IMPROVED VALVE

The present invention relates to valves, and in particular to an improved valve for use in wireline and wellhead control systems for the oil and gas industry. In one aspect the invention relates to an improved blow out preventer (BOP).

Specialised valves, including blow out preventers (BOPs), have been available for many decades, and provide a means for sealing the wellbore at the wellhead against well pressure if the drilling crew loses control of formation of fluids or if required to seal a wireline or logging cable during well service operations. A conventional ram type BOP is located at the wellhead, and consists of two halves of a cover for the wellbore, located on diametrically opposed sides of the wellbore. The covers consist of steel rams and elastomeric ram blocks, and are typically actuated by large diameter hydraulic cylinders located on each side of the wellbore. If a well control event occurs, the hydraulic cylinders will be remotely actuated to force the rams to enter the wellbore from either side, meeting at the centre to seal against well pressure below. Importantly, the BOP must have the ability to seal the wellbore without cutting the wireline, allowing subsequent retrieval of the toolstring.

The ram blocks will typically have cooperating, shaped surfaces to ensure alignment. The ram blocks are available in a variety of configurations, and for applications where pipe or wireline is being run in the well will be provided with a cut-out formation (typically a corresponding pair of semi-circular recesses defining a narrow throughbore) designed to allow the wireline or pipe to extend through the BOP without damage. The ram blocks will be designed such that a tight seal is formed around the pipe or wireline and around the aperture through which the rams move. The ram blocks will often be provided with a guide, such that when the rams move from an open to a closed position, the pipe or wireline is guided into the centre of the wellbore such that it is received in the cut-out formation without damage.

The rams in a typical ram BOP are self-energising, in the sense that after they are initially actuated by the hydraulics, well pressure is allowed to get behind a part of the ram, forcing it towards a closed position. The elastomeric seals of the ram blocks are U shaped in longitudinal section through the plane which the rams extend, and extend fully across the opening of the wellbore. The U-shaped seals allow the well pressure to force the seals upward and inward, such that the well pressure energises the seal and tends to keep the rams in a sealed configuration.

Other variations on the ram BOP are available, including rams designed to completely shear through pipe or wireline. In addition, some arrangements are manually operated rather than hydraulically operated. In this case, the actuators normally consist of large screws and

are rotated by use of a large handle to generate the torque required to drive the rams against the well pressure.

Presently available ram type BOPs suffer from a number of deficiencies and drawbacks. In particular, many of the drawbacks arise from the size of the apparatus. Available designs consist of a pair of rams arranged perpendicular to the wellbore, and extending on either side of the wellbore by up to 2.5 metres (around 100 inches). This has significant implications for the construction of well control apparatus at the rig. Ideally, the BOP stack would be located close to the wellhead, to maximise the height above available to accommodate the toolstring. However, in practice, it is difficult to manoeuvre the BOP stack through platforms on the rig structure. A platform on the rig structure would typically have a hole in the grating of around 24 inches diameter (depending on the diameter of pipe passing through). This opening is too small to allow a ram-type BOP to be passed through in its usual upright configuration where the hydraulic actuators are oriented horizontally. This requires the BOP to be manoeuvred carefully such that the cross-axis access is oriented vertically, allowing the BOP to be passed through the opening. This is a difficult and dangerous operation due to the size and weight of the BOP stack. A reduction in weight is limited by the need for large diameter hydraulic rams and high strength steel components.

As an alternative, the platform may be provided with a larger diameter slot to allow the passing of the BOP to be conducted more easily. However, this has implications for the health and safety of personnel working at the

platform, and may require installation railings or other barriers to prevent personnel from falling through the slots. It is therefore more usual to install the BOP stack at an elevated height above the wellhead, of in excess of 13 metres (40 feet). The consequence is that a greater overall height of well control apparatus is required, or alternatively restrictions are placed on the length of tool string available. This deficiency is particularly important for concurrent operations.

Existing BOP designs suffer from other deficiencies. These include problems with the structural strength of the ram. The ram blocks located on either side of the wellbore will typically include a recess and protrusion which cooperate to ensure that the ram blocks are appropriately aligned. The recess formed on a ram will reduce the structural strength in the ram. Moreover, the recess may in fact be formed on an outer surface of the ram, meaning that as the ram is sealing it has a portion that is unsupported. The ram is therefore "floating" rather than being fully supported by the body of the BOP. This can also result in deformation of the ram, impacting on its application to high pressure BOPs.

The arrangement of a typical ram BOP can also cause difficulties in guiding the pipe or wireline to the right part of the ram block formation (i.e. the cut-out formation). These difficulties arise in part due to the problems with keying the rams appropriately. In addition, typically the piston assembly on one side of the wellbore will be slightly looser than the opposing ram, resulting in the loose piston assembly being driven to the full extent of its travel before the opposing piston assembly begins to move. This increases the

probability of the wireline or pipe being snagged or damaged by the guiding profile. This can damage the wireline or pipe and in severe cases cause it to be sheared.

A further deficiency of typical ram-type BOPs is the time taken to actuate the rams, due to the high volume hydraulic cylinders, or worse, the time required to manually close the rams. This has safety implications.

The present applicant has identified the need for an improved valve design, and in particular an improved BOP design that differs significantly from a conventional ram type BOP.

It is a first aim of the invention to provide an apparatus suitable for sealing a bore that obviates or at least mitigates some of the drawbacks and deficiencies of available valves and/or BOPs. In particular, it is an aim of at least one aspect of the invention to provide an improved valve or BOP for sealing around a wireline, pipe, tubular or conduit in a wellbore.

It is a further aim of the invention to provide apparatus for sealing a wellbore of reduced external size, and in particular apparatus of lesser lateral dimension and reduced weight when compared with a typical ram type BOP.

A further aim of the invention is to provide apparatus for sealing a wellbore, where the apparatus has a reduced requirement for hydraulic actuation when compared with a typical ram type BOP.

Further aims and objects of the invention will become apparent from the following description.

According to a first aspect of the invention, there is provided apparatus for sealing a wellbore, the apparatus comprising a ram assembly having a pair of rams rotatably mounted in a housing and actuating means, the apparatus having a first open position in which fluid may pass through the wellbore and a second closed position in which the rams abut to seal the wellbore, wherein the apparatus is moved between the open and closed positions by rotating the rams.

