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[54] HYDRAULICALLY OPERATED DIVERTER

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[51] **Int. Cl.** **F16k 11/00**

[58] **Field of Search** 137/625.44, 609, 610, 608; 251/62, 63.4, 77, 298, 303; 166/.6, 70

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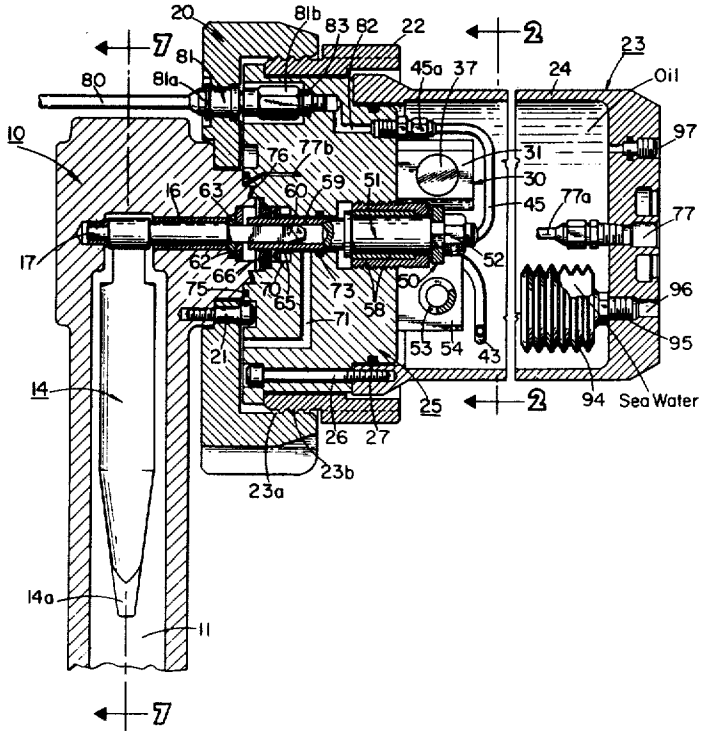
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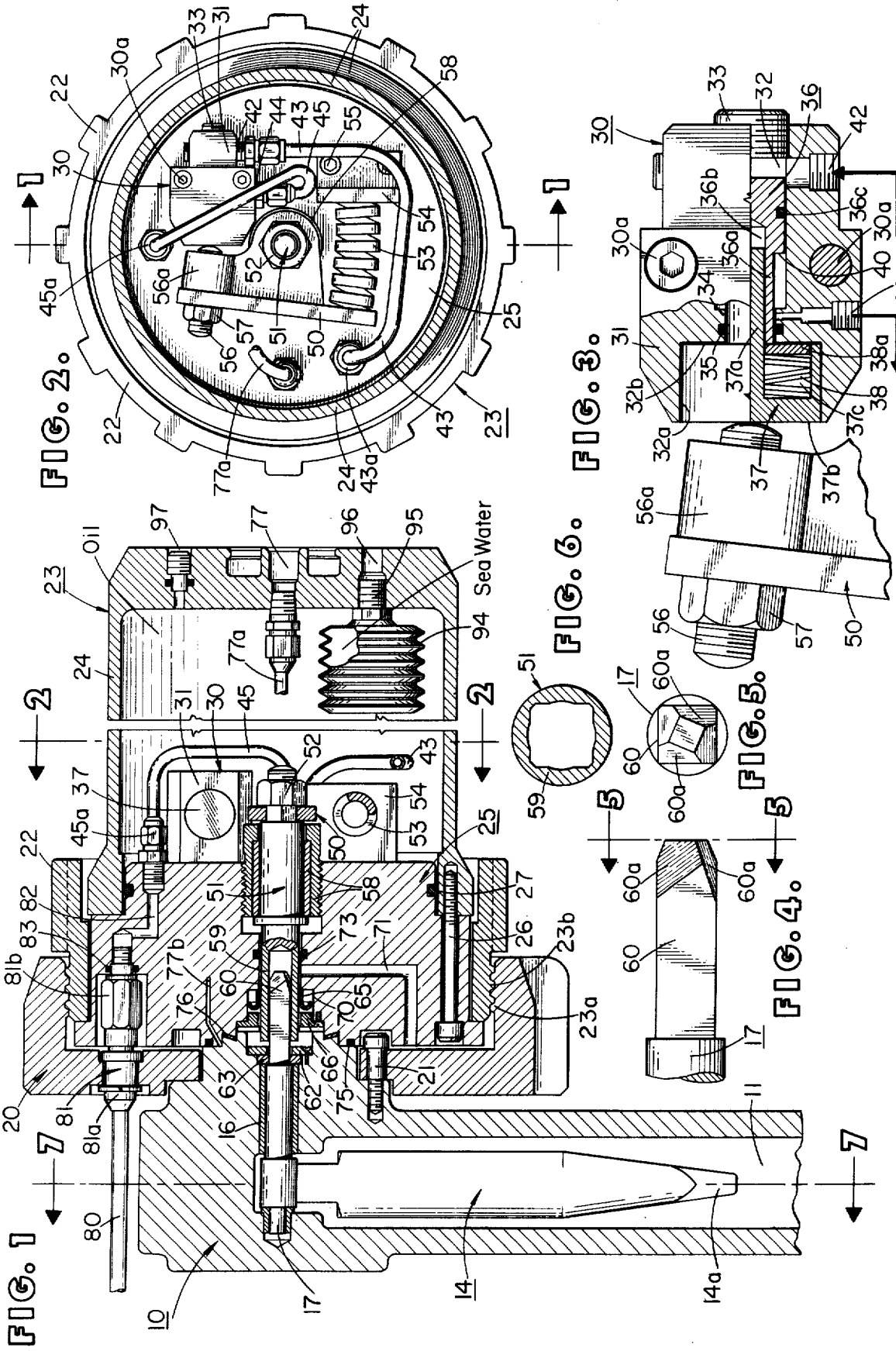
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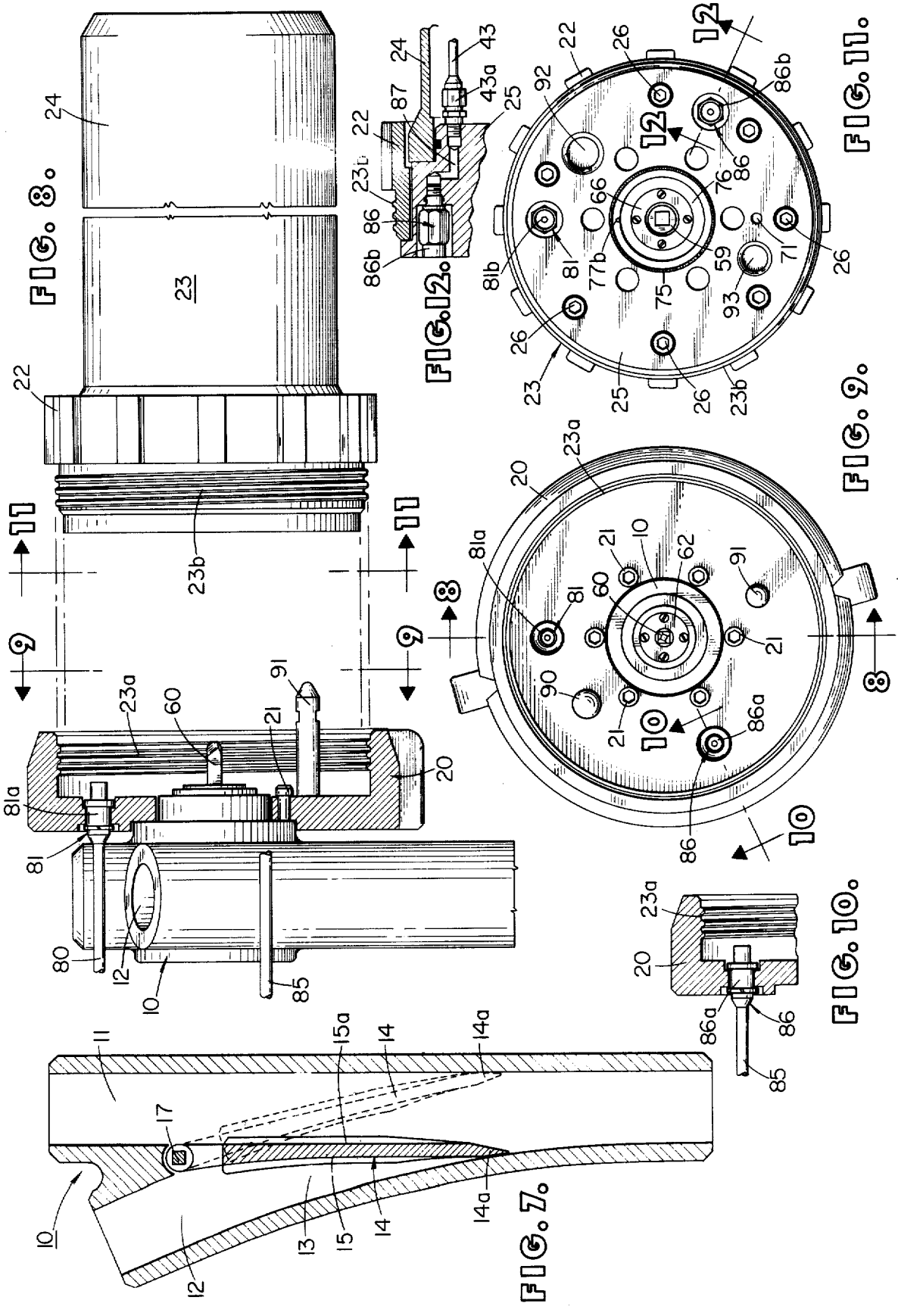
[57] **ABSTRACT**

