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(54) RISER TENSIONER WITH SHROUDED RODS

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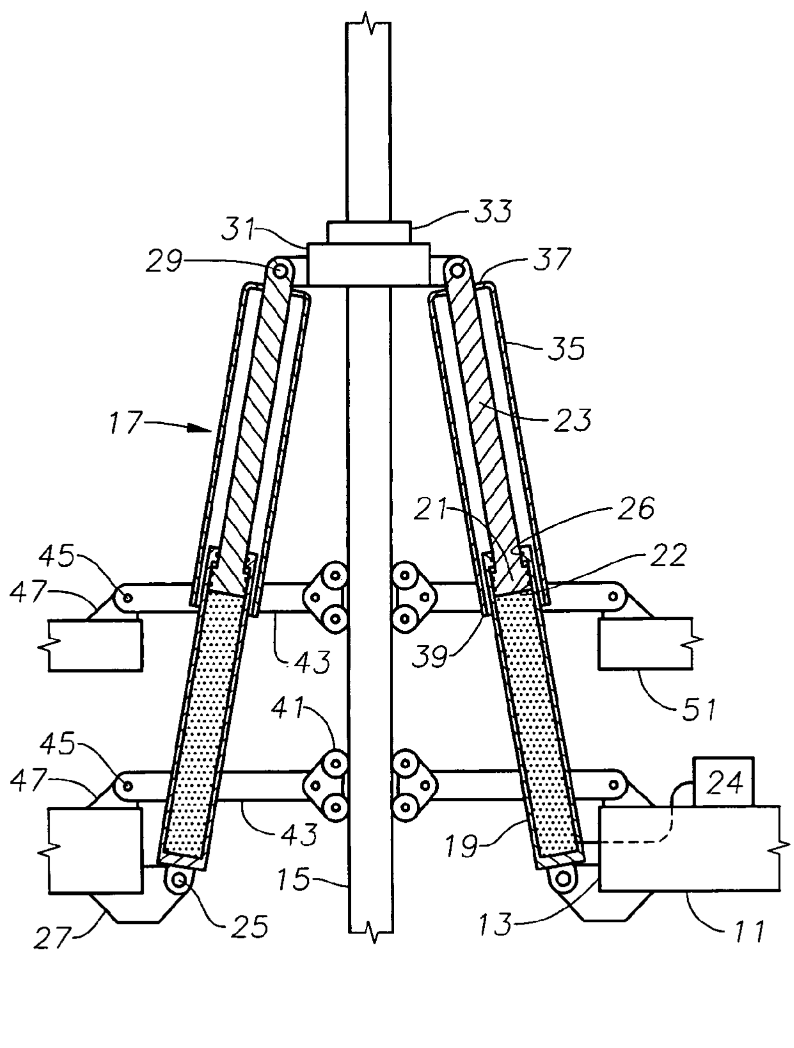
(57) **ABSTRACT**

A surface assembly that communicates with subsea structures and includes a working deck on a floating structure. The working deck has an aperture extending axially therethrough. A riser extends from a subsea location to the working deck and through the aperture. The surface assembly includes a frame extending circumferentially around the riser so that the frame moves axially with the riser. The assembly also includes a tensioner assembly connected between the working deck and the frame. The tensioner assembly has a piston, a piston chamber, and a piston rod extending from the piston and away from the piston chamber. A shroud encloses and moves in unison with the piston rod.



