discussion relating to FIG. **10** of the U.S. Patent of Pitts et al., No. 3,405,763, issued Oct. 15, 1968. In the present instance, the device shown in FIG. **3** hereof replaces the elements **358,360,356** of the Pitts et al. structure.)

Any or all of the contacting surfaces of the ball joint may be provided with a coating of conventional antifouling and/or friction reducing composition.

The foregoing specification is believed to provide one skilled in the art with sufficient information to construct apparatus in accordance with the invention. Of course, it is necessary in many instances to construct a force diagram setting for the various moments about the ball joint ball center of rotation so that one can be sure that the buoyancy provided by the buoyant canister will be sufficient, under expected conditions, to maintain the buoyed conduit and the equipment at the upper end thereof, in a generally upright condition without undue stress on the ball joint seat members due to excessive angular deviation of the buoyed conduit and equipment. Figuring out such force diagrams is well within the skill of those having professional experience or education in the fields of mechanics (dynamics) and marine architecture.

It should now be apparent that the upright, swivelable buoyed conduit for offshore system as described hereinabove possesses each of the attributes set forth in the specification under the heading Summary of the Invention hereinbefore. Because the upright, swivelable buoyed conduit for offshore system of the invention can be modified to some extent without departing from the principles of the invention as they have been outlined and explained in this specification, the present invention should be understood as encompassing all such modifications as are within the spirit and scope of the following claims.

What is claimed is:

1. An upright, buoyed element for an offshore system comprising:

anchoring means structured so as to be secured to the bottom in a body of water;

the anchoring means including internally spherically curved surface means for journalling a ball joint ball member, said surface means including an upwardly directed opening therethrough of lesser radius than the radius of curvature of said internally spherically curved surface means;

a ball joint ball member;

an elongated rigid tubular element having one end secured to said ball member so that the tubular element projects generally radially outwardly from the ball member;

said ball member being surrounded and journalled by said internally spherically curved surface means with said tubular element projecting up through said upwardly directed opening to the vicinity of the upper surface of said body of water in order to permit equipment to be mounted on the upper end thereof for accessibility from the upper surface of the body of water;

means defining a bore through said ball member, said bore having an upper end and a lower end, said upper end thereof being in sealed communication with the bore of said tubular element; and

flexible conduit means having one end connecting with the lower end of the bore of said ball member, said flexible conduit means having the opposite end thereof structured for connection with a conduit system;

valve means mounted on the upper end of the bore of said tubular element for permitting and denying access to the bore of said conduit system from the surface of said body of water and;

positive buoyancy flotation means secured on said tubular element and being disposed below the upper surface of said body of water, said flotation means having sufficient positive buoyancy to maintain said tubular element in an upright condition.

2. The element of claim **1** wherein said anchoring means comprises a pipe driven into the subaquatic floor.

3. The element of claim **1** wherein said upwardly directed opening through said internally spherically curved surface means is of sufficient diameter compared to the outer diameter of said tubular member as to permit the tubular member to deviate up to about 30° from verticality before interference with the periphery of said opening restricts greater deviation of said tubular member.

4. The element of claim **1** wherein said opposite end of said flexible conduit means is connected to a petroleum storage tank.

5. The element of claim **1** wherein the opposite end of the flexible conduit means is connected to a conduit system constituting a natural gas supply and wherein the upper end of said tubular conduit mounts a natural gas flare stack.

6. The element of claim **1** wherein the positive buoyancy flotation means comprises an annular canister of foamed synthetic plastic material.

7. The element of claim **1** further including a navigation aid signal device mounted on the upper end of said tubular element.

8. The element of claim **7** wherein said navigation aid signal includes a light.

9. The element of claim **7** wherein said anchoring means comprises an upper end of a submerged petroleum well.

10. The element of claim **1** wherein said opposite end of said flexible conduit means is connected to at least one wellhead outlet in communication with a tubing string extending to a recoverable mineral-bearing formation.