In the context of this description, the word ram should not be taken to imply a linear movement of components, as with conventional ram-type BOPs. The rams and ram assemblies described herein are analogous to the rams in a conventional ram-type BOP in the sense that they move together to abut and form a seal. References to rams should be taken to mean assemblies, components, members or blocks which are moveable to a position in which they form an obstruction in the wellbore.

Preferably, the apparatus has a maximum lateral dimension of 80cm.

Preferably, the maximum lateral dimension is less than 50cm.

Preferably, the maximum lateral dimension is less than 40cm.

According to a second aspect of the invention, there is provided apparatus for sealing a wellbore around a

wireline or pipe being run in the wellbore, the apparatus comprising a ram assembly and actuating means, wherein the apparatus comprises a first position in which the wellbore is open and a second position in which the wellbore is closed, wherein the actuating means causes the ram assembly to rotate from its first open position to its second closed position in which the wellbore is sealed around the wireline or pipe.

According to a third aspect of the invention there is provided a apparatus for sealing a wellbore, the apparatus comprising a pair of rams moveable from a first position in which the wellbore is open and a second position in which the rams seal the wellbore around a wireline or pipe, characterised in that when the apparatus is in its operating orientation, the apparatus has a maximum lateral dimension which allows it to pass through an aperture in a rig platform through which the wellhead control equipment passes.

Preferably, the maximum lateral dimension is less half of the maximum lateral dimension of a ram-type BOP operating on an equivalent diameter wellbore at equivalent well pressure.

Preferably, the maximum lateral dimension is less a third of the maximum lateral dimension of a ram-type BOP operating on an equivalent diameter wellbore at equivalent well pressure.

Preferably, the maximum lateral dimension is less than 80cm.

Preferably, the maximum lateral dimension is less than 50cm.

Preferably, the maximum lateral dimension is less than 40cm.

According to a fourth aspect of the invention there is provided a apparatus for sealing a wellbore, the apparatus comprising a pair of rams moveable from a first position in which the wellbore is open and a second position in which the rams seal the wellbore around a wireline or pipe, characterised in that when the apparatus is in its operating orientation, the apparatus has a maximum lateral dimension of less than 80cm.

Preferably, the apparatus comprises a pair of rams rotatably mounted in a housing and actuating means, wherein the apparatus is moved between the open and closed positions by rotating the rams.

According to a fifth aspect of the invention, there is provided apparatus for sealing a wellbore, the apparatus comprising a ram assembly having a pair of rams, and actuating means, the apparatus having a first open position in which fluid may pass through the wellbore and a second closed position in which the rams abut to seal the wellbore, wherein the rams are moved from the first and second positions without substantially changing the volume of the actuating means exposed to well pressure.

Preferably, the apparatus comprises a pair of rams rotatably mounted in a housing and actuating means, wherein the apparatus is moved between the open and closed positions by rotating the rams.

According to a sixth aspect of the invention there is provided a blowout preventer comprising a ram assembly having a pair of rams rotatably mounted in a housing, the blowout preventer having a first open position in which fluid may pass through the wellbore and a second closed position in which the rams abut to seal the wellbore, wherein the blow out preventer is adapted to be moved between the open and closed positions by rotating the rams.

The following statements reflect optional features of any of the first to sixth aspects of the invention.

Optionally, the rams comprise formations for locating a wireline or pipe in the closed position.

Preferably, the apparatus comprises alignment means for guiding a wireline or pipe towards the centre of the wellbore during rotation of the rams.

More preferably, the apparatus comprises alignment means for guiding a wireline or pipe towards the formations during rotation of the rams.

The alignment means may be a drum adapted to rotate about the axis of rotation of a ram.

The drum may comprise a throughbore of a first diameter, through which the wireline or pipe extends.

Preferably, the throughbore defines an aperture which decreases in cross sectional area during rotation of the drum.

Preferably, the throughbore is perpendicular to the axis of rotation of the drum.

The first diameter is preferably equal to or greater than the inner diameter of the wellbore.

Preferably, a first opening of the throughbore is provided with a channel formed outwardly from an edge of the throughbore.

More preferably, a second opening of the throughbore is provided with a formation on its edge, diametrically opposed from the channel.

The formation may be a second channel formed outwardly from an edge of the throughbore, such that the first an second channels together form an aperture extending through the drum perpendicular to the axis of rotation.

The aperture may extend through the axis of rotation of the drum.

Preferably, the aperture is aligned with the formations for locating a wireline or pipe in the closed position.

Alternatively, the formation is a cutting edge adapted to shear a wireline or pipe as the apparatus moves to its closed position.

Preferably, each ram comprises a sealing assembly having one or more elastomeric seals.

More preferably, the sealing assembly comprises an inner seal adapted to cooperate with an inner seal on the opposing ram to seal against the wireline or pipe.

More preferably, the sealing assembly comprises an outer seal adapted to seal edges of the wellbore against well pressure.

Optionally, the inner seal is retained on the ram by the outer seal.

Preferably, the apparatus is hydraulically actuated.

Optionally, the apparatus is provided with a manual override mechanism.

Alternatively, the apparatus is manually actuated.

The device may comprise an actuating assembly or actuating means for selectively actuating the device. The actuating assembly may be adapted to selectively rotate the cutting members, to cut the object. The actuating assembly may comprise an actuating member coupled to the first and second cutting members, for exerting a force on the cutting members to thereby rotate the cutting members. The actuating member may be adapted to simultaneously rotate the first and second cutting members in respective opposite rotational directions, and thus to contra-rotate the cutting members. In embodiments of the invention, the actuating assembly is a hydraulic actuating assembly, where the actuating member takes the form of a piston. However, it will be understood that the actuating assembly may alternatively

be an electric, electronic, mechanical or electro-mechanical actuating assembly.

The actuating assembly may comprise a drive transfer mechanism for transferring force from the actuating member to the cutting members. The drive transfer mechanism may be adapted to convert a translational movement of the actuating member into a rotational movement of the first cutting member, and a contra-rotational movement of the second cutting member. The drive transfer mechanism may comprise first and second drive transfer couplings, each associated with a respective one of the first and second cutting members and coupled to the actuating member. The first and second drive transfer couplings, and thus the associated first and second cutting members, may be rotatable about common axes of rotation. Thus the first and second drive transfer couplings may be located coaxially. Translational movement of the actuating member may be adapted to rotate one of the first and second drive transfer couplings in a first rotational direction and the other one of the first and second drive transfer couplings in a second, opposite rotational direction. This may contra-rotate the cutting members.