A hydraulically operated diverter for use subsea in directing "pumpdown" or through-flow-line (TFL) tools through wye-branched flow passageways formed in a diverter body member located on submerged wellheads. In the diverter body member a paddle is hinged to a shaft at the junction of the wye-branched flow passageways for alternately diverting tools through one and the other of such passageways. A removable and replaceable paddle operator assembly, which when in operating position sealingly engages the diverter body member, contains a hydraulic piston assembly which causes a shaft, nonrotatably connected to the paddle, to rotate the paddle against the bias of a spring from one of its diverting positions in which it is normally maintained by the spring to the other of its diverting positions. The operator assembly is removable and replaceable by means of a subsea manipulator. Means are provided for testing the seals used in sealing the operator assembly to the diverter body member. The diverter shaft is configured so as to ensure its proper connection to an operator assembly shaft with which it engages. The piston assembly is designed to prevent overstressing of the diverter shaft and paddle and to limit the side load on the operator shaft bearing.

20 Claims, 12 Drawing Figures




FIG. 1
FIG. 2
FIG. 3
FIG. 4
FIG. 5
FIG. 6
Oil
Sea Water


FIG. 8.
FIG. 12.
FIG. 11.
FIG. 9.
FIG. 10.
FIG. 7.

HYDRAULICALLY OPERATED DIVERTER

BACKGROUND OF THE INVENTION

1. Field of the Invention.

The present invention concerns hydraulically operated diverters for directing the flow of tools used in conducting various operations on remotely located oil and/or gas wells, particularly those located subsea.

