

Title: Slip Joint and Method of Operating a Slip Joint

Description of Invention

The present invention relates to a slip joint and method of operating a slip joint,
5 particularly but not exclusively to a slip joint for use in a riser of drilling system
for offshore drilling, which permits fluid in the riser to be pressurised.

During drilling of a subsea wellbore, a riser is provided to return the drilling
fluid (mud), cuttings and any other solids or fluids from the wellbore to the
surface. The drill string extends down the centre of the riser, and the returning
10 drilling fluid, cuttings etc flow along the annular space in the riser around the
drill string (the riser annulus).

When drilling of the wellbore is carried out using a floating rig such as a drill
ship, a semi-submersible, floating drilling or production platform, it is known to
provide the riser with a slip joint which allows the riser to lengthen and shorten
15 as the rig moves up and down as the sea level rises and falls with the tides
and the waves. Such a slip joint is, for example, described in US 4,626,135,
and comprises an outer tube section which is connected to the wellhead, and
an inner tube section which sits within the outer tube section and which is
connected to the rig floor. Seals are provided between the outer and inner
20 tube sections, and these substantially prevent leakage of fluid from the riser
whilst allowing the inner tube section to slide relative to the outer tube section.

Conventional slip joints, such as the one disclosed in US 4,626, 135, are not
designed to retain significant pressure in the riser. Drilling methods, such as
managed pressure drilling or mud cap drilling, which involve the pressurisation
25 of fluid in the wellbore annulus are becoming increasingly important, and these
require the ability to contain fluid pressure in the riser annulus during drilling.

A prior art example of a slip joint which is specifically designed to operate at much higher operating pressures is disclosed in US 2003/0111799.

The present invention relates to an alternative configuration of high pressure slip joint.

- 5 According to the first aspect of the invention we provide a slip joint having a tubular inner barrel and a tubular outer barrel, the inner barrel lying at least partially within the outer barrel, the slip joint further comprising a sealing assembly which is operable to provide a substantially fluid tight seal between two sealing surfaces comprising an interior surface of the outer barrel and an
10 exterior surface of the inner barrel, the sealing assembly including an actuator and a seal, the actuator being movable to push the seal into engagement with one of the sealing surfaces.

- The actuator may comprise a piston which is located in a chamber in a slip joint housing, the piston being movable in response to fluid pressure in the
15 chamber, to push the seal into engagement with one of the sealing surfaces. In this case, the sealing assembly may further comprise an annular packing element which is mounted with the piston in the housing and which is arranged radially outwardly of the seal, the piston in use engaging with the annular packing element so that movement of the actuator to push the seal into
20 engagement with one of the sealing surfaces causes the annular packing element to constrict around the seal. Preferably, the annular packing element is caused to constrict around the seal by virtue engagement of the annular packing element with the housing.

- The piston may be movable generally parallel to a longitudinal axis of the inner
25 and outer barrels to push the seal into engagement with one of the sealing surfaces.

In one embodiment of the invention, the actuator is movable to push the seal into engagement with the exterior surface of the inner barrel. In this case, the actuator may be mounted in a housing on the outer barrel.

5 The slip joint may include two sealing assemblies displaced with respect to one another generally parallel to a longitudinal axis of the inner and outer barrels, both of which are operable to provide a substantially fluid tight seal between two sealing surfaces comprising an interior surface of the outer barrel and an exterior surface of the inner barrel. In this case, the sealing assemblies are preferably mounted in a housing on the outer barrel, there
10 being a fluid flow passage in the housing which provides fluid communication between the exterior of the housing and the space between the inner and outer barrels and between the two seals.

The slip joint may include three sealing assemblies displaced with respect to one another generally parallel to a longitudinal axis of the inner and outer
15 barrels, each of which are operable to provide a substantially fluid tight seal between two sealing surfaces comprising an interior surface of the outer barrel and an exterior surface of the inner barrel. In this case, the sealing assemblies are preferably mounted in a housing on the outer barrel, there being two fluid flow passages in the housing the first one of which provides
20 fluid communication between the exterior of the housing and the space between the inner and outer barrels and between the two seals of the first and second sealing assemblies, and the second one of which provides fluid communication between the exterior of the housing and the space between the inner and outer barrels and between the two seals of the second and third
25 sealing assemblies.

