ABSTRACT OF THE DISCLOSURE

An improved blowout preventer in which a packing element having a resilient sealing means and a plurality of metallic translating means slidably moves against a curved inner surface of a housing for moving into a sealed position in which the packing element is positioned against but not connected to an actuating piston for increased sealing performance, freedom of movement, and for ease of replacement and in which the axial extent of the curved portion of the translating means is less than the curved outer surface of the packing element whereby the sealing means may circumferentially contact the curved inner surface of the housing to form a seal to provide an improved closing characteristic, and the bases of the translating means are further away from the bore whereby the sealing means on the bottom of the packing element is only slightly compressed allowing a fast response and quick adjustment of the packing element to changes in diameter and configuration of moved-through components of the drilling string.

BACKGROUND OF THE INVENTION

Pat. No. 3,323,773 generally describes a spherical blowout preventer having a resilient sealing means and metallic translating means for converting the axial movement of the actuating means into a rolling inward motion of the sealing means to completely seal the well hole with or without a drilling string therein. The present invention is directed to various improvements to a blowout preventer such as providing a packing element which has no connection with the actuating piston thereby providing an easy replacement of a worn packing element, providing a blowout preventer with an improved closing characteristic, one which is self-opening, and an improved packing element which provides increased sealing performance and in which the translating means does not interfere with the sealed-off objects when these are vertically moved through the closed packing element.

SUMMARY

The present invention is directed to an improved blowout preventer one feature of which is providing a housing with a curved inner surface, preferably spherical, extending to a receiving port in which the resilient means and metallic translating means slidably cooperate with the curved inner surface of the housing to move into a sealing position in which the translating means has an outer curved surface mating with the curved inner surface of the housing but of an axial extent less than the curved outer surface of the packing element and the resilient sealing means circumferentially extends below said outer curved surface of the translating means and contacts the curved inner surface of the housing to form a circumferential seal to provide an improved sealing action and to provide an improved closing characteristic especially on subsea applications.

In connection with the improved closing characteristic, a further object of the present invention is the provision of an annular space between the outer circumference of the lower portion of the sealing means and the housing in a spherical blowout preventer and outside of the actuating piston whereby the annular space increases in size as the seal is moved to a closing position thereby avoiding a fluid trap.

A further object of the present invention is the provision of a resilient sealing means bonded to a plurality of radially spaced metallic translating segments to form a packing element in a spherical blowout preventer wherein the resilient sealing means includes on its exterior a recess between adjacent segments thereby preventing interference with the metal-to-metal action of the segments on the housing as the blowout preventer closes.

A further object of the present invention is the provision of a resilient sealing means bonded to a plurality of metallic translating means having a curved portion slidably cooperating with a curved inner surface of the housing of the blowout preventer in which the translating means and resilient sealing means of the packing element are positioned against but free of a connection to an actuating piston thereby providing a structure in which the packing element may be easily replaced and the piston does not restrict the movement of the seal and in which the lower end of the translating means are arcuate thereby providing a free rocking movement of the translating means on the piston during opening and closing of the blowout preventer.

The present invention is also directed to provide a blowout preventer with an improved stripping characteristic of the packing element by allowing the resilient seal to easily and flexibly adjust to changes in the configuration of the drilling string during stripping operations while still maintaining the desired seal, all with least possible damage to the packing element.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatical view of a subsea drilling rig in which the blowout preventer of the present invention may be used.

FIG. 2 is an elevational view in cross section of the preferred embodiment of the present invention in the open and nonsealing position with a drilling string within the apparatus.

FIG. 3 is a fragmentary elevational view, partly taken in cross section along the line 3—3 of FIG. 2.

FIG. 4 is an elevational view, in cross section, illustrating the blowout preventer of the present invention in an intermediate position closing around the drilling string.

FIG. 4A is a fragmentary elevational view in cross section, illustrating the blowout preventer of the present invention in a closed position around the drilling string.

FIG. 4B is a fragmentary elevational view, in cross section, illustrating the blowout preventer of the present invention in a closed position with no drilling string therein.