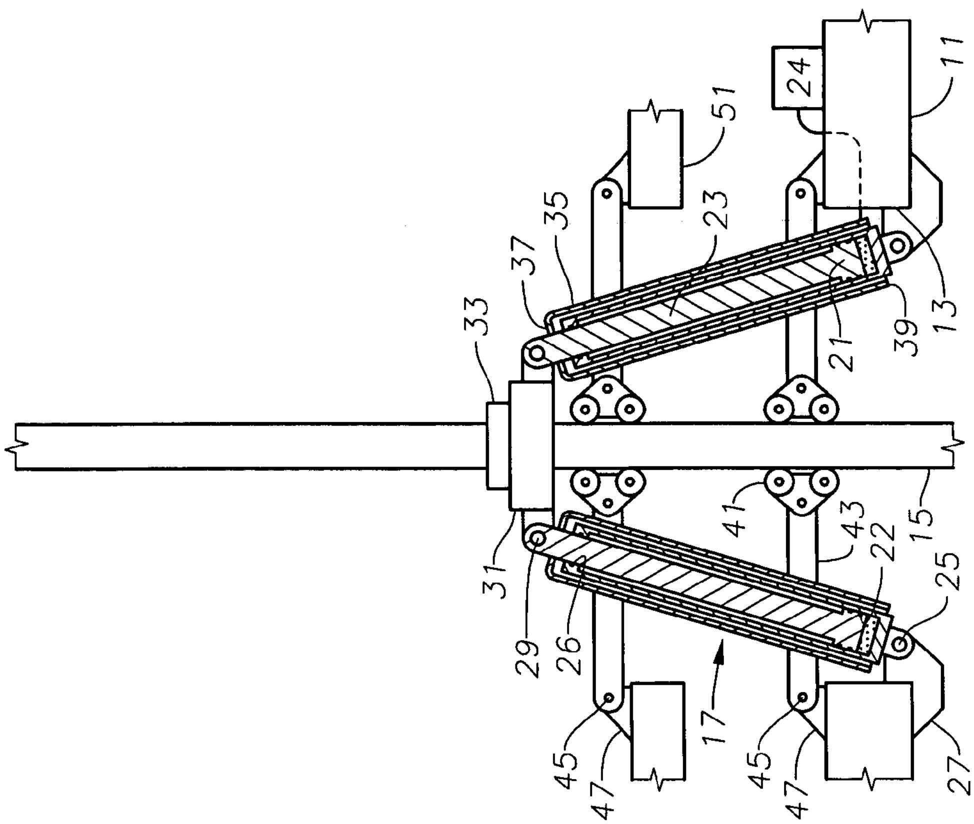

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Fig. 2

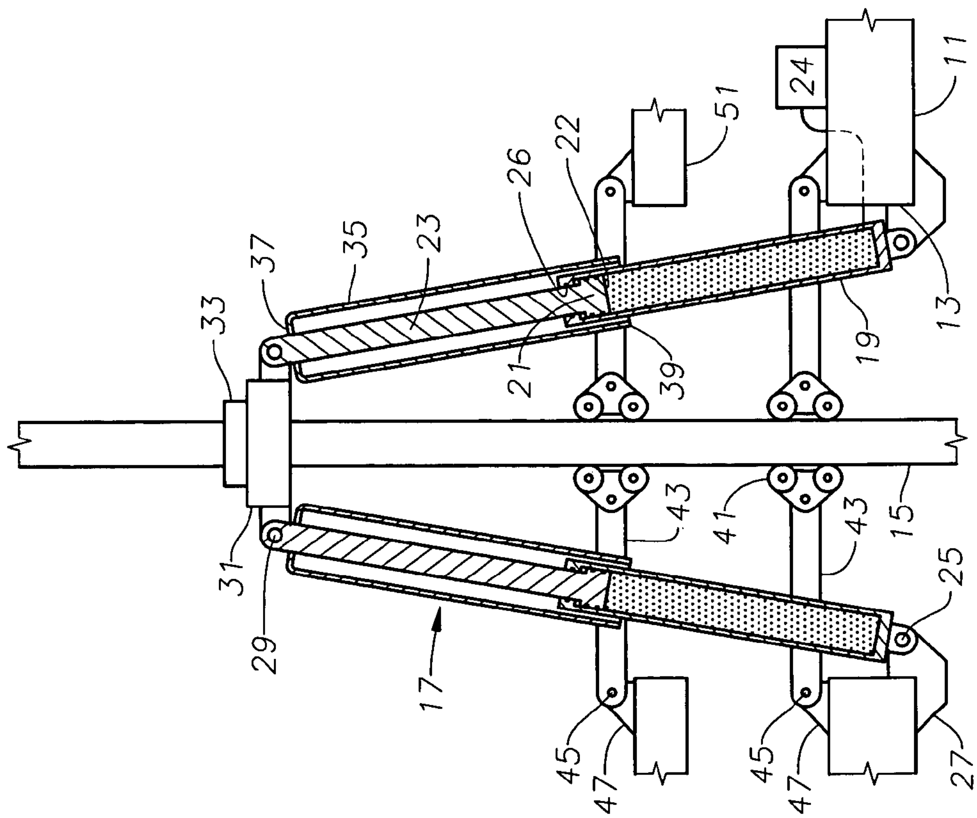
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Fig. 1