According to a second aspect of the invention we provide a method of operating a slip joint according to the first aspect of the invention, where provided with two sealing assemblies and one fluid flow passage, wherein the method comprises supplying fluid to the fluid flow passage at a pressure which
5 is between the pressure of fluid inside the slip joint and the pressure of fluid outside the slip joint.

The three sealing assemblies may be arranged in the order of first sealing assembly, second sealing assembly and third sealing assembly when travelling in the direction along the longitudinal axis of the slip joint towards the
10 end of the outer barrel.

According to a third aspect of the invention we provide a method of operating a slip joint according to the first aspect of the invention where provided with three sealing assemblies and two fluid flow passages, wherein the method comprises supplying fluid to the first fluid flow passage at a pressure which is
15 between the pressure of fluid inside the slip joint and the pressure of fluid outside the slip joint, and supplying fluid to the second fluid flow passage at a pressure which is less than the pressure of fluid in the first fluid flow passage, and greater than the pressure outside the slip joint.

Alternatively, the method may comprise supplying fluid to the second flow
20 passage at a pressure which is greater than the pressure inside the riser. In this case, the method may further comprise supplying fluid to the first flow passage at a pressure which is greater than the pressure inside the riser but less than the pressure at the second flow passage.

Embodiments of the invention will be described, by way of example only, with
25 reference to the accompanying figures, of which

FIGURE 1 shows a longitudinal cross-section through a first embodiment of riser slip joint according to the invention,

FIGURE 2 shows a longitudinal cross-section through a second embodiment of riser slip joint according to the invention.

Referring now to Figure 1, there is shown a riser slip joint 10 comprising an outer barrel 11a, an inner barrel 11b, and three sealing assemblies 12a, 12b, 12c. For clarity, only the elements of the first sealing assembly 12a are specifically described and numbered, and it should be appreciated that, in this example of slip joint, the second 12b and third 12c sealing assemblies are identical.

The sealing assembly 12a comprises a housing 14 which is divided into a first part 14a and a second part 14b which are fastened together using a plurality of fasteners 16. In this example, conventional stud and nut fasteners are used. Alternatively, in order to maximise the packing of the fasteners around the housing 14, nuts which are not tightened by external flats like the conventional nuts, but which are taller and which are provided with a drive hole (square/hexagonal or the like) in the top of the nut may be used, so that a tool for tightening the nut may be attached directly to the top of the nut. Cap head screws or bolts may be used instead, however.

The first part 14a of the housing 14 is connected to the outer barrel 11a, whilst the inner barrel 11b extends along a central passage through the housing 14.

The exterior surface of each housing part 14a, 14b is generally cylindrical, but the first housing part 14a is provided with a shoulder 14c which extends generally perpendicular to the longitudinal axis A of the slip joint 10 between a smaller outer diameter portion and a larger outer diameter portion, the larger outer diameter portion being between the smaller outer diameter portion and the second part 14b of the housing 14. The outer diameter of the second part 14b of the housing 14 is approximately the same as the outer diameter of the larger outer diameter portion of the first part 14a of the housing 14.

A plurality of generally cylindrical fastener receiving passages ("bolt holes") are provided in the housing 14, and in this embodiment of the invention, these extend generally parallel to the longitudinal axis A of the slip joint 10 from the shoulder 14c through the larger outer diameter portion of the first part 14a of the housing 14 into an outer wall 28 of the second part 14b of the housing 14. Preferably the portion of each bolt hole in the second part 14b of the housing 14 is threaded, so that the two parts 14a, 14b of the housing 14 may be secured together by passing a stud 16 through each of these bolt holes so that a threaded shank of each stud 16 engages with the threaded portion of the bolt hole whilst a nut 16a mounted on the free end of the stud 16 engages with the shoulder 14c.

