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Seabourn

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[54] **METHOD AND APPARATUS FOR WELL BORE WORK**

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[52] **U.S. Cl.** **166/.5;** 166/154; 166/224

[51] **Int. Cl.** **E21b 7/12**

[58] **Field of Search** ..... 166/.5, .6, 154, 155, 224; 175/5, 7, 231

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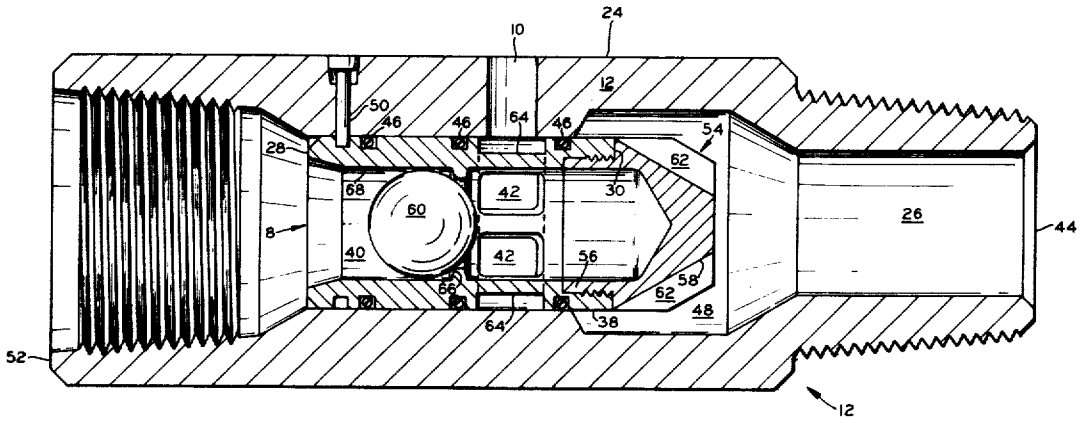
Assistant Examiner—Richard E. Favreau

[57] **ABSTRACT**

A method and apparatus for re-entering a well bore and working on said well bore has a fluid diverting element slidably mounted within a body. The fluid diverting element is movable in response to an actuating element from a first position at which fluid is directed substantially only through a port on the side of the body to a second position at which fluid is directed substantially only through a second end of the body.