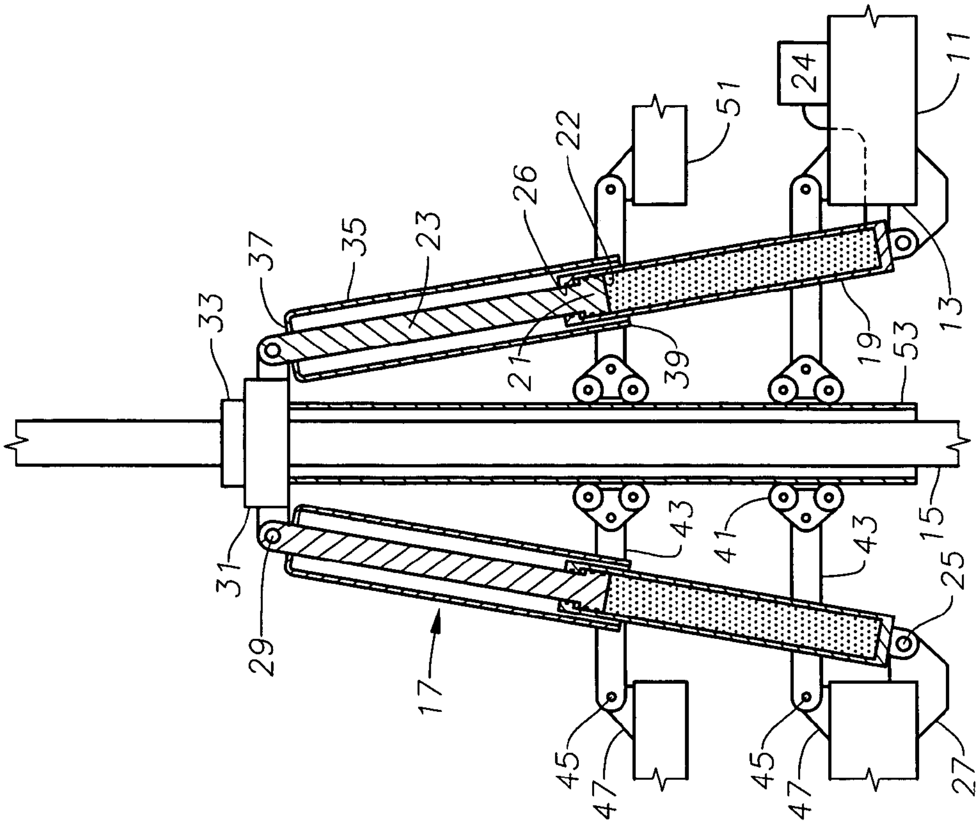

Fig. 4

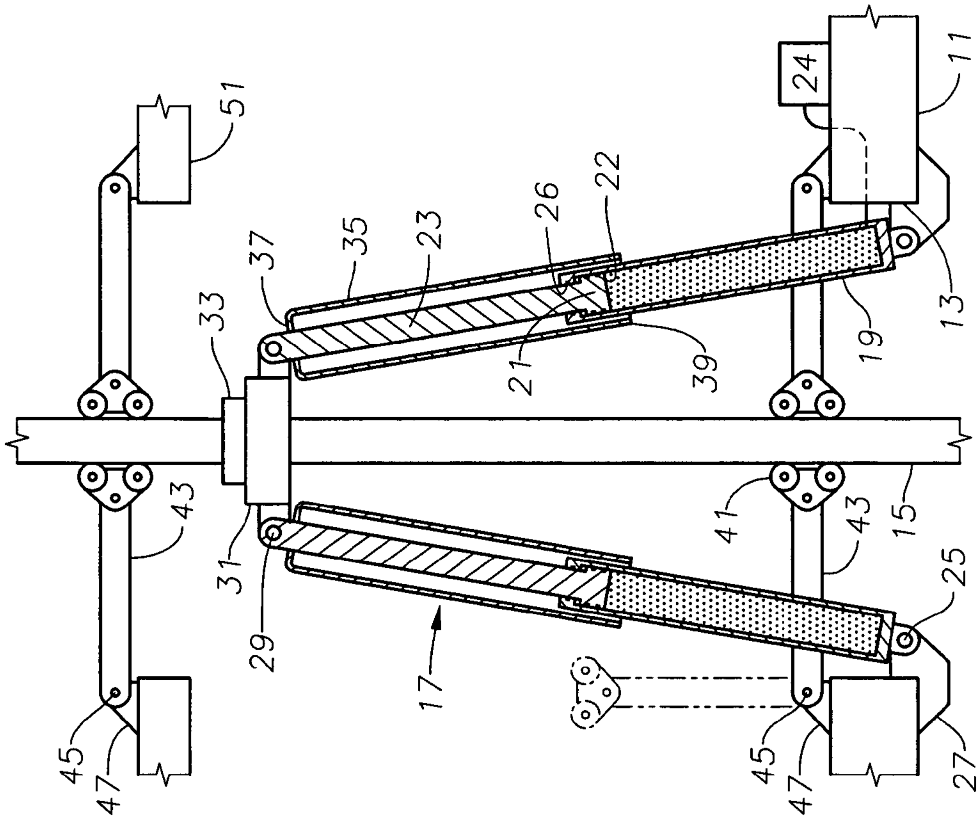

Fig. 3

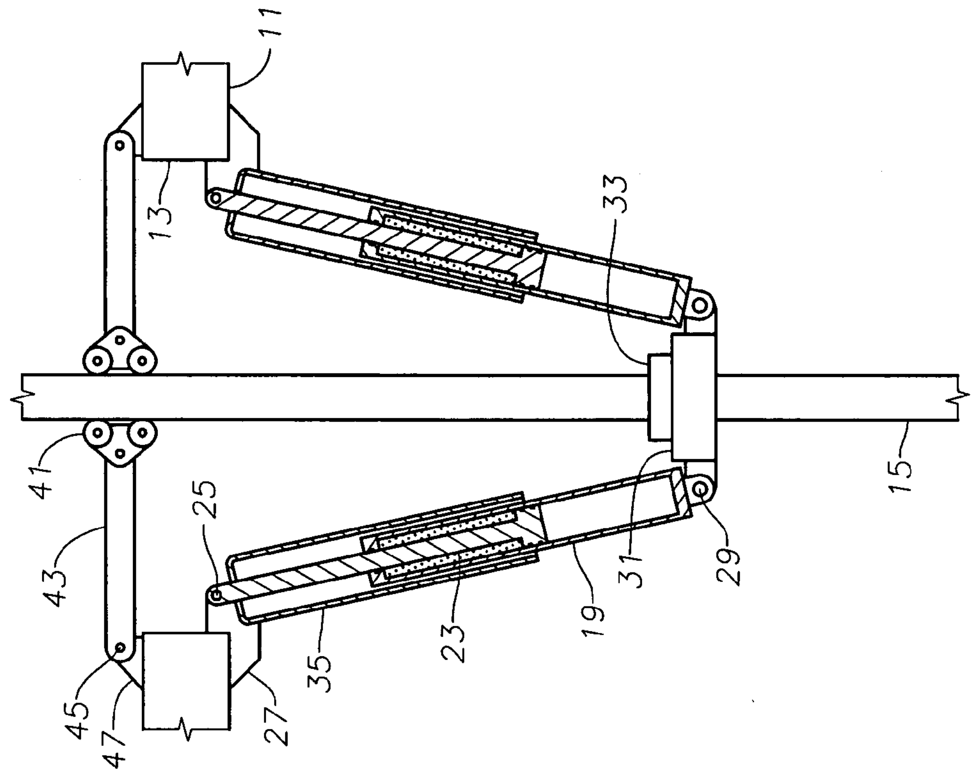
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Fig. 6

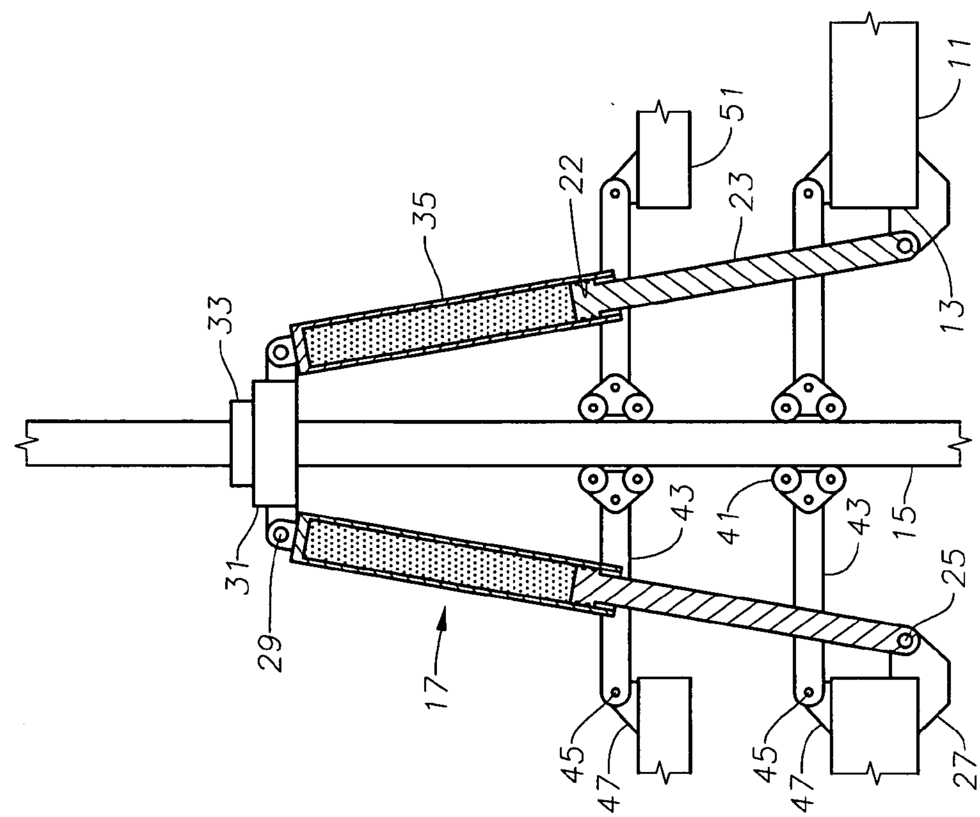
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Fig. 5

RISER TENSIONER WITH SHROUDED RODS

RELATED APPLICATIONS

[0001] This nonprovisional patent application claims the benefit of co-pending, provisional patent application U.S. Ser. No. 60/534,831, filed on Jan. 7, 2004, which is hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] This invention relates in general to hydro/pneumatic tensioners for applying tension to a riser supported from a floating platform.