The actuating mechanism may comprise a driver coupled to the actuating member and to the first and second drive transfer couplings. Translational movement of the actuating member may be transferred to the drive transfer couplings through the driver, to thereby contra-rotate the drive transfer couplings. Alternatively, the actuating member may be coupled directly to the drive transfer couplings.

The drive transfer mechanism may comprise a first drive transfer pin coupled between the driver and the first drive transfer coupling, and a second drive transfer pin coupled between the driver and the second drive transfer coupling. The first and second drive transfer pins may be coupled to the respective drive transfer couplings at points spaced from the respective drive transfer coupling axes of rotation. In this fashion, translation of the actuating member may carry the pins, rotating the drive transfer couplings about their axes of rotation. The driver may include a guide slot or channel, and the drive transfer pins may be engaged in the driver channel and coupled to the respective drive transfer coupling. The driver guide slot may be shaped such that translation of the actuating member contra-rotates the drive couplings. In embodiments of the invention, the driver guide slot comprises a slot portion disposed substantially perpendicular to an axis of the actuating member.

The first and second drive transfer couplings may be located straddling the driver, and thus the driver may be movable between the couplings. To facilitate this, the first and second drive transfer couplings may comprise respective concentrically oriented shafts, and one of the shafts may extend through an aperture in the driver for locating the drive transfer couplings straddling the driver.

The first and second drive transfer couplings may be adapted for rotation between open and closed positions corresponding to the open and closed positions of the cutting members. The drive transfer mechanism may be arranged to restrain the first and second drive transfer couplings in their respective open and closed positions.

This may ensure that the drive transfer couplings cannot move further beyond their respective open and closed positions. The first and second drive transfer couplings, and thus the first and second cutting members, may be coupled together such that movement of the drive transfer couplings beyond their open/closed positions is prevented. To achieve this, the first and second drive couplings may each comprise a curved cam track, slot, channel or the like, each of which may be adapted to receive the drive transfer pin which is connected to the other one of the drive couplings. The cam track of one of the drive transfer couplings may permit movement of the pin connected to the other one of the drive transfer couplings, and thus movement between the open and closed positions. However, the pin may be restrained against movement beyond the open and closed positions by abutment with ends of the cam track.

According to a seventh aspect of the invention there is provided a method of configuring pressure control equipment at a rig, the method comprising the steps of:

- Providing a blowout preventer at the rig, the blowout preventer comprising a pair of rams moveable from a first position in which the wellbore is open and a second position in which the rams seal the wellbore around a wireline or pipe;
- Passing the blowout preventer through an aperture in a rig platform while the blowout preventer is in its operating orientation;
- Installing the blowout preventer on the pressure control equipment.

According to a eighth aspect of the invention there is provided a method of sealing a wellbore, the method

comprising the step of rotating a pair of rams in a ram assembly from a first open position in which fluid may pass through the wellbore and a second closed position in which the rams abut to seal the wellbore.

There will now be described, by way of example only, embodiments of the invention with reference to the following drawings, of which:

Figure 1 is a front view of a blow out preventer (BOP) stack in accordance with an embodiment of the invention;

Figure 2 is a view of the BOP stack of Figure 1 from a first side, showing longitudinal section through the actuating means;

Figure 3 is a plan view of the apparatus of Figure 1;

Figure 4 is a perspective view of the embodiment of Figure 1, showing the main body of the BOP being partially transparent to display internal components;

Figure 5A is a perspective view from one side and above of the ram assembly in accordance with an embodiment of the invention, shown in its open position;

Figure 5B is a perspective view from above and one side of the ram assembly of Figure 5A, shown in its closed position;

Figure 6A is a perspective view of a ram of the embodiment of Figures 4 and 5;

Figures 6B and 6C are perspective views of an alignment drum of the embodiments of Figures 4 and 5;

Figure 6D is a perspective view of a ram key plate of the embodiment of Figures 4 and 5;

Figure 7A is a perspective view of an outer seal of a sealing assembly used with an embodiment of the invention;

Figure 7B is a perspective view of an inner seal of a sealing assembly used with an embodiment of the invention;

Figure 8A is a plan view of the ram assembly of the embodiments of Figures 4 and 5 in a fully open position;

Figure 8B is a plan view of the embodiment of Figure 5 in a partially closed position;

Figure 8C is a plan view of the ram assembly of the embodiment of Figure 5 in a partially open position;

Figure 8D is a plan view of the ram assembly of Figure 5 in a fully closed position;

Figures 9A and 9B are perspective views of an alignment drum in accordance with an alternative embodiment of the invention;

Figures 10A and 10B are perspective views of the alignment drum of Figures 9A and 9B in a ram assembly in accordance with an embodiment of the invention;

Fig. 11 is a view of part of an actuating assembly in accordance with an alternative embodiment of the invention, taken from one side and showing part of the actuating assembly in ghost outline;

Fig. 12 is a view of the actuating assembly of Fig. 11, taken from the other side;

Fig. 13 is a view of part of a further part of the actuating assembly of Fig. 11;

Fig. 14 is an enlarged view of an actuator forming part of the actuating assembly of Fig. 11;

Fig. 15 is an enlarged view of a first drive transfer coupling forming part of the actuating assembly of Fig. 11, taken from one side;

Fig. 16 is a view of the first drive transfer coupling of Fig. 15, taken from the other side;

Fig. 17 is an enlarged view of a second drive transfer coupling forming part of the actuating assembly of Fig. 11, taken from one side;

Fig. 18 is a view of the second drive transfer coupling of Fig. 17, taken from the other side;

Fig. 19 is an enlarged view of a torque sub forming part of the actuating assembly of Fig. 13, taken from one side; and

Fig. 20 is a view of the part of the torque sub of Fig. 19 shown from the other side.