2. Description of the Prior Art.

In performing completion and workover operations in subsea wells, tools are moved hydraulically into and out of the well tubings through large radius flowline loops mounted on the submerged wells. In one preferred subsea production system one pair of pumpdown headers services several wells. Each well tubing is provided with wye-branched flow passageways to permit the conduct of operations either through a vertical conduit or through loops. Hydraulically operated tool diverters are required at each of the wells to enable selectively deflecting tools into the desired wells. One type of hydraulically operated TFL tool diverter designed to so direct passage of the TFL tools is shown and described in a paper by Drouin and Fowler entitled "Diverters for TFL Tools" presented at the ASME Petroleum mechanical Engineering Conference, Tulsa, Oklahoma, September, 1969. The hydraulically operated diverter of the invention described and claimed herein is an improvement in that type diverter. Maintenance of such diverters and operators have been provided for in the design of the system. An analysis of hydraulically operated type diverters has shown that failures would occur principally in the operator mechanism and in the diverter shaft seal. Thus, the present invention is directed to an improved hydraulically operated diverter and, particularly, such a diverter having a removable and replaceable operator and shaft seal.

SUMMARY OF THE INVENTION

In accordance with the teachings of this invention a diverter paddle pivots on a rotatable shaft at the junction of branched passageways formed in a diverter body member in a wye pattern for diverting flow through either of the branched passageways. A diverter shaft is non-rotatably connected to the paddle. The diverter shaft is connected to an operator assembly through an operator shaft. The operator assembly causes the diverter shaft to rotate to move the paddle from one position which diverts flow through one of the branched passageways to another position which diverts flow through the other branched passageway. A hydraulically operated piston operates to move the paddle from its one to its other position against the bias of a spring. Spring or resilient means associated with the piston prevents over-stress of the paddle and overstressing of the shaft and, in addition, limits the sideload on the operator shaft bearing and seal. The operator assembly is sealingly connectable to the diverter body member and removable therefrom and replaceable thereon.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partial vertical section through the diverter of the invention and its operating mechanism;

FIG. 2 is a view taken along lines 2—2 of FIG. 1:

FIG. 3 is an enlarged, partly sectional view, of a portion of FIG. 2;

FIG. 4 is an enlarged view of the operator shaft shown in FIG. 1;

FIG. 5 is a view taken along lines 5—5 of FIG. 4;

FIG. 6 is an enlarged view of the operator shaft socket shown in FIG. 1;

FIG. 7 is a view taken along lines 7—7 of FIG. 1;

FIG. 8 is a vertical and exploded view of the diverter and its operating mechanism;

FIG. 9 is a view taken along lines 9—9 of FIG. 8;

FIG. 10 is a view taken along lines 10—10 of FIG. 9:

FIG. 11 is a view taken along lines 11—11 of FIG. 8; and

FIG. 12 is a view taken along lines 12—12 of FIG. 11.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, and particularly to FIGS. 1 and 7, there is shown a wye section or diverter body 10 having a vertical bore 11 and a curved bore 12 which forms a smooth internal transition 13 to a loop section, not shown. A diverter paddle 14 is shaped to conform to curved bore 12 on its one side, as at 15, and to vertical bore 11 on its other side, as at 15a. The free end 14a of paddle 14 is tapered on both sides and engages the inner bore wall of the wye in each of its two positions. Paddle 14 is non-rotatably mounted on one end of a shaft 17 which extends through the wall of diverter body 10 at the junction of bores 11 and 12. Shaft 17 serves as the axis of rotation for the paddle.

Diverter body 10 is connected to a threaded receiver flange 20 by threaded bolts 21. A threaded lock ring 22 is rotatably mounted on an operator assembly 23 and is threadedly connectable to receiver flange 20. Operator assembly 23 includes a housing 24 secured to a closure plate 25 at one end by threaded bolts 26. O-ring 27 seals off the connecting inner surface of housing 24 and outer surface of closure plate 25.