[0004] 2. Background of the Invention

[0005] An offshore facility includes a riser extending to a subsea facility such as a subsea well or subsea manifold located at the sea floor. Offshore facilities that float, such as a tension leg platform, move up and down and horizontally relative to the subsea well with the oscillations of the waves and currents. It is often desirous to maintain a desired tension on the riser during these oscillating movements. Tensioners are often utilized in order to react to the movements of offshore facilities moving with the wave oscillations and currents.

[0006] Previous tensioner assemblies, like those on tension leg platforms, include a plurality of piston assemblies suspended from a deck that connect to a tension ring surrounding the riser. One type relied upon gas positioned in a chamber surrounding the piston rod to create tension. These piston assemblies are pull-type piston assemblies because they react when the piston is being pulled through the piston chamber and the fluid surrounding the piston rod is compressed. These assemblies require large piston assemblies to accommodate the necessary fluid for creating tension in reaction to the movements of the platform.

[0007] Other previous tensioner assemblies include ram style or push-type piston assemblies that have the reactive fluid on the side of the piston opposite from the piston rod. Ram style piston assemblies react when the piston is being pushed through the piston chamber. This arrangement allows for smaller piston assemblies because there is no piston rod in the chamber containing the fluid. Previous ram style assemblies are positioned vertically upward relative to the deck. This arrangement can have stability problems, especially when one of the piston assemblies fails. Moreover, in previous assemblies, the piston rod extends downward to the piston housed with the piston chamber. Therefore, drippings and debris from above often fall onto the piston rods which can damage the seals of the piston assembly. Failure and less reactive tensioning can occur when the seals are damaged.

SUMMARY OF THE INVENTION

[0008] A surface assembly that communicates with subsea structures includes a working deck on a floating structure. The working deck has an aperture extending axially therethrough. A riser extends from a subsea location to the working deck. The riser extends through the aperture. The surface assembly includes a frame extending circumferentially around the riser. The frame is connected to the riser so that the frame moves axially with the riser. The assembly also includes a tensioner assembly connected between the working deck and the frame. The tensioner assembly comprises a piston, a piston chamber, a sealing portion between the piston and the piston chamber, a piston rod extending from the piston and away from the piston chamber, and a shroud enclosing the piston rod and at least the sealing portion of the piston assembly.

[0009] In another configuration, the sealing portion is between the piston and an interior surface of the shroud. A piston chamber is defined by the sealing portion, the piston, and the shroud. The tensioner assembly can also include a cylinder. The sealing portion can then be located between the piston and the cylinder. The piston chamber is then defined by the sealing portion, the piston, and the cylinder.

[0010] The shroud typically has a closed upper end, and an open lower end that exposes a portion of its interior surface to atmospheric pressure.

[0011] The surface assembly can alternatively include a frame extending circumferentially around the riser above the working deck. The frame is connected to the riser so that the frame moves axially with the riser. The surface assembly also includes a hydraulic tensioner assembly having an end connected to the working deck and another end connected to the frame. The hydraulic tensioner assembly inclines radially inward from the deck to the frame. The hydraulic tensioner assembly can define a frame angle between the working deck and the frame. The frame angle varies as the working deck moves relative to the riser.

[0012] The surface assembly can alternatively include a tensioner assembly connected between the working deck and the frame. This tensioner assembly has a contracted positioned when the work deck moves axially downward relative to the riser. The tensioner comprises a piston, a piston rod, and a shroud surrounding a part of the piston rod while in the contracted position. The shroud has at least one end open to atmospheric pressure. The tensioner assembly can also have a retracted position when the work deck moves axially upward relative to the riser. The shroud surrounds a larger portion of the piston rod while in the retracted position than in the contracted position.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] **FIG. 1** is a schematic side view of a riser tensioner constructed in accordance with this invention and shown in a retracted or extended position.

[0014] **FIG. 2** is a schematic side view of the riser tensioner in **FIG. 1**, shown in an extended position.

[0015] **FIG. 3** is a schematic side view of an alternate embodiment of a riser tensioner in accordance with this invention and shown in an extended position.

[0016] **FIG. 4** is a schematic side view of an alternate embodiment of a riser tensioner in accordance with this invention and shown in an extended position.

[0017] **FIG. 5** is a schematic side view of an alternate embodiment of a riser tensioner in accordance with this invention and shown in an extended position.