Referring firstly to Figures 1 to 4, a first embodiment of the apparatus of the invention is shown, implemented as a blow out preventer (BOP) stack, generally depicted at 10. The BOP stack comprises a pair of BOPs, shown generally at 14A and 14B. The BOPs are contained within a main body 12, which contains a lower tubular 11B for connecting the apparatus to, for example, a riser, and an upper tubular section 11A for connection to, for example, a lubricator stack.

It will be appreciated that although the drawing shows a dual BOP stack, the BOP can also be used in a single, triple, or other multiple configuration.

As most clearly shown in Figure 4, the BOP stack houses an upper ram assembly 15A and a lower ram assembly 15B, housed in cylindrical cavities oriented in the Y-axis perpendicular to the main wellbore axis Z.

Actuator assemblies 16 and 18 are provided on front and rear sides of the apparatus respectively, each actuator assembly including a pair of hydraulic pistons. In this embodiment, actuator assembly 16 includes one piston 17A which functions to actuate a ram of assembly 15A, and one piston functioning to actuate a ram of assembly 15B. Similarly, actuating assembly 18 comprises pistons 19A and 19B, respectively functioning to actuate opposing

rams in ram assemblies 15A and 15B. In each case, the pistons are coupled to the rams by scotch yoke type actuators 13, although it will be appreciated that other arrangements could be adopted.

Also shown in Figures 1 to 4 are equalising spool sub-assemblies 20, located on the diagonal of the body 12. These allow the controlled release of well pressure prior to moving the ram assembly from a closed back to an open position. Figures 1 to 4 also show 3 injection ports 22 allowing fluid to be injected into the cylindrical sections of the BOP stack.

Figure 4 also shows positioning of the ram assemblies 15A and 15B. In Figure 4, both ram assemblies 15A and 15B are shown in their fully open positions. The actuation mechanism will be described in more detail below.

Figures 5A and 5B show components of the ram assembly 15A in more detail. The main body and actuators of the BOP have been removed for clarity. The ram assembly comprises a pair of rams 50, 51, an alignment drum 52, and a ram key plate 54. The individual components of the ram assembly are shown in Figures 6A to 6D.

Figure 5A shows ram assembly 15A in an open position, whereas Figure 5B shows ram assembly 15A in a closed position.

Figure 6A shows an individual ram 50, having a sealing assembly 60 mounted thereon. The ram 50 comprises a main body 62 which is formed from a cylindrical quadrant with main axis Y. In use, the ram rotates about the main cylindrical axis Y. The ram has an interior section

removed, to form a part-cylindrical seat 63 for the alignment drum of the ram assembly. The internal radius of the removed section corresponds to the radius of the alignment drum 52, and is approximately 50% of the total radius of the ram.

The part-cylindrical removed section of the ram 50 does not extend along the entire axial length of the ram. The ram comprises an end plate 64, which is received into a corresponding formation 65 in the alignment drum.

Formed in the lower edge 66 of the ram is a channel 67 extending parallel to the main axis Y of the ram assembly. The bore is semi-circular in cross section so that when the lower edge of corresponding ram 51 is placed adjacent, a circular throughbore is provided. The throughbore is arranged to have inner diameter greater or equal to the inner diameter of the wellbore.

Along an opposing, sealing edge 68 of the ram, an additional channel is formed in the main body of the ram, in the axis perpendicular to the main axis Y of the ram assembly and the channel 69 in the opposing edge. The channel is semi-circular such that when the sealing edge of the opposing ram is placed adjacent, a circular aperture (56, Figure 5B) is formed in the ram pair.

The ram is provided with a seal assembly 60 comprising an outer seal 71 and an inner seal 72. The inner and outer seal are elastomeric, and are adapted to seal against a wireline when the rams are in a closed position. It should be noted that no recess is formed in the inner seal corresponding to the aperture 56 formed in the ram pair.

Figures 6B and 6C show the alignment drum 52 from two different perspectives. The alignment drum is generally cylindrical, and has a flat end 79 with an axle 80 formed therein. The opposing end of the alignment drum has a section 65 removed. This is a quadrant of axial extent equal to the thickness of the end plate 64 on the ram, and receives the end plate of a ram when the apparatus is assembled. Members 82 are provided for engaging with a spindle of the actuating means.

The alignment drum 52 has a cross-axial bore 81 formed therein. The bore 81 is substantially circular in cross section, with diameter corresponding to the inner diameter of the wellbore. In opposing edges 83a, 83b of the cross-axial bore, channels 84a and 84b are formed, extending outwardly from the centre of the cross-axial bore. The channels 84a, 84b are formed on diametrically opposed sides of the drum, with a diameter less than that of the cross axial bore 81, but large enough to accommodate a wireline or pipe being run in the wellbore. The channels extend to a distance such that they define another cross-axial bore or aperture passing through the central axis of the alignment drum. The ends of the channels are rounded to provide a smooth surface for the wireline or pipe. The edge defined by the rim of the main bore and the rim of the channel is shaped to create a smooth, tapered path from the main bore to the channel. In this example, this is by a pair of tangents inclined to one another at around 90 degrees, with smoothed edges where they intersect the channels.

Figure 6D shows the ram key plate 54, which is formed to an outer diameter equal to that of the alignment drum 52.

The ram plate comprises a central bore 86, which receives the axle 80 of the flat end of the alignment drum 52. The plate 54 is therefore able to rotate with respect to the alignment drum. Members 87 are provided for engaging with a spindle of the actuating means. The plate is a circular disc with a quadrant removed. This quadrant corresponds to the end plate of a ram, and receives the end plate when in the ram assembly.

In its assembled state, the ram assembly is arranged such that the quadrant recess in the alignment drum 52 receives the end plate 64 of one of the rams, ram 50, such that rotation of the drum effects rotation of the ram, and vice versa. In contrast, the opposing ram 51 is able to rotate with respect to the alignment drum 52. However, the ram key plate 54, by virtue of its corresponding quadrant will cause the ram 51 to be rotated along with the ram key plate 54.

Figures 7A and 7B show components of a seal assembly used with an embodiment of the invention. The seal assembly comprises an outer seal 71 and an inner seal 73, each comprised of elastomeric materials. The outer seal 71 is U-shaped in the plane perpendicular to the sealing surface, and has a curved outer profile 75 shaped to be flush with the outer surface of the ram. Inwardly extending retaining edges 76 are provided at the prongs of the U. The inner seal 73, which in this example is a different material from the outer seal 71, is formed in a broad inverted T-shape. The lower surface 77 of the inner seal 73 abuts a supporting member on the main body of the ram, and the edges 76 of the outer seal fit onto the corners 78 of the inner seal.