A small hydraulic piston assembly, generally designated 30, is secured to the inner wall of closure plate 25 by threaded bolts 30a. Housing 31 of assembly 30 defines a cylindrical chamber 32 closed at the rear end of housing 31 by a plug 33, which forms at the forward end of housing 31 an enlarged cylindrical chamber 32*a*. An inwardly projecting annular shoulder 34 formed on the wall of chamber 32 is provided with an annular seal ring 35. A piston head 36 provided with a forward hollow section 36*a* of reduced diameter is slidably arranged in chamber 32. Section 36*a* projects through the bore of shoulder 34 and sealingly engages seal ring 35. A cup-shaped piston member 37 is slidably arranged in chamber 32*a*. Piston member 37 is provided with a rearwardly projecting rod section 37*a* which slidingly extends into the bore 36*b* of hollow section 36*a* of piston head 36. The forward end 37*b* of cup-shaped member 37 is closed to form an annular chamber 37*c* which contains a bellville-type spring 38. A retainer ring 38*a* confines spring 38 and abuts against the forward end of piston head section 36*a*. An O-ring seal 36*c* provides a seal between the outer periphery of piston head 36 and the wall of chamber 32. As seen in FIG. 3, cup-shaped piston member 37, in its fully retracted position, and retainer ring 38*a* abut the rear wall 32*b* of chamber 32*a*. The arrangement as shown allows relative longitudinal movement between the two piston members 36 and 37. A shoulder 40 of piston head 36 bottoms out on shoulder 34 to limit piston travel and to provide a static seal as a backup to spring

seal 36c. A port 42 formed in housing 31 fluidly communicates chamber 32 behind piston head 36 to a closed hydraulic power fluid system, not shown, through a power fluid line 43, a connection 43a, a passageway 87, a poppet valve connector 86 and a conduit 85. Poppet valve 86 includes a female portion 86b attached to closure plate 25 and a male portion 86a attached to receiver flange 20 (see FIGS. 9, 10, 11 and 12). Also, a port 44 fluidly communicates chamber 32, ahead of piston head 36, with a closed ambient pressure reservoir system (not shown) through a fluid conduit 45, a threaded connection 45a, a passageway 82 in closure plate 25, a poppet connector 81 and a conduit 80. Poppet connector 81 includes a female portion 81b attached to closure plate 25 and a male portion 81a attached to receiver flange 20. An O-ring 83 seals off the connection between portion 81b and closure plate 25.

A cam arm 50 is non-rotatably attached to a stem extension 51 of shaft 17 by a nut 52. One end of cam arm 50 is connected to one end of a spring 53. The other end of spring 53 is secured to a plate member 54 which is bolted to closure plate 25 by bolts 55. The other end of cam arm 50 is threadedly attached by hub 56a to a member 56 which is urged by spring 53 against the face 37b of piston member 37. A lock nut 57 is threaded on member 56. This arrangement allows adjustment to vary the distance between hub 56a and the face 37b of piston member 37.

Stem extension 51 extends through closure plate 25. One end is mounted for rotation within a support bearing 58 threaded to closure plate 25. The other end of stem extension 51 forms a socket 59 for receiving the other end 60 of shaft 17. The interior cross-section of socket 59 is configured the same as the cross-section of shaft end 60, as also shown in FIGS. 4, 5 and 6. Such configuration is illustrated herein as square; however other suitable shapes may be used. The cross-section of the tip of shaft end 60 is reduced and configured as at 60a so that socket 59 will pick up shaft 17 regardless of its rotational position. A sleeve bushing 61 surrounds a portion of shaft 17 and a plate member 62 confines a retainer ring 63 against bushing 61. A J-shaped pressure seal 65 retained in place by a plate member 66 provides a pressure seal between socket 59 and closure plate inner wall 70. Any other suitable stem pressure seal may be used. A bleeder passageway 71 is positioned in closure plate 25 and communicates with the bore between O-ring seal 73 and J-seal 65 to prevent fluids which may escape by shaft seal 65 from contaminating the closed hydraulic system. Any fluids that may escape past seal 65 will leak out between the coarse acme threads 23a and 23b. An annular O-ring seal 75 on the face of closure plate 25 enables a manipulator, not shown, to test the metal-to-metal ring seal 76 located between closure plate 25 and body 10. Test pressure is applied by the manipulator through a port 77 in housing 24 and fluid pressure line 77a connected thereto and a passageway 77b in closure plate 25 to which line 77a is connected.