[0018] **FIG. 6** is a schematic side view of an alternate embodiment of a riser tensioner in accordance with this invention and shown in a partially an extended position.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0019] Referring to **FIGS. 1 and 2**, a floating platform deck **11** is schematically shown. Deck **11** may, for example, be a deck of a barge, a tension leg platform, a spar or other types. However, the arrangement of **FIG. 1** is particularly suited for a spar. Deck **11** has an opening **13** through which a riser **15** extends.

[0020] Riser **15** is connected on its lower end to a subsea well. In this embodiment, riser **15** is a production riser. Typically, a production tree (not shown) is mounted to the upper end of riser **15**. Well fluids flow from the subsea wellhead of production riser **15** to the tree. Typically, the floating platform will support a number of risers **15**.

[0021] A tensioner assembly comprising a plurality of hydro/pneumatic cylinder assemblies **17** supplies tension to each riser **15** as deck **11** moves upward and downward. Two cylinder assemblies **17** are shown in **FIG. 1**, but preferably, at least two more cylinder assemblies **17** will provide tension to each riser **15**. Each cylinder assembly **17** includes a cylinder **19** and a piston **21** that strokes within cylinder **19**. Piston **21** has a rod **23** that protrudes from one end of cylinder **19**. In this embodiment, rod **23** is located on the upper end of cylinder **19** above deck **11**. A closed system of pressurized gas over fluid is utilized to provide force. The pressurized fluid and gas may be internal or external to the cylinder. Both internal and external sources may be used together. An external pressurized fluid and gas source or accumulator **24** is shown. If desired, fluid under atmospheric or low pressure may be placed in the annular space surrounding rod **23** above piston **21** to serve as lubricant for piston **21**. The lubricant may lead to a reservoir for maintaining a constant supply as piston **21** strokes up and down.

[0022] In the preferred embodiment, a plurality of seals **22** surround the circumference of piston **21**. In the embodiment shown in **FIGS. 1 and 2** seals **22** engage an interior surface of cylinder **19**. A piston chamber is defined by piston **21**, seals **22** and cylinder **19**. In the embodiment shown in **FIGS. 1 and 2**, a plurality of seals **26** also extend from cylinder **19** to sealingly engage rod **23**.

[0023] Cylinder **19** is connected on its lower end to a brace **27** by a pin **25**. In the preferred embodiment, pin **25** is spherical so as to allow pivotal rotation not only in the plane containing the drawing, but also in a Z-plane perpendicular to the plane containing the drawing. Brace **27** in this embodiment is secured to deck **11**, and the lower ends of cylinders **19** are located approximately at the same level as deck **11**.

[0024] Each cylinder assembly **17** inclines relative to riser **15** and deck **11** in the embodiment shown in **FIGS. 1 and 2**. The upper ends of rods **23** are closer to riser **15** than the lower ends of cylinders **19**. Rods **23** are secured by spherical pins **29** to a top frame **31**. Top frame **31** is mounted to a tension ring **33** that is clamped or otherwise secured to riser **15** for movement therewith. The radial distance from the axis of riser **15** to upper pins **29** is less than the radial distance from the riser axis to lower pins **25**. The angle of each cylinder assembly **17** relative to the riser **15** will change as rods **23** stroke from a retracted position as shown in **FIG. 2** to an extended position shown in **FIG. 1**. In **FIG. 2**, a wave or tidal variation has caused deck **11** to rise relative to riser **15**, causing cylinder assembly **17** to retract. In **FIG. 1**, deck **11** has moved downward from that shown in **FIG. 2** due to wave movement or tidal action. The pressurized gas over fluid **(FIG. 1)** maintains pressure on the lower side of piston **21** to cause cylinder assemblies **17** to extend.

[0025] A shroud **35** encloses the exposed portion of rod **23** of each cylinder assembly **17**. Shroud **35** is a cylindrical member having a closed upper end **37** and an open lower end **39**. Each rod **23** extends through a hole in closed end **37** that is preferably sealed to prevent corrosive fluids from contacting rod **23**. Shroud **35** protects rod **23** and seals **26** from any debris falling onto cylinder assemblies **17** from above. The length of shroud **35** is selected so that lower end **39** will be close to the lower ends of cylinders **19** while cylinder assembly **17** is fully retracted as shown in **FIG. 2**. When fully extended, as shown in **FIG. 3**, lower end **39** of each shroud **35** is spaced below the upper end of cylinder **19**. The interior of shroud **35** is at low or atmospheric pressure.