The seal arrangement described above is self retaining in the sense that the outer seal secures the inner seal to the ram body. In use, when the rams are closed to seal the wellbore, the extreme force of the well pressure will tend to cause the elastomeric inner seals to stick together. In the prior art, when moving the ram assembly from a closed position in which the inner seals of opposing rams are in contact to an open position in which the rams are separated, the ram blocks will tend to remain in place in the centre of the wellbore unless they are securely fitted to the rams. It is conventional to provide metal inserts moulded in the seals to provide support for screws or bolts used to attach the seal to the ram. In the embodiment of the present invention, the outer seal provides the retention force for the inner seal, removing the requirement for screws and metal inserts. This simplifies the process for manufacturing the seals, which may be by a simple injection moulding process.

In the start position, shown in Figure 4, the pair of rams occupies the lower half of the cylindrical cavity in the BOP body. In this position, the cross axial bore of the alignment cylinder is aligned with wellbore. In addition, the bore defined by the semicircular channels 67 in the lower edges of the rams is in alignment with the main wellbore, and the rams are in an open position.

In use, with reference to Figures 1 and 4, the piston 17A is actuated, causing rotation of the scotch yoke type actuator, which is coupled to the alignment drum. This effects rotation of the alignment drum 90 degrees in an anti-clockwise sense from the perspective of Figure 1. Simultaneously, the corresponding piston 19a on the rear

face is actuated and causes rotation of the ram plate. The cooperating quadrant formation engages with the ram causing the ram to be rotated 90 degrees in a clockwise sense from the perspective of Figure 1.

After actuation, the two rams occupy the volume of the top half of the cylindrical cavity in the BOP body. In this position, the sealing edges 68 of the ram are located together. The outer seals 71 seals around the edge between the body of the cavity and the main wellbore, and the inner seals 72 seal against the wireline or pipe extending through the wellbore. The shape of the seal assembly is such that the apparatus is self-energising, as well pressure tends to force the seals upward and inwards, causing the seal to be maintained.

Figures 8A to 8D show the operation of the embodiment of Figures 5 and 6 in more detail, and in particular show the function of the alignment drum.

Figure 8A is a plan view of the ram assembly in its open position. In this position, the rams 50, 51 occupy the bottom half of the cylindrical cavity in the BOP body. The Figure shows the throughbore 81 fully aligned with the wellbore. In addition, the semi circular channels 67 formed in the lower edges of the rams provide full clearance of the rams from the wellbore. The wireline 89 extends through the bore defined by the cross axial bore in the alignment drum and the semi-circular recesses in the lower edges of the rams. In practice, the wireline is unlikely to be perfectly central in the bore.

Figure 8B shows the ram assembly partially through its rotation cycle, approximately 50% through rotation. Here, the alignment drum has rotated through around 45 degrees, and the sealing faces of the rams are inclined at approximately 90 degrees to one another. The wireline extends through the aperture defined by the bore and channels formed either side of the bore, which is now in the shape of a square, rotated though 45 degrees, with an elongate channel extending across the diagonal of the square, formed from the channels 84a and 84b and aligned with the cut-out formations in the sealing edges of the ram.

As the alignment drum continues to rotate in the direction of the arrow, the aperture in which the wireline resides becomes progressively smaller, and the wireline is guided towards the centre of the bore and the locating channels 84a, 84b. The guiding edges of the bore are shaped to provide a smooth path for the wireline. It is notable that the wireline is guided by the upper guiding edge of the bore, and by the lower guiding edge of the bore simultaneously. This is in contrast to a conventional ram-type BOP, in which the one guiding means on one of the rams moves before the other.

Figure 8C shows the ram assembly almost fully in its closed position. In this position, the rotated square aperture is no longer present, and the aperture is an elongate locating channel aligned with the cut-out formations in the sealing edges of the ram.

Figure 8D shows the ram assembly in its fully closed position.

Figures 9A and 9B show an alternative embodiment of the invention, in which the alignment drum 91 has shape different from that in the embodiment of Figures 5 and 6.

In this example, the invention is implemented as a shear and seal BOP, used when the wireline needs to be cut to release the tool string below. The shearing alignment drum shown in Figures 9A and 9B differs from the alignment drum of Figures 6A and 6B in that a locating channel 94 is only provided in one edge of the bore in the alignment drum 91, which becomes the lower edge as the drum rotates towards the closed position. This lower edge functions to guide the wireline towards the centre of the bore.

In place of the upper locating channel on the opposing edge, a rounded cutting edge 92 is formed at the intersection of guiding edges. In this example, the guiding edges are two tangents to the bore edges, inclined to one another at around 90 degrees.

Figures 10A and 10B show a ram assembly 100 including the alignment drum 91 at different stages in the rotation cycle. The wireline, guided to the centre of the bore by the lower guiding edges is met by the cutting edge 92 before the drum is fully through its rotation cycle. As the ram assembly proceeds to the fully closed position, the cutting edge shears through the wireline. The wellbore is sealed by the sealing assembly, as described above.

Figures 11 to 20 show an actuating assembly 158 in accordance with an alternative embodiment of the invention.

Figures 11 and 12 show a part of the actuating assembly 158 together with the ram assembly 15, and Figure 13 shows a part of the actuating assembly 158 together with a single ram 50. Additionally, the actuating assembly 158 is shown in the further enlarged view of Figure 14.

The actuating assembly 158 is hydraulically operated, and serves for actuating the device to contra-rotate the rams 50, 51. The actuating assembly includes a piston 160 which is mounted within a cylinder 162, and which is held captive between upper and lower retaining plates which are secured to the main housing of the BOP. The cylinder 162 is coupled to both the rams through a drive transfer mechanism 164, such that translation of the cylinder 162 rotates the rams 50 and 51 between their open and closed positions.

In more detail, the actuating assembly 158 includes a driver in the form of a shaped plate 168 which is mounted on the cylinder 162, and which is coupled to the drive transfer mechanism 164. The drive transfer mechanism 164 includes first and second drive transfer couplings in the form of a torque plate 170 which is associated with the ram 51, and a torque plate 172 which is associated with the ram 50. The torque plates 170 and 172 are shown in more detail in the further enlarged views of Figs. 15 and 16, and Figs. 17 and 18, respectively. The torque plates 170 and 172 serve for converting a translational movement of the cylinder 162 into a contra-rotational motion of the rams, as will be described below.