11. The element of claim **10** wherein said wellhead is disposed entirely under water.

12. The element of claim **10** wherein said wellhead is disposed at least partly under water.

13. The element of claim **10** wherein said wellhead is disposed on a production platform.

14. The element of claim **10** wherein said flexible conduit means and said at least one wellhead outlet include a manifold interposed therebetween and wherein the element further includes a second wellhead outlet communicating with said manifold and, via said manifold, with said flexible conduit means, said second wellhead outlet being in communication with a second tubing string extending to a recoverable mineral-bearing formation.

15. The element of claim **14,** wherein the manifold further includes a valve on the side thereof towards the wellhead outlets for each said wellhead outlet, whereby each of the wellhead outlets connected to the manifold may be selectively placed in communication with the tubular element.

16. The element of claim **15** further including a remote control operator at the surface of said body of water for each last-mentioned valve; a control line for each last-mentioned valve extending from each last-mentioned valve to the tubular element near said ball member, up along the tubular element and to the respective valve remote control operator; and a rotary commutator mounted on said tubular element near said ball member, said rotary commutator being interposed in the control lines for the last-mentioned valves for maintaining the integrity of the valve control lines in spite of swiveling of said ball member and tubular element.

17. The element of claim **16,** wherein the valve remote control operators are disposed on board a surface vessel on said body of water adjacent the upper end of said tubular element.

18. The element of claim **10** wherein the tubing string extends to a petroleum-bearing formation and wherein the wellhead includes a normally closed valve between said tubing string and said flexible conduit means, which valve must be opened in order to permit fluid flow between said tubular element and said tubing string.

19. The element of claim **18** wherein the last-mentioned valve is a one-way, back-pressure openable valve oriented so that pressurized fluid pumped down the tubular element can open said last-mentioned valve and enter the tubing string.

20. The element of claim **18** wherein the last-mentioned valve comprises a fusible plug normally stopping means defining a fluid passageway so as to permit fluid passage through said fluid passageway only after said fusible plug has been melted.

21. An upright, buoyed element for an offshore system comprising:

anchoring means structured so as to be secured to the bottom in a body of water;

the anchoring means including internally spherically curved surface means for journalling a ball joint ball member, said surface means including an upwardly directed opening therethrough of lesser radius than the radius of curvature of said internally spherically curved surface means;

a ball joint ball member;

an elongated rigid tubular element having one end secured to said ball member so that the tubular element projects generally radially outwardly from the ball member;

said ball member being surrounded and journalled by said internally spherically curved surface means with said tubular element projecting up through said upwardly directed opening to the vicinity of the upper surface of said body of water in order to permit equipment to be mounted on the upper end thereof for accessibility from the upper surface of the body of water;

means defining a bore through said ball member, said bore having an upper end and a lower end, said upper end thereof being in sealed communication with the bore of said tubular element; and

flexible conduit means having one end connecting with the lower end of the bore of said ball member, said flexible conduit means having the opposite end thereof structured for connection with a conduit system; and

positive buoyancy flotation means secured on said tubular element and being disposed below the upper surface of said body of water, said flotation means having sufficient positive buoyancy to maintain said tubular element in an upright condition;

the opposite end of flexible conduit means being connected to a conduit system constituting a water sprinkler system disposed on an offshore platform, said water sprinkler system including a plurality of branch conduits extending to the vicinity of items of equipment to be protected and sprinkler heads on said branch conduits.

22. A device which includes:

a water-submerged, underwater bottom-supported ball joint including a ball member having a conduit extending upwardly therefrom;

a body of flotation material secured on the conduit above the center of gravity thereof so that the conduit is buoyed in a generally vertical condition and emergent means at the upper end of the conduit including means for connecting another conduit thereto;

means defining a bore through said ball member, said bore having an upper end and a lower end, said upper end thereof being in sealed communication with the bore of said conduit; and

flexible conduit means having one end connecting with the lower end of the bore of said ball member, said flexible conduit means having the opposite end thereof structured for connection with a conduit system;

valve means mounted on the upper end of the bore of said conduit for permitting and denying access to the bore of said conduit system from the surface of said body of water.

23. The device of claim **22** wherein the emergent means includes a valve.

24. The device of claim **22** further including means anchoring the ball joint to the bottom.

25. The device of claim **24** wherein the anchoring means comprises an at least partly completed petroleum well.

26. The device of claim **24** wherein the anchoring means comprises an anchor pipe secured in the bottom.

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