In order to ensure that the housing 14 is substantially fluid tight, in a preferred embodiment of the invention, a sealing device is provided between the first part 14a and the second part 14b of the housing 14. This sealing device may comprise an O-ring or the like located between the adjacent end faces of the two parts 14a, 14b of the housing 14, the end faces extending generally perpendicular to the longitudinal axis A of the slip joint 10. This means that the sealing device is crushed between the two parts 14a, 14b of the housing 14 as the bolts 16 are tightened. Obtaining a good seal between the two parts 14a, 14b of the housing 14 would, however, rely on the interface being free from damage or particulate contaminates, and the crushing of the sealing device could result in damage to the sealing device. As such, in the preferred embodiment of the invention, illustrated in Figure 1, the sealing device comprises a sealing ring 17 which engages with the interior face of the housing 14, extending between the first and second parts 14a, 14b. By locating the seal device in this position, the sealing device is not subjected to loading from the bolts 16 as the bolts 16 are tightened, and installation of this configuration of sealing device is more straightforward.

An annular packing element 18 is housed in the first part 14a of the housing 14, and a hydraulic actuating piston 20 is housed in the second part 14b of

housing 14. Circular axial ports 22, 24 are provided in the first 14a and second 14b parts of the housing 14 respectively, the first part 14a of the housing 14 including an enlarged cylindrical bore 26 which extends from the port 22 to the second part 14b of the housing 14.

- 5 The second part 14b of the housing 14 includes a generally cylindrical outer wall 28, and a generally coaxial, cylindrical inner wall 30, connected by a base part 31. The piston 20 is located in the annular space between the outer wall 28 and the inner wall 30, and engages with each of the outer wall 28 and inner wall 30 so that the piston 20 divides this annular space into two chambers, and
10 prevents any substantial leakage of fluid round the piston 20 from one chamber to the other.

In this example, the piston 20 has a generally cylindrical body 20a which engages with or is very close to the inner wall 30 but which is spaced from the outer wall 28. At a lowermost end of the piston 20 (the end which is furthest
15 from the packing element 18), there is provided a sealing part 20b which extends from the lowermost end of the piston body 20a to the inner wall 30, The sealing ring 17 is also in sealing engagement with the uppermost end of the piston body 20a (the end which is closest to the packing element 18). A first fluid tight chamber 34 is therefore formed between the outer wall 28, inner
20 wall 30, base part 31 and the sealing part 20b of the piston 20, and a second fluid tight chamber 36 is formed between the outer wall 28, the sealing device 17 and the sealing part 20b and the body 20a of the piston 20.

In this embodiment of the invention, the uppermost end of the piston body 20a is provided with a cam surface 21 which extends at around 45° to the
25 longitudinal axis A of the slip joint 10, facing towards the outer barrel 11a of the riser. The cam surface 21 engages with a correspondingly angled cam surface 18a on the packing element 18.

The piston 20 is movable between a rest position in which the volume of the first chamber 34 is minimum, and an active position in which the cam surface 21 and the uppermost end of the piston 20 extend into the first part 14a of the housing 14.

- 5 A first control passage 37a is provided through the second part 14b of the housing 14 to connect the first chamber 34 with the exterior of the housing 14, and, in this embodiment of the invention, a second control passage 37b is provided through the second part 14b of the housing 14 to connect the second chamber 36 with the exterior of the housing 14. The piston 20 may thus be
10 moved to the active position towards the packing element 18 by the supply of pressurised fluid through the first control passage 37a, and to the rest position away from the packing element 18 by the supply of pressurised fluid through the second control passage 37b. It should be appreciated, however, that in an alternative design, only one control passage may be provided if there is an
15 alternative means (such as a spring) to return the piston 20 to its original position following release of fluid pressure from the one control passage.

The piston 20 is arranged such that when it is in the rest position, it does not exert any forces on the packing element 18, whereas when it is in the active position, it pushes the cam surface 21 against the packing element 18, which,
20 in turn, pushes the packing element 18 radially inwardly towards the inner barrel 11b.