The torque plates 170 and 172 are coupled to the rams as follows. A torque sleeve 174, which is also shown in the

further enlarged views of Figs. 19 and 20, is coupled to the ram 51, as shown in Fig. 11. The torque sleeve 174 includes a flange 176 which extends around part of a circumference of a body 178 of the torque sleeve 174, and which has a cut-out quadrant 180, which is shaped to engage a flange quadrant provided on the ram. Engagement of the torque sleeve flange 176 with the flange quadrant on the ram permits transfer of a rotational drive force to the ram. The torque sleeve 174 carries two hub portions 184 which are shaped to engage corresponding hub portions on the torque plate 170, for securing the torque sleeve to the torque plate, and which together form a hollow shaft 188.

In a similar fashion, the ram 50 has a shaft 190 which carries hub portions 192 that are shaped to engage corresponding hub portions 194 on the second torque plate 172, for securing the inner drum 18 to the torque plate 172. The drum shaft 190, the shaft hub portions 192 and the torque plate hub portions 194 are shaped to pass through an internal bore 196 which extends through the shaft 188 and the first torque plate 170, for coupling the ram 50 to the driver plate 168.

Additionally, the drive transfer mechanism 166 includes respective first and second drive transfer pins 198 and 200, for coupling the first and second torque plates 170 and 172 to the driver plate 168. The driver plate 168 includes a main channel 202 and a cross-channel 204, and the pins 198 and 200 each engage in opposite portions adjacent ends 206 and 208 of the cross-channel 104. In this way, translation of the cylinder 162 and thus of the driver plate 168, rotates the torque plates 170 and 172.

The actuating assembly 158 is assembled as follows. The hollow shaft 188 of the ram 51 is coupled to the first torque plate 170, by engagement of the hub portions 184 and 186. The first drive pin 198 is secured in a threaded bore 210 of the torque plate 170 and is located extending through the end 206 of the driver plate cross-channel 204. The protruding end of the first drive pin 198 engages in a cam track 212 formed in the second torque plate 172. The shaft 190 of the ram 50 is then rotatably mounted within the hollow shaft 188, and extends through the driver plate main channel 202. The second drive pin 200 is secured in a threaded bore 214 of the torque plate 172, and is located extending through the driver plate cross-channel end 208 into a cam track 216 of the first torque plate 170. The torque plate 172 is then secured to the shaft 190 by engagement of the hub portions 192 and 194. The first and second torque plates 170 and 172 are thus located straddling the driver plate 168, and are coupled to the driver plate 168 by the drive pins 198 and 200. As the drive pins 198 and 200 are located off-centre from the axes of rotation 146 and 148 of the rams 50, 51, and are movable along the cross-channel 204, translation of the driver plate 168 rotates the torque plates 170 and 172, to thereby rotate the drums.

The mechanism thus operates as follows. The device 10 is initially in the open position, where the through-bore 126 is open. When it is desired to close the bore, hydraulic fluid is supplied to the cylinder 162 in a region below a lower piston face (not shown) of the piston 160, and is allowed to bleed from an area above an upper piston face (also not shown). As the piston 160 is captive, this causes the cylinder 162 to translate

downwardly relative to the main housing of the BOP. This movement of the piston carries the driver plate 168 downwardly around the shaft 90, which is received in the main channel 202. During this movement, the drive pin 198 is carried downwardly by its engagement in the cross-channel 204. The off-centre location of the pin 98 causes a corresponding rotation of the ram 51 in a first rotational direction towards its closed position, through its connection with the torque plate 170. During this movement of the driver plate 168, the pin 198 translates along the cross-channel 204 between the end 206 and the shaft 190.

Simultaneously, the pin 200 is carried downwardly by its engagement in the cross-channel 204. The off-centre location of the pin 200 causes a corresponding rotation of the ram 50 in a second, opposite rotational direction towards its closed position, through its connection with the torque plate 172. During this movement of the driver plate, the pin 200 translates along the cross-channel 204 between the end 208 and the shaft 190. The ram 51 is thus contra-rotated relative to the ram 50.

During movement of the rams 50, 51 towards their closed positions, the guides guide the wireline into the central location within the main bore, until the rams reach the sealed position. The rams 50, 51 are restrained against movement beyond their closed positions by the pin 198 abutting an end of the torque plate 172 cam track 212, and the pin 200 abutting an end of the torque plate 170 cam track 216.

If desired, the rams 50, 51 may be locked in their open or closed positions. The drums are locked in their

closed positions by locating a retaining pin (not shown) in an aperture 218 in the torque plate 172, which extends through the driver plate main channel 202 and engages in an aligned aperture 220 in the torque plate 170. In a similar fashion, the rams may be locked in their open positions by locating a retaining pin (not shown) in an aperture 222 in the torque plate 172, which extends through the driver plate main channel 202 and engages in an aligned aperture 224 in the torque plate 170.

The present invention offers numerous improvements over previously proposed valves.

Firstly, embodiments of the invention introduce a component of the movement of rams in the vertical, rather than lateral dimensions. In the embodiment described, this is achieved by using a circular movement of the rams used to close a conduit. By "wrapping around" the movement of the rams, the lateral extension of the valve components is significantly reduced.

The reduction in lateral dimensions over conventional ram-type BOPs varies according to operating pressure of the BOP and diameter of the wellbore.

For 3 inch diameter wellbore, a 10,000 PSI BOP would be expected to have a maximum lateral dimension of around 30 cm, compared with 110 cm for a conventional ram-type BOP.

For 6 inch diameter wellbore, a 10,000 PSI BOP would be expected to have a maximum lateral dimension of around 60cm, compared with 190 cm for a conventional ram-type BOP.

In another example, the largest lateral dimension of a BOP stack of the type described is less than 75 cm, compared with around 2.5 metres in an equivalent ram-type BOP.

In the example shown in Figures 1 to 3, the maximum lateral dimension, including hydraulic actuators, is around 40cm.