FIG. 5 is a fragmentary cross-sectional view taken along the line 5—5 of FIG. 2, and

FIG. 6 is an enlarged perspective view of the metallic translating segments of the packing element.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The blowout preventer apparatus of the present invention is generally indicated by the reference numeral 10 and is shown in FIG. 1, for example only, as used in an offshore subsea drilling operation, although of course the present apparatus 10 may be used in all types of drilling rigs whether they are underwater or not.

The blowout preventer 10, as best seen in FIG. 2, may include a housing 12 including an upper portion 14 and a lower portion 16 which are releasably fastened together by a plurality of bolts 18. The bolts 18 may be easily disassembled to remove the upper housing 14 for easily re-
placing the packing element which is generally indicated by the reference numeral 19. Axially aligned well tool receiving ports 22 and 24 are provided in the upper housing 14 and the lower housing 16, respectively, for receiving a well tool or drilling string 16 adapted to be axially moved within the apparatus 10. The housing 12 and preferably the upper housing 14 includes an enlarged cylindrical bore 28 which includes a curved inner surface 30, preferably spherical, extending from the port 22.

The packing element 19 includes a resilient sealing means 20 positioned within the enlarged cylindrical bore 28 and adapted to be selectively moved between nonsealing position shown in FIG. 1 to a sealing position as shown in FIGS. 4A and 4B. The sealing means 20 may include a continuous ring of resilient material such as natural or synthetic rubber. The seal 20 includes an inner bore 32 and an outer surface 34 with the diameter of the inner bore 32 being approximately equal to the diameter of the bores 22 and 24 and the outer surface 34 including a curved portion.

The packing element 19 also includes a plurality of radially spaced translating means 36 which are provided for slidably cooperating with the curved inner housing surface 30 for converting axial motion of an actuating means such as piston 38 into a rolling inward motion of the sealing means 20 to provide a seal adjacent the well receiving port 22. Preferably, the translating means 36 are a plurality of radially spaced steel segments bonded to the resilient sealing ring 20.

Suitable actuating means are positioned in the bore 28 adjacent the lower end of the packing element 19 for applying an axial movement thereto for moving the sealing means 20 and translating means 36 toward the curved inner housing surface 30 to a closed position, and may include a piston 38. A fluid actuating line 40 is provided through the lower housing 16 to the underside of the piston 38 having an actuating head 39 and may be connected to remotely controlled fluid sources and controls (not shown) for actuating the piston 38.

Referring now to FIGS. 2, 3, 4, 4A, 4B, 5 and 6, the metallic translating means 36 generally includes a base 42, a web 44 and a curved plate 46. The outer surface 48 of the curved plate 46 is preferably a portion of a sphere and coacts with the curved inner surface 30 of the upper housing 14 to provide a low friction, metal-to-metal sliding surface during the inward closing action of the packing element 19. It is to be noted from FIGS. 2, 4A and 4B that the curved plate 46 does not extend continuously from top to bottom of the base 42 of the translating means 36 but is spaced from the base 42 thereby allowing the provision of a continuous circumferential surface 50 of resilient sealing means between the bottom of the curved plate 46 and the top of the base 42 of the translating means 36. This continuous strip of resilient material 50 forms a circumferential seal contacting the curved inner surface 30 of the upper housing 14 to form a seal therewith and is of particular importance in providing an improved closing action of the blowout preventer as will be more fully described hereinafter.

The bases 42 of the translating means 36 translate the vertical motion of the piston 38 into the inward rolling motion of the whole packing element 19 by transmitting the piston force through the web 44 and the curved plates 46. It is to be noted that the translating means 36 and sealing means 20 have no pivotal connection with piston 38 but merely rest thereon thereby providing ease of replacement of the packing element 19 merely by removal of the upper housing 14 and replacement therein. It has also to be noted that the bottom 52 of the base 42 of the translating means 36 is arctically shaped, such as cylindrically, thus allowing for the rocking movement of the translating means 36 on the head 39 of the piston 38 during the closing and opening operation. The improved stripping action of the packing element 19 results from the inward spherical motion of the translating means 36 and their location with reference to the sealing means 20. Thus a metal supported sealing is generated on the top side of the packing element 19. The bottom side of the packing element 19 is free of rigid metal and since the packing element 19 is not connected to the piston 38 the bottom side of the sealing means 20 can seal and easily and flexibly change the configuration of the drilling string during stripping operations.