A diaphragm member or bellows 94 is connected into a passageway 96 in the rear wall of housing 24 by means of a threaded connector 95. The interior of housing 24 is filled with oil through plugged opening 97. The interior of the bellows is open to ambient sea pressure (as is the aforementioned fluid reservoir system) and pressure is equalized inside and outside housing 24. Although not shown, instead of the bellows arrangement, pressure equalization could be achieved inside and outside housing 24 by connecting the housing to the fluid reservoir system through another conduit, flange 20, closure plate 25 and another poppet valve connector arrangement (such as 81 or 86).

Proper orientation of operator assembly 23 is assured by the two different size alignment pins 90 and 91 mounted in receiver flange 20. These pins engage openings 92 and 93, respectively, in closure plate 25 (see FIGS. 8, 9 and 11 particularly).

Diverter body 10 and the components associated therewith and the closed hydraulic system and its connection portions of the poppet valves are permanently located subsea adjacent the subsea wellhead. Operator assembly 23 is disconnectable and removable from and reconnectable to diverter body 10 using remotely controlled manipulators. When installing operator assembly 23 the manipulator carries operator assembly 23 into position adjacent diverter body 10. Operator assembly 23 and diverter body 10 are properly aligned when alignment pins 90 and 91 on receiver flange 20 enter openings 92 and 93 in closure plate 25. The end 60 of shaft 17 enters socket 59 and, if necessary, is rotated as it enters by the slanted surfaces 60a at the tip of the shaft. The two halves of each of the poppet valves 81 and 86 engage and when the operator assembly and diverter body 10 are positioned as shown in FIG. 1 the manipulator rotates lock ring 22 to thread it to receiver flange 20. Test pressure is then applied by the manipulator through port 77, hose 77a and passageway 77b by a special fitting, not shown, on the manipulator.

The hydraulic piston assembly 30 is designed to limit the total force on diverter paddle 14 and also be self-adjusting. Spring 38 has a spring coefficient considerably greater than the return spring 53.

In operation, when it is desired, for example, to divert flow through curved bore 12, assuming the normal position of paddle 14 is as shown in solid lines and its diverting position is as shown in dashed lines in FIG. 7, power fluid is supplied from the reservoir through conduit 85, poppet valve 86, passageway 87, connection 43a, conduit 43 and opening 42 to piston chamber 32 and acts on piston head 36 causing the end 37b of member 37 to move against threaded member 56. Cam arm 50 is rotated against the bias of spring 53 causing socket 59 to turn which in turn rotates shaft 17 and causes paddle 14 to move from its solid line position to its dashed line position when piston head 36 has completed its travel and shoulders 40 and 34 are in tight sealing contact. Spring 38 prevents overstressing of diverter shaft 17 and paddle 14 and limits the side load on shaft bearing 61 and seal 63 and compensates for tolerance variations in travel of the paddle. The latter self-adjusting feature is desired to make the operators interchangeable. In the event of overstress, cup-shaped member 37 is forced inwardly against the bias of spring 38 when cup-shaped member 37 is extended outwardly from housing 31 by outward movement of piston head 36.

Changes and modifications may be made in the illustrative embodiments shown and described herein without departing from the scope of the invention as defined in the appended claims.