These dimensions are less than half, and indeed less than a third, of the dimensions of the equivalent conventional ram-type BOP.

This improves the manoeuvrability of the apparatus, and allows it to be lowered in, around and through platforms on the rig. Significantly, the BOPs may be installed much closer to the wellhead, having positive effects on the height available for the lubricator stack and the tool string.

The present invention also provides apparatus of reduced weight when compared with conventional ram-type BOPs, which further improves manoeuvrability.

In addition, the ram assembly design is significant in that the rams move from an open to a closed position without changing the volume of components at well pressure. The cylindrical cavities in which the ram assemblies are located are at well pressure when the apparatus is in its open position. When actuated, there is no requirement to force piston-connecting rods into the well volume, in contrast to the conventional ram-type BOP. This feature of conventional BOPs means that there

is a requirement to overcome well pressure, which can only be achieved by significant force.

In manually actuated BOPs this requires large screws and large levers in order for the operator to generate enough torque, and this places a huge burden on the operator. In hydraulically actuated systems, there is a requirement for large diameter cylinders, which increases the weight and size of the apparatus. During operation of the present invention, the volume swept by the rams does not change, and the result is that less force is required to actuate the rams. This means that smaller diameter hydraulic actuators can be used. In addition, manually actuated systems are more feasible using the present design. In both manually and hydraulically actuated apparatus, the time taken to close the wellbore is greatly reduced, improving the safety at the rig.

The reduced requirement for hydraulics reduces the need to provide screw locking mechanisms which are typically used in conventional ram-type BOPs to manually secure the rams in their closed configuration after actuation by the hydraulics. In the present design, the apparatus could be locked in one position by a simple peg and hole arrangement in the actuating mechanism and the main body of the BOP stack.

The manner in which the apparatus is constructed is simple, and allows simple installation and stripping down by removal of two plates on one side of the apparatus.

The construction of the apparatus allows convenient location of equalisation channels and injection channels, without conflicting with screws and fittings.

The alignment drum offers a number of advantages over conventional ram-type BOPs.

In the present embodiment, the rams are fully supported around the entire outer surface of the rams. The alignment of the wireline or pipe is not done by any component of the rams themselves, and thus compromising the strength of the rams by providing recesses on the supporting surface is not necessary.

Alignment of the wireline is by the profiles of the upper and lower edge of the cross axial bore of the drum. The alignment is therefore at two spatially separated locations on the wireline, reducing the likelihood of damage or snagging of the wireline during closing.

In addition, the movement of the guiding edges against the wireline is such that the edges move across the wire while moving a small distance along the wireline as the drum rotates. The force is therefore imparted over a short range of points, rather than being a slicing effect at a single point of the wire. This further reduces the tendency of the wireline to snag.

The movement of the alignment drum to the closed position provides two guiding edges for the wireline, moving in opposite senses, which by their nature must act in concert, as opposed to the guides in the conventional ram-type BOP which are likely to move separately, reducing their effectiveness.

References to wireline applications should not be taken as limiting. The above described apparatus is suitable

for sealing a conduit around any wireline, slickline, pipe, drill pipe, coiled tubing, tubular, umbilical or cable. Indeed, the apparatus has certain advantages for general valves, even where there is no requirement to seal around an internal line.

Various modifications and improvements may be made to the above-described embodiments within the scope of the invention herein intended.

CLAIMS

1. Apparatus for sealing a wellbore, the apparatus comprising a ram assembly having a pair of rams rotatably mounted in a housing, the apparatus having a first open position in which fluid may pass through the wellbore and a second closed position in which the rams abut to seal the wellbore, wherein the apparatus is adapted to be moved between the open and closed positions by rotating the rams.

2. Apparatus as claimed in Claim 1 wherein each ram is adapted to rotate about an axis perpendicular to a longitudinal axis of the wellbore.

3. Apparatus as claimed in Claim 1 or Claim 2 wherein the rams are adapted to be moved between the open and closed positions by rotating the rams in opposite senses.

4. Apparatus as claimed in any of Claims 1 to 3, wherein the apparatus has a maximum lateral dimension of 80 cm.

5. Apparatus as claimed in Claim 4, wherein the maximum lateral dimension is less than 50 cm.

6. Apparatus as claimed in Claim 5, wherein the maximum lateral dimension is less than 40 cm.

7. Apparatus as claimed in any preceding claim, wherein the rams comprise locating formations for locating a wireline or pipeline when in the closed position.

8. Apparatus as claimed in any preceding claim, further comprising alignment means for guiding a wireline or pipeline towards the centre of the wellbore during rotation of the rams.

9. Apparatus as claimed in Claim 8, wherein the alignment means is a drum adapted to rotate about an axis of rotation of the rams.

10. Apparatus as claimed in Claim 9, wherein the drum is keyed with one of the rams and rotates with said ram.

11. Apparatus as claimed in Claim 9 or Claim 10, wherein the drum comprises a throughbore through which the wireline or pipe extends.

12. Apparatus as claimed in Claim 11, wherein the throughbore defines an aperture extending in a longitudinal axis of the wellbore, arranged such that the aperture decreases in cross sectional area during rotation of the drum.

13. Apparatus as claimed in Claim 11 or Claim 12, wherein the throughbore is perpendicular to the axis of rotation of the drum.

14. Apparatus as claimed in any of Claims 11 to 13, wherein a first opening of the throughbore is provided with a channel formed outwardly from an edge of the throughbore.

15. Apparatus as claimed in Claims 11 to 14, wherein a second opening of the throughbore is provided with

an edge formation diametrically opposed from the channel.

16. Apparatus as claimed in Claim 15, wherein the edge formation is a second channel formed outwardly from an edge of the throughbore, such that the first and second channels together form an aperture extending through the drum perpendicular to the axis of rotation.

17. Apparatus as claimed in Claim 16, wherein the aperture extends longitudinally in the wellbore and is central in the wellbore when the apparatus is in its closed position.

18. Apparatus as claimed in any of Claims 15 to 17, wherein the edge formation is a cutting edge adapted to shear a wireline or pipe as the apparatus moves to its closed position.

19. Apparatus as claimed in any preceding claim, wherein each ram comprises a sealing assembly having one or more elastomeric seals.

20. Apparatus as claimed in Claim 19, wherein each sealing assembly comprises an inner seal adapted to cooperate with an inner seal on the opposing ram to seal against the wireline or pipe.