Referring now to FIGS. 3 and 5, it is noted that a plurality of spaced recesses 54 are positioned around the exterior 34 of the sealing means 20 and positioned above the circumferential seal 50 and between the curved plates 46 of the translating means 36. Thus, during the closing process, when the translating means 36 move inwardly and the space or recess 54 between the curved plates 46 is diminishing in width, the resilient material does not flow between the plates 46 to become pinched off or interfere with the closing operations, but may flow inwardly between the vertical webs 44.

The packing element 19 has a self-opening capability. The force resulting from the potential energy stored in the compressed resilient sealing means 20 exerts sufficient downward pressure on the piston 38 to provide a compensating return element to the translative motion. A temporary relieved position of FIG. 1 after the control pressure in line 40 has been relieved. Thus, only a single hydraulic line 40 is required to actuate the piston 38 on land based operations. For subsea applications two hydraulic lines are required in order to balance the forces which act on the piston 38 and result from the static fluid head in the control lines. For this purpose a sealing insert 56 (FIGS. 2, 4, 4A and 4B) carrying the seals 57a, 57b and 57c is provided. Seals 57a and 57b seal-off the space above the piston and allow fluid pressure to be applied on the back side of the piston 38 through a hydraulic line 58. Seal 57c prevents sea water from entering the housing 12.

In addition to the main sealing action of the resilient sealing means 20 against the pipe 26, or open hole, as best seen in FIGS. 4A and 4B, two additional sealing actions are automatically obtained during the closing process as the force of the piston 38 is applied to close the packing element 19. One additional sealing action takes place between the resilient sealing means 20 and the top of the piston head 39 along the surface 60 and another sealing action occurs between the circumferential seal 50 and the inner curved surface 30 of the upper housing 14 along surface 62. Thus, the resilient sealing means 20 performs all of the internal sealing functions of the blowout preventer and thus the replacement of a worn-out packing element 19 does not require a disengagement or a replacement of any additional seal.

In subsea applications, the sealing area 62 formed by the upper housing 14 and the circumferential seal 50 of the resilient seal 20 determines the balance of forces which results from the static fluid head of the drilling mud within a riser pipe and the static fluid head in both control lines. The hydraulic balance of the submerged spherical blowout preventer 10 can best be seen from FIG. 2. In the open position of the apparatus 10, when the packing element 19 is exerting no sealing action the forces acting on the piston 38 in the direction opposing closing are the head of the drilling mud acting on the area A, and the head of the control fluid in the control lines acting on the piston 38.

The opposing connection with piston 38 but merely rest thereon thereby providing ease of replacement of the packing element 19 merely by removal of the upper housing 14 and replacement therein. It has also to be noted that the bottom 52 of the base 42 of the translating means 36 is arctically shaped, such as cylindrically, thus allowing for the rocking movement of the translating means 36 on the head 39 of the piston 38 during the closing and opening operation. The improved stripping action of the packing element 19 results from the inward spherical motion of the translating means 36 and their location with reference to the sealing means 20. Thus a metal supported sealing is generated on the top side of the packing element 19. The bottom side of the packing element 19 is free of rigid metal and since the packing element 19 is not connected to the piston 38 the bottom side of the sealing means 20 can seal and easily and flexibly change the configuration of the drilling string during stripping operations.