Having fully described the nature, objects, operation and advantages of our invention we claim:

1. Apparatus for diverting flow comprising:

a flow diverter body member containing branched passageways joined together in a wye configuration;

a paddle arranged at the junction of said passageways and movable from one position in which flow through one of said passageways is blocked to another position in which flow through said other passageway is blocked;

a shaft nonrotatably connected to said paddle;

rotatable means connected to said shaft;

means for rotating said rotatable means including piston means and spring means, said piston means rotating said rotatable means against the bias of said spring means from one position of said rotatable means to another position of said rotatable means and said spring means rotating said rotatable means in a counter direction; and

means on said piston means for limiting stress on said rotatable means, said shaft and said paddle, and for adjusting travel of said paddle to permit full rotation of said paddle from said one to said other position where differences might exist in the distance to be travelled by said paddle between its two positions.

2. Apparatus for diverting flow from one conduit into another conduit comprising:

a diverter body member having branched passageways;

a paddle arranged at the junction of said branched passageways and movable from one position in which flow through one of said passageways is blocked to another position in which flow through another passageway is blocked and vice versa;

a shaft nonrotatably connected to said paddle;

an operator assembly connected to said shaft, said operator assembly including

a hydraulically operable piston assembly having a chamber and piston means reciprocal in said chamber, said piston means comprising inner and outer piston members capable of moving relative to each other, said two piston members being movable outwardly together in response to fluid pressure applied to said inner piston member;

rotatable means engageable with said shaft for causing rotation of said shaft and movement of said paddle;

pivotal means connected to said rotatable means for rotating said rotatable means, said outer piston member engaging said pivotal means to urge said pivotal means in one direction;

biasing means also connected to said pivotal means for urging said pivotal means in a counter direction to said one direction; and

said piston assembly including resilient means permitting said outer piston member to move inwardly relative to said inner piston member to prevent over-stressing said diverter shaft and paddle and to compensate for variations in travel of said paddle.

3. Apparatus as recited in claim **2** including a shoulder formed on said inner piston member; and

another shoulder formed in said chamber sealingly engageable with said piston shoulder when said inner piston member is in its most outwardly extended position.

4. Apparatus as recited in claim **3** in which said pivotal means comprises a cam arm mounted on said rotatable means, one end of said cam arm being connected to said biasing means and the other end of said cam arm engaging said outer piston member.

5. Apparatus as recited in claim **4** in which said rotatable means comprises a socket having the same configuration as said shaft and providing at least one flat linearly extending portion, said shaft also being configured to provide at least one flat linearly extending portion and engaging said socket such that said flat portions mate.

6. Apparatus as recited in claim **5** in which said operator assembly includes;

a closed housing filled with hydraulic oil;

a closure plate arranged on one end of said housing;

seal means on said closure plate for sealing off said shaft and socket when said closure plate and said diverter body are engaged;

means extending through said other end of said housing adapted to equalize pressure inside and outside said housing; means for testing said seal means;

a flange mounted on said body member; and

a remotely operable lock ring mounted on said housing engageable with said flange for locking said operator assembly to said body member.

7. Apparatus for diverting flow from one conduit into another conduit in a subsea environment comprising:

a diverter body member having branched passageways;

a paddle arranged at the junction of said branched passageways and movable from one position in which flow through one of said passageways is blocked to another position in which flow through another passageway is blocked and vice versa;

a shaft nonrotatably connected to said paddle;

a closed housing having a closure plate arranged on one end thereof and being filled with hydraulic fluid;

an operator assembly arranged in said housing, said operator assembly including

a hydraulically operable piston assembly having a chamber and piston means reciprocal in said chamber, said piston means comprising inner and outer piston members capable of moving relative to each other, said two piston members being movable outwardly together in response to fluid pressure applied to said inner piston member;

rotatable means engageable with said shaft for causing rotation of said shaft and movement of said paddle;

pivotal means connected to said rotatable means for rotating said rotatable means, said outer piston member engaging said pivotal means to urge said pivotal means in one direction;

biasing means also connected to said pivotal means for urging said pivotal means in a counter direction to said one direction;

said piston assembly including resilient means permitting said outer piston member to move inwardly relative to said inner piston member to prevent overstressing said diverter shaft and paddle and to compensate for variations in travel of said paddle.