21. Apparatus as claimed in Claim 19 or Claim 20, wherein the sealing assembly comprises an outer seal adapted to seal edges of the wellbore against well pressure.

22. Apparatus as claimed in Claim 21, wherein the inner seal is retained on the ram by the outer seal.

23. Apparatus for sealing a wellbore around a wireline or pipe being run in the wellbore, the apparatus comprising a ram assembly and actuating means, wherein the apparatus comprises a first position in which the wellbore is open and a second position in which the wellbore is closed, wherein the actuating means is adapted to cause the ram assembly to rotate from its first open position to its second closed position in which the wellbore is sealed around the wireline or pipe.

24. Apparatus as claimed in Claim 23, the apparatus further comprising a pair of rams rotatably mounted in a housing, wherein the apparatus is adapted to be moved between the open and closed positions by rotating the rams.

25. Apparatus as claimed in Claim 23 or Claim 24, wherein the rams comprise formations for locating a wireline or pipe in the closed position.

26. Apparatus as claimed in Claim 24 or Claim 25 wherein the apparatus further comprises alignment means for guiding a wireline or pipe towards the centre of the wellbore during rotation of the rams.

27. Apparatus as claimed in Claim 26, wherein the alignment means is a drum adapted to rotate about the axis of rotation of a ram.

28. Apparatus for sealing a wellbore, the apparatus comprising a pair of rams moveable from a first position in which the wellbore is open and a second position in which the rams seal the wellbore around a wireline or pipe, characterised in that when the apparatus is in its operating orientation, the apparatus has a maximum lateral dimension which allows it to pass through an aperture in a rig platform through which the wellhead control equipment passes.

29. Apparatus as claimed in Claim 28, wherein the maximum lateral dimension is less than half of the maximum lateral dimension of a ram-type BOP operating on an equivalent diameter wellbore at equivalent well pressure.

30. Apparatus as claimed in Claim 29, wherein the maximum lateral dimension is less a third of the maximum lateral dimension of a ram-type BOP operating on an equivalent diameter wellbore at equivalent well pressure.

31. Apparatus as claimed in any of Claims 28 to 30, wherein the maximum lateral dimension is less than 80 cm.

32. Apparatus as claimed in Claim 31, wherein the maximum lateral dimension is less than 50 cm.

33. Apparatus as claimed in Claim 32, wherein the maximum lateral dimension is less than 40 cm.

34. Apparatus as claimed in any of Claims 28 to 33, wherein the rams are rotatably mounted in a housing and the apparatus is adapted to be moved between the open and closed positions by rotating the rams.

35. Apparatus as claimed in Claim 34, wherein the rams comprise formations for locating a wireline or pipe in the closed position.

36. Apparatus as claimed in Claim 34 or Claim 35, wherein the apparatus further comprises alignment means for guiding a wireline or pipe towards the centre of the wellbore during rotation of the rams.

37. Apparatus as claimed in Claim 34 or Claim 35, wherein the alignment means is a drum adapted to rotate about the axis of rotation of a ram.

38. Apparatus for sealing a wellbore, the apparatus comprising a pair of rams moveable from a first position in which the wellbore is open and a second position in which the rams seal the wellbore around a wireline or pipe, characterised in that when the apparatus is in its operating orientation, the apparatus has a maximum lateral dimension of less than 80 cm.

39. Apparatus as claimed in Claim 38, wherein the rams comprise formations for locating a wireline or pipe in the closed position.

40. Apparatus as claimed in Claim 38 or Claim 39, wherein the apparatus further comprises alignment

means for guiding a wireline or pipe towards the centre of the wellbore during rotation of the rams.

41. Apparatus as claimed in Claim 40, wherein the alignment means is a drum adapted to rotate about the axis of rotation of a ram.

42. Apparatus for sealing a wellbore, the apparatus comprising a ram assembly having a pair of rams, and actuating means, the apparatus having a first open position in which fluid may pass through the wellbore and a second closed position in which the rams abut to seal the wellbore, wherein the rams are adapted to be moved from the first and second positions without substantially changing the volume of the actuating means exposed to well pressure.

43. Apparatus as claimed in Claim 42, wherein the rams are rotatably mounted in a housing and, wherein the apparatus is adapted to be moved between the open and closed positions by rotating the rams.

44. Apparatus as claimed in Claim 42 or Claim 43, wherein the rams comprise formations for locating a wireline or pipe in the closed position.

45. Apparatus as claimed in any of Claim 42 to 44, wherein the apparatus further comprises alignment means for guiding a wireline or pipe towards the centre of the wellbore during rotation of the rams.

46. Apparatus as claimed in Claim 45, wherein the alignment means is a drum adapted to rotate about the axis of rotation of a ram.

47. A blowout preventer comprising a ram assembly having a pair of rams rotatably mounted in a housing, the blowout preventer having a first open position in which fluid may pass through the wellbore and a second closed position in which the rams abut to seal the wellbore, wherein the blow out preventer is adapted to be moved between the open and closed positions by rotating the rams.

48. A method of configuring pressure control equipment at a rig, the method comprising the steps of:

- Providing a blowout preventer at the rig, the blowout preventer comprising a pair of rams moveable from a first position in which the wellbore is open and a second position in which the rams seal the wellbore around a wireline or pipe;
- Passing the blowout preventer through an aperture in a rig platform while the blowout preventer is in its operating orientation;
- Installing the blowout preventer on the pressure control equipment.

49. A method of sealing a wellbore, the method comprising the step of rotating a pair of rams in a ram assembly from a first open position in which fluid may pass through the wellbore and a second closed position in which the rams abut to seal the wellbore.

50. The method as claimed in Claim 49 wherein each ram is rotated about an axis perpendicular to a longitudinal axis of the wellbore.

51. The method of Claim 49 or Claim 50 wherein the rams are rotated in opposite senses.

52. The method of any of Claims 48 to 51 comprising the additional step of guiding a wireline or pipe towards the centre of the wellbore during rotation of the rams.

53. The method of any of Claims 48 to 52 comprising the additional step of sealing the wellbore around a wireline or pipe.

54. The method of any of Claims 48 to 53 comprising the additional step of shearing a wireline or pipe being run in the wellbore.