The packing element 18 is made from an elastomeric material, typically a rubber. The packing element 18 may include metallic inserts or ribs to assist in maintaining its structural integrity, but this is not essential, and inserts are
25 not provided in a preferred embodiment of the invention. The action of the piston 20 forcing the packing element 18 against the cam surface causes the packing element 18 to be compressed, and to constrict, like a sphincter, reducing the diameter of its central aperture. An annular sealing part 46 is provided between the packing element 18 and the inner barrel 11b constriction

of the packing element 18 pushing the sealing part 46 against the inner barrel 11b to form a substantially fluid tight seal. The sealing part 46 thus acts to prevent flow of fluid from inside the outer barrel 11a of the slip joint 10 to the outside of the inner barrel 11b, and thus substantially prevents leakage of fluid
5 from the slip joint 10. It will be appreciated that the integrity of the seal thus provided can be improved by increasing the pressure of the fluid supplied to the first control passage 37a, as this increases the force with which the piston 20 pushes the packing element 18 against the sealing part 46. In this way, the fluid pressure containable by the sealing assembly may be increased.

10 It will be appreciated, of course, that, in use, there is sliding movement of the outer barrel 11a with respect to the inner barrel 11b of the slip joint 10 as the floating structure to which the riser extends moves with the swell of the ocean. This movement is permitted even when the sealing part 46 is pushed against the inner barrel 11b as described above. It will also be appreciated, however,
15 that this movement will cause wear of the sealing part 46 and the resulting frictional forces may also cause localised heating of the sealing part 46 and inner barrel 11b. The sealing part 46 is specifically designed to provide a good seal with reduced wear and frictional heating.

In a preferred embodiment of the invention, the sealing part is made from
20 PTFE (polytetrafluoroethylene) or a PTFE based polymer. The sealing part 46 may, instead be made from a polymer/elastomer combination such as PTFE in combination with polyurethane or hydrogenated acrylonitrile-butadiene rubber (HNBR), or PTFE in combination with ultra-high molecular weight polyethylene and polyurethane. The elastomeric component and polymeric component may
25 be fabricated as separate tubes and placed in mechanical engagement with one another, or they may be co-moulded to form a single part. The polymeric component may include a plurality of apertures, (preferably radially extending apertures), and the elastomeric component may be cast or moulded onto the polymeric component so that the elastomer extends into, and preferably
30 substantially fills these apertures.

It should be appreciated that by virtue of using an actuator to actively push the sealing part 46 against the inner barrel 11b of the slip joint 10, wear of the sealing part 46 will not immediately affect the seal integrity, since, as the sealing part 46 wears, fluid pressure in the piston chamber 34 will push the piston 20 further up relative to the housing 14, and this will, in turn, push the sealing part 46 further towards the inner barrel 11b.

In a preferred embodiment of the invention, the seal assembly components including the piston 20, the packing element 18 and the sealing part 46, or at least the portions of these components which bear on and move relative to another component may be coated with a low friction coating, for example made from Xylan, as this may assist in reducing the fluid pressure required to actuate the sealing assembly (by minimising the frictional forces between the components) and enhancing its corrosion resistance.

Whilst fluid pressure across the slip joint may be retained using only one sealing assembly, as mentioned above, in preferred embodiments of the invention, the slip joint 10 comprises a plurality of (in this example three) sealing assemblies 12a, 12b, 12c, which are co-axially aligned about a single longitudinal axis A and displaced relative to one another generally parallel to this axis A. This means that, if one of the sealing assemblies 12a, 12b, 12c fails, there are still two sealing assemblies 12a, 12b, 12c maintaining the capability of the slip joint 10 to retain fluid pressure in a riser.

The second part 14b of the housing 14 of the top sealing assembly 12a is integrally formed with the first part of the housing of the middle sealing assembly 12b (thus forming a first combined housing part 38), and the second part of the housing of the middle sealing assembly 12b is integrally formed with the first part of the housing of the bottom sealing assembly 12c (thus forming a second combined housing part 40). The housings of each sealing assembly 12a, 12b, 12c thus form a continuous central passage which

extends parallel to the longitudinal axis A of the slip joint 10 around the inner barrel 11b of the riser.