[0026] Sets of guide rollers **41** are employed to engage riser **15** and maintain riser **15** generally centralized in opening **13** but allow for angular offset of the riser relative to the platform. Although only two guide rollers **41** are shown, preferably more would be employed for each riser **15**. Each guide roller **15** is mounted to an arm **43** that is fixed in length in the preferred embodiment. Arm **43** has an outer end that is secured by a pin **45** to a lug **47**. Lug **47** mounts to deck **11** in this embodiment. Pivot pins **45** allow rods **43** to be pivoted and rotated away from deck opening **13** for other operations, such as when a larger diameter drilling riser is employed in a preliminary operation. In this embodiment, arms **43** are spaced above deck **11** only a short distance, thus provide centralizing to riser **15** at opening **13**.

[0027] An upper deck **51** is located below tensioning ring **33** and above deck **11** in this embodiment. Mounting guide rollers to deck **51** reduces any moment arm on guide rollers **41** due to the failure of a cylinder assembly **17**. Preventing angular movements are desirable during many workover and intervention operations. Preferably, pivot pins **45** allow rods **43** to be pivoted and rotated so that rollers **41** connected to upper deck **51** may be disengaged and pivoted away from riser **15**. This may be desirable during operations where angular movements are allowable, or when a larger diameter drilling riser is employed.

[0028] The embodiment of **FIG. 3** is the same as the embodiment of **FIGS. 1 and 2** except for placement of guide rollers **41** and upper deck **51**. Consequently, the same numerals will be used except for the different structure. In this embodiment, upper deck **51** is mounted above tension ring **33** and a considerable distance above deck **11**. Arms **43** for guide rollers **41** are mounted to upper deck **51**. An advantage of the embodiment of **FIG. 3** occurs if one of the cylinder assemblies **17** loses pressure. A loss in pressure causes a bending moment arm to be applied to riser **15**, which is resisted by guide rollers **41**. Because of the placement above tension ring **33**, the force applied by the moment arm is reduced over that which would exist if rollers **41** were placed as in **FIGS. 1 and 2**.

[0029] The embodiment shown in **FIG. 4** includes the use of a sleeve or conductor **53**. Conductor **53** is mounted to top frame **31** and extends concentrically around riser **15**. Conductor **53** extends downward a distance that is at least equal to the total stroke of cylinder assemblies **17**. Guide rollers **41** engage conductor **53** rather than directly engaging riser **15**. Conductor **53** provides wear protection to riser **15** due to contact with rollers **41**.

[**0030**] Referring to the embodiment shown in **FIG. 5**, cylinder assemblies **17** are inverted in this alternative embodiment. Piston **21** sealingly engages the interior surface of cylinder **19** which contains pressurized gas as in the previously discussed embodiments. Cylinder **19** has an open lower end for receiving piston **21**, but it does not sealingly engage rod **23** in this embodiment. Accordingly, the lower end of piston **21**, below seals **22** is open to atmospheric pressure. Any fluid or debris dripping onto cylinder assembly **17** from above lands on cylinder **19**, which protects the sealing region between seals **22** and the interior surface of cylinder **19**. There is no separate surrounding rods **23** in this embodiment.

[**0031**] Referring to another alternative embodiment shown in **FIG. 6**, cylinder assemblies **17** and tension ring **33** are located below deck **11**. Cylinder assemblies **17** extend downward at an angle so that the lower ends of cylinder assemblies **17** are radially inward and below the upper ends of cylinder assemblies **17**. Shroud **35** continues to protect rod **23** from any debris falling onto cylinder assemblies **17** from above. This embodiment is particularly useful for replacing tensioner assemblies on existing structures, like existing tension leg platforms, wherein the tension ring is located below the deck. In this embodiment, gas over fluid pressure acts on the annular space between rod **23** and housing **19** to pull housing **19** upward.

[**0032**] In operation of the embodiments in **FIGS. 1-5**, tension ring **33** is mounted to riser **15**, and guide rollers **41** are mounted in engagement with riser **15** or conductor **53** (**FIG. 3**). Gas pressure in cylinder **19** exerts a desired upward force on riser **15** to maintain a desired tension in riser **15**. As deck **11** moves upward relative to riser **15**, cylinder assemblies **17** retract. As deck **11** moves downward relative to riser **15**, cylinder assemblies **17** extend.

[**0033**] In each of the embodiments, seals **22** are protected from drippings and debris from above while in both the contracted and retracted positions. Moreover, in the embodiments shown in **FIGS. 1-4**, and **6**, shroud **35** also protects rod **23** and seals **26**, in addition to the sealing region located between piston **21** and the interior surface of cylinder **19**.

[**0034**] While the invention has been shown in only three of its forms, it should be apparent to those skilled in the art that it is not so limited but is susceptible to various changes without departing from the scope of the invention.

That claimed is:

1. A surface assembly for subsea wells, comprising

a working deck on a floating structure, the working deck having an aperture extending axially therethrough;

a riser extending from a subsea location to the working deck and through the aperture;

a frame extending circumferentially around the riser, the frame being connected to the riser so that the frame moves axially with the riser; and

a tensioner assembly connected between the working deck and the frame comprising a piston slidably carried in a piston chamber, a piston rod extending from the piston and away from the piston chamber, and a shroud enclosing and movable in unison with the piston rod.