When the apparatus head is opened, as shown in FIG. 2, the forces acting upon the piston 38 are balanced since the drilling mud acting upon the area A is usually heavier than the control fluid acting on the opposite side C of the piston 38. Thus in order to start closing the packing element 19, more control pressure than on a comparable land based operation must be applied through
move between a nonsealing and a sealing position, and translating means slidably cooperating with said curved inner surface of said housing and cooperating with said sealing means for converting axial movement of an actuating means into an inward motion of said sealing means, the improvement comprising,

said translating means having an outer surface mating with the curved inner surface of said housing, said outer surface being of an axial extent less than the curved outer surface of the sealing means and being of an axial extent less than the curved inner surface of the housing.

said resilient sealing means circumferentially extends below said outer surface, the translating means and contacting the curved inner surface of the housing to form a circumferential seal with the inner surface which decreases the effective fluid pressure area of the sealing means responsive to the fluid pressure at the receiving port as the sealing means moves to the sealing position.

2. The apparatus of claim 1 wherein said translating means including a plurality of radially spaced metallic segments, and the resilient sealing means includes an exterior recess between adjacent segments positioned above said circumferential seal and of sufficient dimension to prevent flow of the resilient material between the curved outer surface of adjacent segments to interfere with closing of same.

3. In a blowout preventer adapted for use on an oil well rig, and having a housing provided with a well tool receiving port and a curved inner surface extending from the receiving port, resilient sealing means within said housing having a curved outer surface and adapted to move between a nonsealing and a sealing position, a plurality of curved metallic translating means slidably cooperating with said curved inner surface of said housing, axial movable actuating means in said housing for moving said translating means and said housing toward said curved inner surface of said housing, the improvement comprising,

said translating means including a curved outer surface mating with the curved inner surface of the housing, said curved outer surface of the translating means is of an axial extent less than the axial extent of the curved outer surface of the sealing means and of an axial extent less than the axial extent of the housing curved inner surface.

said resilient sealing means circumferentially extending below said outer curvature of the translating means to form a circumferential seal in contact with the inner surface of the housing which decreases the effective fluid pressure area of the sealing means responsive to the fluid pressure at the receiving port as the sealing means moves to the sealing position, said translating means having a base, and said base and the resilient sealing means positioned against but free of said actuating means whereby the sealing means may flexibly adjust to changes in the configuration of equipment passing through the receiving port.

4. The apparatus of claim 3 wherein said translating means including a plurality of radially spaced metallic segments, and the resilient sealing means includes an exterior recess between adjacent segments positioned above said circumferential seal and of sufficient dimension to prevent flow of the resilient material between the curved outer surface of adjacent segments to interfere with closing of same.

5. In a blowout preventer adapted for use on an oil well rig, and having a housing provided with a well tool receiving port and a curved inner surface extending from the receiving port, resilient sealing means within said housing having a curved outer surface and adapted to move between a nonsealing and a sealing position and a plurality of radially spaced metallic translating means
slidably cooperating with said curved inner surface of the housing and the sealing means for sealing, axially movable actuating means in the housing for moving the translating means and sealing means toward said curved inner surface to provide an inward motion of the sealing means, the improvement comprising, said translating means including a base, a rib extending upward therefrom, and a curved plate having an outer surface for mating with the curved inner surface of said housing, said curved plate being spaced from the base and the extent of the curved plate being less than the extent of the curved outer surface of the sealing means and being less than the extent of the curved inner surface of said housing, and said resilient sealing means circumferentially extending between the curved plate and the base and contacting the curved inner surface of the housing for forming a circumferential seal therewith which decreases the effective fluid pressure area of the sealing means responsive to the fluid pressure of the receiving port as the sealing means moves to the sealing position.

6. The apparatus of claim 5 wherein the base includes an arcuate surface in contact with but disconnected from the said actuating means.

7. The apparatus of claim 5 wherein the resilient sealing means includes an exterior recess between adjacent segments positioned above said circumferential seal and of sufficient dimension to prevent flow of the resilient material between the curved outer surface of adjacent segments to interfere with closing of same.

8. The apparatus of claim 5 including, an annular space defined by the outer circumference of the lower portion of the seal, the actuating means, the housing, the translating means, and the sealing means which increases in size as the actuating means moves the seal toward a closed position to avoid a fluid trap.

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277—73