It should be appreciated that this integration of housing parts means that there are two shoulders in the exterior surface of the combined housing part 38, 40, the first of which extends between the second part 14b of the upper sealing assembly 12a and the smaller diameter portion of the first part 14a of the middle sealing assembly 12b, and the second of which extends between the second housing part of the middle sealing assembly and the smaller diameter portion of the first part of the lower sealing assembly 12c.

- 10 The housing parts of the sealing assemblies 12a, 12b, 12c are, in this example, all fastened together using nut and stud assemblies as described above in relation to the first sealing assembly 12a. The bolt holes for connecting the first combined housing part 38 to the second combined housing part 40 extend from the second shoulder in the first combined housing part 38 and into the outer wall of the second housing part of the middle sealing assembly 12b. The bolt holes for connecting the second combined housing part 40 to the second housing part of the lowermost sealing assembly 12c extend from the second shoulder in the second combined housing part 40 and into the outer wall of the second housing part of the lowermost sealing assembly 12c. The nuts thus engage with the second shoulder on each of the combined housing parts 38, 40.

In this embodiment of the invention, each of the three sealing assemblies is identical in construction and operation, although it will be appreciated that this need not be the case.

- 25 As each sealing assembly 12a, 12b, 12c is independently actuated, it is possible to choose how many sealing assemblies are activated when the slip joint is in use. For example, when the pressure in the riser is relatively low, say 200 psi or lower, the operator may choose to activate only the uppermost

12a and lowermost 12c sealing assemblies, with the middle sealing assembly 12b being kept as a spare for use only if one of the others fails.

Where the pressure in the riser is high, typically over 200 psi, it is preferably for all three sealing assemblies 12a, 12b, 12c to be used.

- 5 A first pressurisation flow passage 42 extends through the first combined housing part 38 into the cylindrical space enclosed by the housing 14 between the housing 14, the inner barrel 11b of the riser, the first sealing assembly 12a and the second sealing assembly 12b. A second pressurisation flow passage 44 extends through the second combined housing part 40 into the cylindrical
10 space between the housing 14, the inner barrel 11b of the riser, the second sealing assembly 12b and the third sealing assembly 12c. The fluid in these flow passages 42, 44 may act as a lubricant to reduce wear of the sealing parts 46.

- The provision of these pressurisation flow passages 42, 44 also means that is
15 possible for the pressure to be dropped in stages across each seal assembly 12a, 12b, 12c. For example, if the fluid pressure in the riser is 900 psi, the first pressurisation flow passage 42 may be connected to fluid at 600 psi, and the second pressurisation flow passage 44 may be connected to fluid at 300 psi. The space between the lowermost 12c and middle 12b seal assemblies is thus
20 pressurised to 300 psi, and the space between the middle 12b and uppermost seal assemblies is thus pressurised to 600 psi. This means that there is only a 300 psi pressure drop across each seal, and this may further reduce the wear on the seal and the likelihood of failure of the seal.

- Alternatively, the second pressurisation flow passage 44 may be connected to
25 fluid at a higher pressure than the riser pressure, so that clean lubricant is forced into the space between the housing 14 and the inner barrel 11b of the riser, i.e. to the seal contact zone. This may minimise the risk of drilling mud with solid contaminants entering the seal contact zone and adversely affecting

the integrity of the seals. In this case, the first pressurisation flow passage 42 is advantageously connected to fluid at an intermediate pressure - lower than the pressure at the second pressurisation flow passage 44 but higher than the riser pressure. In this way, the pressure differential across the sealing part 46
5 of the uppermost sealing assembly 12a is minimised.