8. Apparatus as recited in claim **7** including means arranged on said body member and means arranged on said housing for locking said body member and said operator assembly together.

9. Apparatus as recited in claim **8** in which said means for locking said body member and said operator assembly together includes:

a flange arranged on said diverter body member; and

a threaded lock ring mounted on said housing for locking said operator assembly to said flange and said diverter body upon rotation thereof.

10. Apparatus as recited in claim **9** including means for supplying fluid pressure to said chamber to move said piston members.

11. Apparatus as recited in claim **10** including:

a shoulder formed on said inner piston member;

another shoulder formed in said chamber engageable with said piston shoulder when said inner piston member is in its most outwardly extending position;

means sealingly engaging the outer wall of said inner piston member; and

means to permit hydraulic fluid from within said housing escaping past said sealing means to be conducted outside said housing.

12. Apparatus as recited in claim **11** including:

means extending through said housing adapted to equalize pressure inside and outside said housing; and

said flange containing alignment pins and said closure plate containing openings, said body member and said operator assembly being aligned with each other when said pins and said openings are engaged.

13. Apparatus as recited in claim **12** in which said pivotal means comprises a cam arm mounted on said rotatable means, one end of said cam arm being connected to said biasing means and the other end of said cam arm engaging said outer piston member.

14. Apparatus as recited in claim **13** in which said rotatable means comprises a socket having the same configuration as said shaft and providing at least one flat linearly extending portion, said shaft also being configured to provide at least one flat linearly extending portion and engaging said socket such that said flat portions mate when said body member and said operator assembly are engaged.

15. Apparatus as recited in claim **14** including:

seal means on said closure plate for sealing off said shaft and socket when said closure plate and said diverter body are engaged; and

means for testing said seal means.

16. Apparatus for diverting flow comprising:

a flow diverter body member containing branched passageways;

blocking means arranged at the junction of said passageways and movable from one position in which flow through one of said passageways is blocked to another position in which flow through said other passageway is blocked;

a shaft nonrotatably connected to said blocking means;

an operator assembly connected to said shaft, said operator assembly including

a hydraulically operable piston assembly having a chamber and piston reciprocal in said chamber, said piston means comprising inner and outer piston members capable of moving relative to each other, said two piston members being movable outwardly together in response to fluid pressure applied to said inner piston member;

rotatable means connected to said shaft for causing rotation of said shaft and movement of said paddle;

pivotal means connected to said rotatable means for rotating said rotatable means, said outer piston member engaging said pivotal means to urge said pivotal means in one direction; and

biasing means also connected to said pivotal means for urging said pivotal means in a counter direction to said one direction.

17. Apparatus as recited in claim **16** in which said operator assembly includes

a closed housing filled with hydraulic oil;

a closure plate arranged on one end of said housing;

seal means on said closure plate for sealing off said shaft and socket when said closure plate and said diverter body are engaged;

means extending through said other end of said housing adapted to equalize pressure inside and outside said housing;

means for testing said seal means;

a flange mounted on said body member; and

a remotely operable lock ring mounted on said housing engagable with said flange for locking said operator assembly to said body member.

18. Apparatus as recited in claim **17** including

a shoulder formed on said inner piston member; and

another shoulder formed in said chamber sealingly engagable with said piston shoulder when said inner piston member is in its most outwardly extending position.

19. Apparatus as recited in claim **18** in which said pivotal means comprises a cam arm mounted on said rotatable means, one end of said cam arm being connected to said biasing means and the other end of said cam arm engaging said outer piston member.

20. Apparatus as recited in claim **19** in which said rotatable means comprises a socket having the same configuration as said shaft and providing at least one flat linearly extending portion, said shaft also being configured to provide at least one flat linearly extending portion and engaging said socket such that said flat portions mate.

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