2. The surface assembly of claim 1, wherein the piston chamber is sealed from the shroud.

3. The surface assembly of claim 1, wherein the interior surface of the shroud is substantially at atmospheric pressure.

4. The surface assembly of claim 1, wherein the frame is located above the working deck and the tensioner assembly inclines radially inward from the working deck to the frame.

5. The surface assembly of claim 1, wherein the shroud telescopes over the piston chamber while the tensioner assembly moves between contracted and extended positions.

6. The surface assembly of claim 1, further comprising upper and lower sets of guide rollers engaging the riser at axially spaced apart locations below the frame.

7. The surface assembly of claim 1, further comprising an upper set of guide rollers engaging the riser at an axial location above the frame, and a lower set of guide rollers engaging the riser at an axial location below the frame.

8. The surface assembly of claim 1, wherein the tensioner assembly inclines radially inward from the working deck to connect with the frame.

9. The surface assembly of claim 1, wherein an annular clearance exists between the piston rod and the shroud.

10. A surface assembly for subsea wells, comprising:

a working deck on a floating structure, the working deck having an aperture extending axially therethrough;

a riser extending from a subsea location to the working deck and through the aperture;

a frame extending circumferentially around the riser, the frame being connected to the riser so that the frame moves axially with the riser; and

a tensioner assembly connected between the working deck and the frame and inclining radially inward between the working deck and the frame, the tensioner assembly having a contracted position and an extended position, the tensioner assembly comprising a piston slidably carried in a piston chamber, a piston rod extending from the piston chamber, and a shroud surrounding at least part of the piston rod while in the contracted and extended positions position, the shroud having at least one end open to atmospheric pressure and being movable in unison with the piston, the piston chamber containing a pressurized fluid on an end of the piston opposite from the piston rod.

11. The surface assembly of claim 10, further comprising upper and lower sets of guide rollers engaging the riser at axially spaced apart locations below the frame.

12. The surface assembly of claim 10, further comprising an upper set of guide rollers engaging the riser at an axial location above the frame, and a lower set of guide rollers engaging the riser at an axial location below the frame.

13. The surface assembly of claim 11, further comprising:

a secondary deck on the floating structure, the secondary deck being spaced apart from the working deck and having a secondary aperture for the riser to extend therethrough; and

wherein the lower set of guide rollers extend from the working deck, and the upper set of guide rollers extend from the secondary deck and engage the riser at an elevation spaced apart from and above the lower roller assemblies extending from the working deck.

14. A surface assembly for subsea wells, comprising:

a working deck on a floating structure, the working deck having an aperture extending axially therethrough;

a riser extending from a subsea location to the working deck and through the aperture;

a frame extending circumferentially around the riser above the working deck, the frame being connected to the riser so that the frame moves axially with the riser;

a hydraulic tensioner assembly having an end connected to the working deck and another end connected to the frame, the hydraulic tensioner assembly inclining radially inward from the deck to the frame.

15. The surface assembly of claim 14, wherein the hydraulic tensioner assembly comprises a piston, a piston chamber, a piston rod extending from the piston out of the piston chamber, and a pressurized fluid carried in the piston chamber on an end of the piston opposite the piston rod.

16. The surface assembly of claim 14, wherein the hydraulic tensioner assembly comprises a piston, a piston chamber, a piston rod extending downward from the piston and out of the piston chamber, and a pressurized fluid carried in the piston chamber on an end of the piston opposite the piston rod.

17. The surface assembly of claim 14, wherein the hydraulic tensioner assembly comprises a piston, a piston chamber, a piston rod extending upward from the piston and out of the piston chamber, and a pressurized fluid carried in the piston chamber on an end of the piston opposite the piston rod.

18. A surface assembly for subsea wells, comprising:

a working deck on a floating structure, the working deck having an aperture extending axially therethrough;

a riser extending from a subsea location to the working deck and through the aperture;

a frame extending circumferentially around the riser above the working deck, the frame being connected to the riser so that the frame moves axially with the riser;

a tensioner assembly having an end connected to the working deck and another end connected to the frame with the tensioner assembly inclining radially inward from the deck to the frame, the tensioner comprising a piston, a piston chamber, and a piston rod extending upward from the piston and out of the piston chamber, the piston chamber containing a pressurized fluid on a lower side of the piston, and a shroud having at least one end open to atmospheric pressure enclosing and moving in unison with the piston rod and at least the sealing portion of the piston assembly; and

upper and lower sets of guide rollers engaging the riser at axially spaced apart locations below the frame.

* * * * *