In this embodiment of the invention, a further passage, hereinafter referred to as lubricant scavenging port 48 is provided in the housing. In this example, it extends through the first part 14a of the housing 14 of the uppermost sealing assembly 12a from the exterior of the housing 14 to the space between the
10 inner barrel 11b and the housing 14 above the uppermost sealing part 46. This passage can be used to monitor the leak rate from the slip joint 10 and for scavenging of lubricant or mud.

Yet another passage, hereinafter referred to as the pressure monitoring port 50, extends through the housing 14 from the exterior of the housing 14 to the
15 space between the inner barrel 11b and the housing 14 below the lowermost sealing assembly 12c. This may be used for pressure monitoring of the riser bore.

In this example, wiper seals 52a, 52b, 52c, 52d are provided in circumferential grooves around the interior surface of the housing 14. A first wiper seal 52a is
20 located above the lubricant scavenger port 48, a second wiper seal 52b is located above the first pressurisation flow passage 42, a third wiper seal 52c is located above the second pressurisation flow passage 44, and a fourth wiper seal 52d is located below the pressure monitoring port 50. Although not essential, the provision of such wiper seals 52a, 52b, 52c, 52d is
25 advantageous to minimise the ingress of contaminants or floating debris into the slip joint 10. Preferably pressure balancing ports (not shown) are provided through the housing to provide a fluid flow path across each wiper seal 52a, 52b, 52c, 52d, so that the wiper seals 52a, 52b, 52c, 52d are in a

pressure balanced configuration, i.e. so that there is no pressure differential across the seal.

Also in this embodiment of the invention, circumferential wear rings 54a, 54b, 54c, 54d are provided between the exterior of the inner barrel 11b and the interior of the housing 14. A first wear ring 54a is provided between the
5 sealing part of the uppermost sealing assembly 12a and the lubricant scavenging port 48. A second wear ring 54b is provided between the sealing part of the uppermost sealing assembly 12a and the second wiper seal 52b. A third wear ring 54c is provided between the sealing part of the middle sealing
10 assembly 12b and the third wiper seal 52c. A fourth wear ring 54d is provided between the sealing part of the lowermost sealing assembly 12c and pressure monitoring port 50.

The wear rings 54a, 54b, 54c, 54d are made from a low friction polymer, such as polyimide, PEEK, Torlon, PTFE or a material based on any of these
15 polymers, and are provided to centralise the inner barrel 11b in the slip joint 10 and to transfer bending moment through the system.

An alternative design of slip joint is illustrated in Figure 2. It will be appreciated that this design shares many similarities with the design shown in Figure 1 and described above, and, as such, the same reference numerals have been
20 used to designate the equivalent parts, but with a "1" inserted before the numerals used in relation to Figure 2. For brevity, only the significant differences between the two designs will be described below.

Main differences between the designs illustrated in Figure 1 and Figure 2 reside in the shape of the packing unit 118, piston 120 and first housing part
25 114a. The surfaces of the packing unit 118 and piston 120 which engage when the piston 120 is moved to the active position extend generally perpendicular to the longitudinal axis A of the slip joint 110. The interior surface of the first housing part 114a is curved, and the packing element 118

is provided with a similar curved portion, engagement of this curved portion of the packing element 118 with the curved portion of the first housing part 114a when the piston 120 moves to the active position, causing the packing element 118 to constrict and push the sealing part 146 into engagement with the inner
5 barrel 111b of the slip joint 110.

The sealing part 146 is also configured differently, and is much longer and thinner (radially relative to the slip joint 110) than the sealing part 46 shown in Figure 1.

The operation of this embodiment of slip joint 110 is, otherwise, identical to
10 that described above in relation to Figure 1.

When used in this specification and claims, the terms "comprises" and "comprising" and variations thereof mean that the specified features, steps or integers are included. The terms are not to be interpreted to exclude the presence of other features, steps or components.

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The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, as appropriate, may, separately, or in any
20 combination of such features, be utilised for realising the invention in diverse forms thereof.

CLAIMS

1. A slip joint having a tubular inner barrel and a tubular outer barrel, the inner barrel lying at least partially within the outer barrel, the slip joint further comprising a sealing assembly which is operable to provide a substantially
5 fluid tight seal between two sealing surfaces comprising an interior surface of the outer barrel and an exterior surface of the inner barrel, the sealing assembly including an actuator and a seal, the actuator being movable to push the seal into engagement with one of the sealing surfaces.
2. A slip joint according to claim 1 wherein the actuator comprises a piston
10 which is located in a chamber in a slip joint housing, the piston being movable in response to fluid pressure in the chamber, to push the seal into engagement with one of the sealing surfaces.
3. A slip joint according to claim 2 wherein the sealing assembly further
15 comprises an annular packing element which is mounted with the piston in the housing and which is arranged radially outwardly of the seal, the piston in use engaging with the annular packing element so that movement of the actuator to push the seal into engagement with one of the sealing surfaces causes the annular packing element to constrict around the seal.
4. A slip joint according to claim 3 wherein the annular packing element is
20 caused to constrict around the seal by virtue engagement of the annular packing element with the housing.
5. A slip joint according to any one of claims 2 to 4 wherein the piston may be movable generally parallel to a longitudinal axis of the inner and outer barrels to push the seal into engagement with one of the sealing surfaces.
- 25 6. A slip joint according to any preceding claim wherein the actuator is movable to push the seal into engagement with the exterior surface of the inner barrel.

7. A slip joint according to claim 6 wherein the actuator is mounted in a housing on the outer barrel.

8. A slip joint according to any preceding claim wherein the slip joint includes two sealing assemblies displaced with respect to one another
5 generally parallel to a longitudinal axis of the inner and outer barrels, both of which are operable to provide a substantially fluid tight seal between two sealing surfaces comprising an interior surface of the outer barrel and an exterior surface of the inner barrel.

9. A slip joint according to claim 8 wherein the sealing assemblies are
10 preferably mounted in a housing on the outer barrel, there being a fluid flow passage in the housing which provides fluid communication between the exterior of the housing and the space between the inner and outer barrels and between the two seals.

10. A slip joint according to any preceding claim wherein the slip joint
15 includes three sealing assemblies displaced with respect to one another generally parallel to a longitudinal axis of the inner and outer barrels, each of which is operable to provide a substantially fluid tight seal between two sealing surfaces comprising an interior surface of the outer barrel and an exterior surface of the inner barrel.

20 11. A slip joint according to claim 10 wherein the sealing assemblies are mounted in a housing on the outer barrel, there being two fluid flow passages in the housing the first one of which provides fluid communication between the exterior of the housing and the space between the inner and outer barrels and between the two seals of the first and second sealing assemblies, and the
25 second one of which provides fluid communication between the exterior of the housing and the space between the inner and outer barrels and between the two seals of the second and third sealing assemblies.

12. A slip joint according to claim 11 wherein the sealing assemblies are arranged in the order of first sealing assembly, second sealing assembly and third sealing assembly when travelling in the direction along the longitudinal axis of the slip joint towards the end of the outer barrel.

5 13. A method of operating a slip joint according to claim 9 wherein the method comprises supplying fluid to the fluid flow passage at a pressure which is between the pressure of fluid inside the slip joint and the pressure of fluid outside the slip joint.

10 14. A method of operating a slip joint according to claim 11 wherein the method comprises supplying fluid to the first fluid flow passage at a pressure which is between the pressure of fluid inside the slip joint and the pressure of fluid outside the slip joint, and supplying fluid to the second fluid flow passage at a pressure which is less than the pressure of fluid in the first fluid flow passage, and greater than the pressure outside the slip joint.

15 15. A method of operating a slip joint according to claim 11 wherein the method comprises supplying fluid to the second flow passage at a pressure which is greater than the pressure inside the riser.

20 16. A method of operating a slip joint according to claim 14 wherein the method comprises supplying fluid to the first flow passage at a pressure which is greater than the pressure inside the riser but less than the pressure at the second flow passage.

17. A slip joint substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

25 18. Any novel feature or novel combination of features described herein and/or in the accompanying drawings.