14 Claims, 6 Drawing Figures



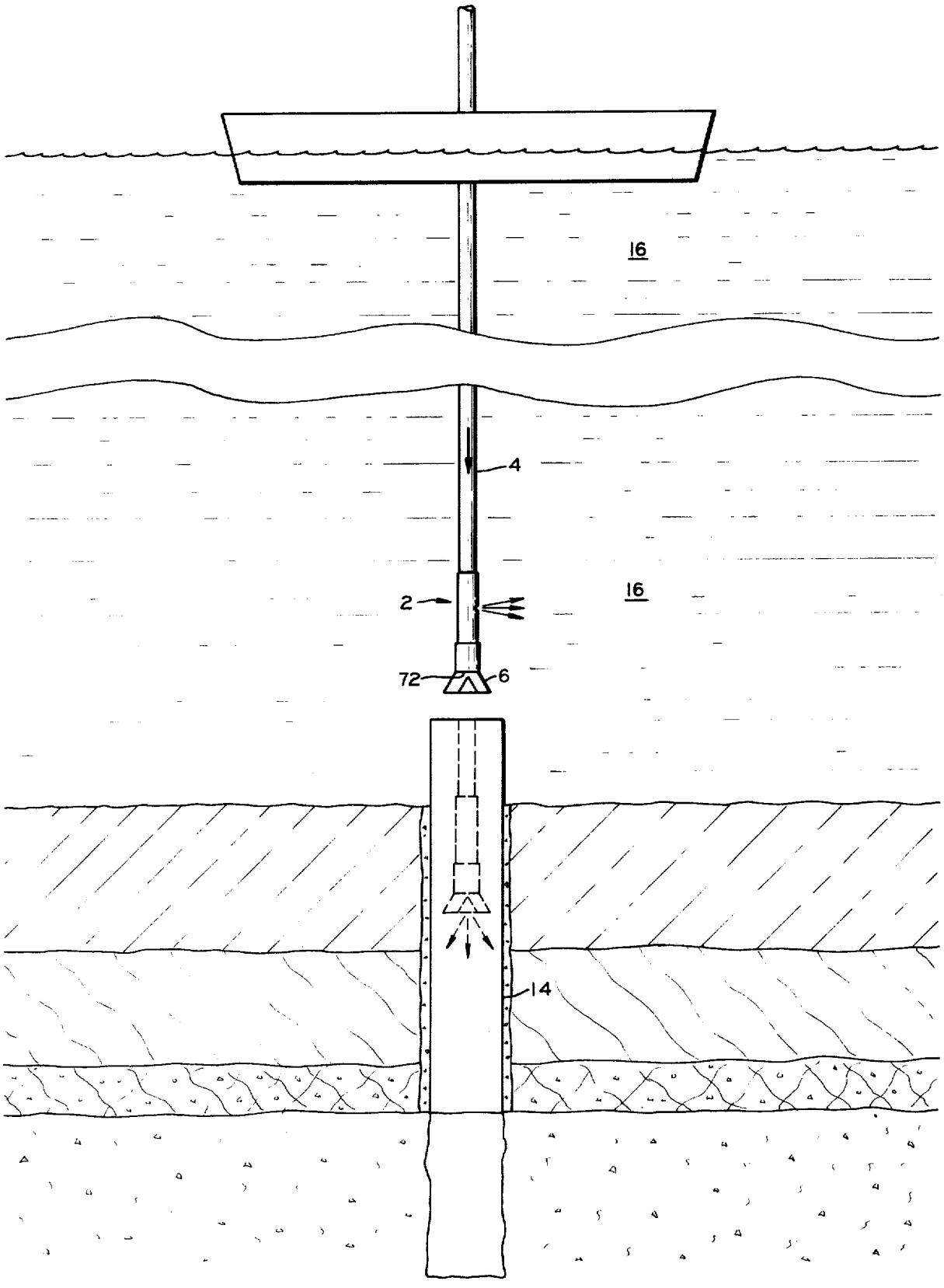


FIG. 1

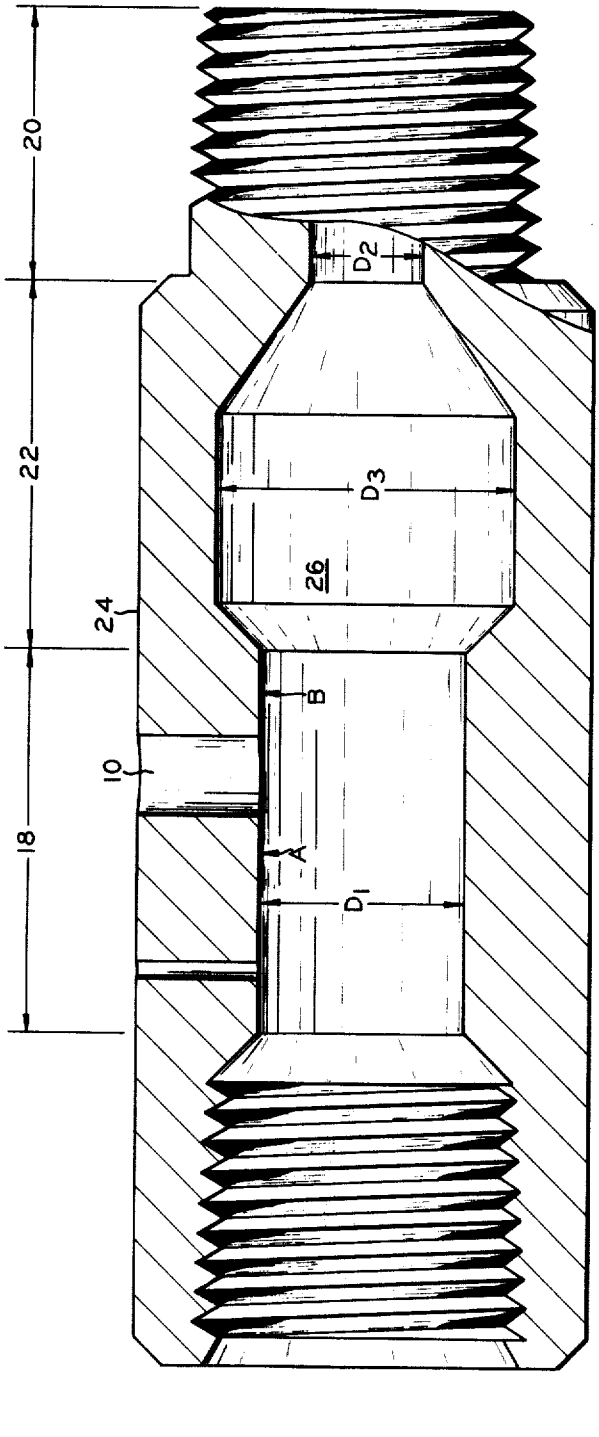


FIG. 2

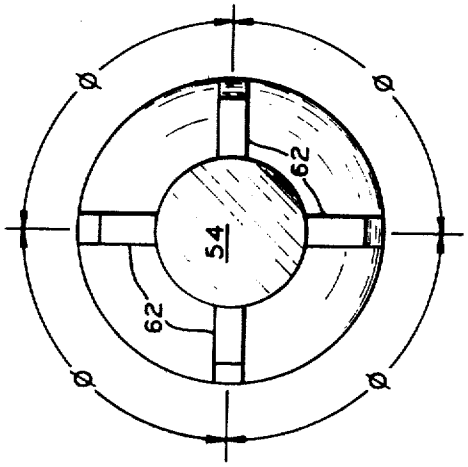

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FIG. 3A

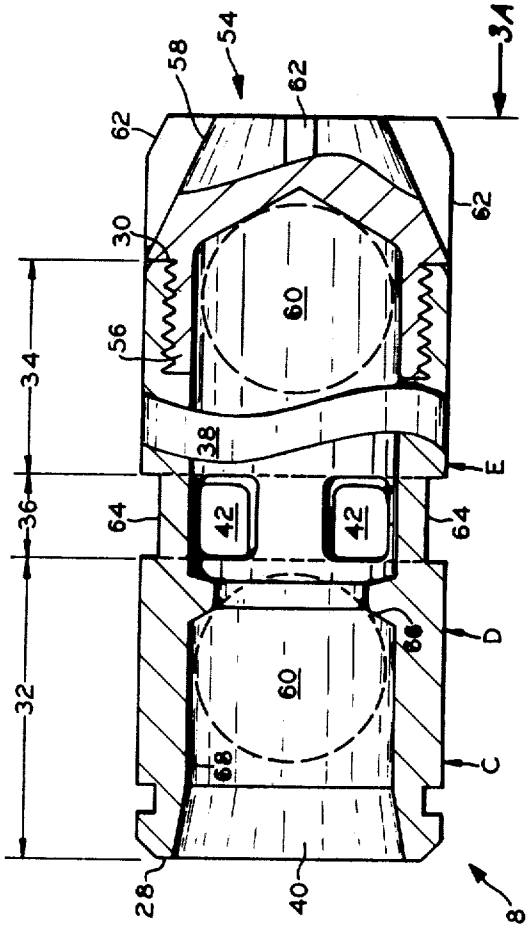
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FIG. 3

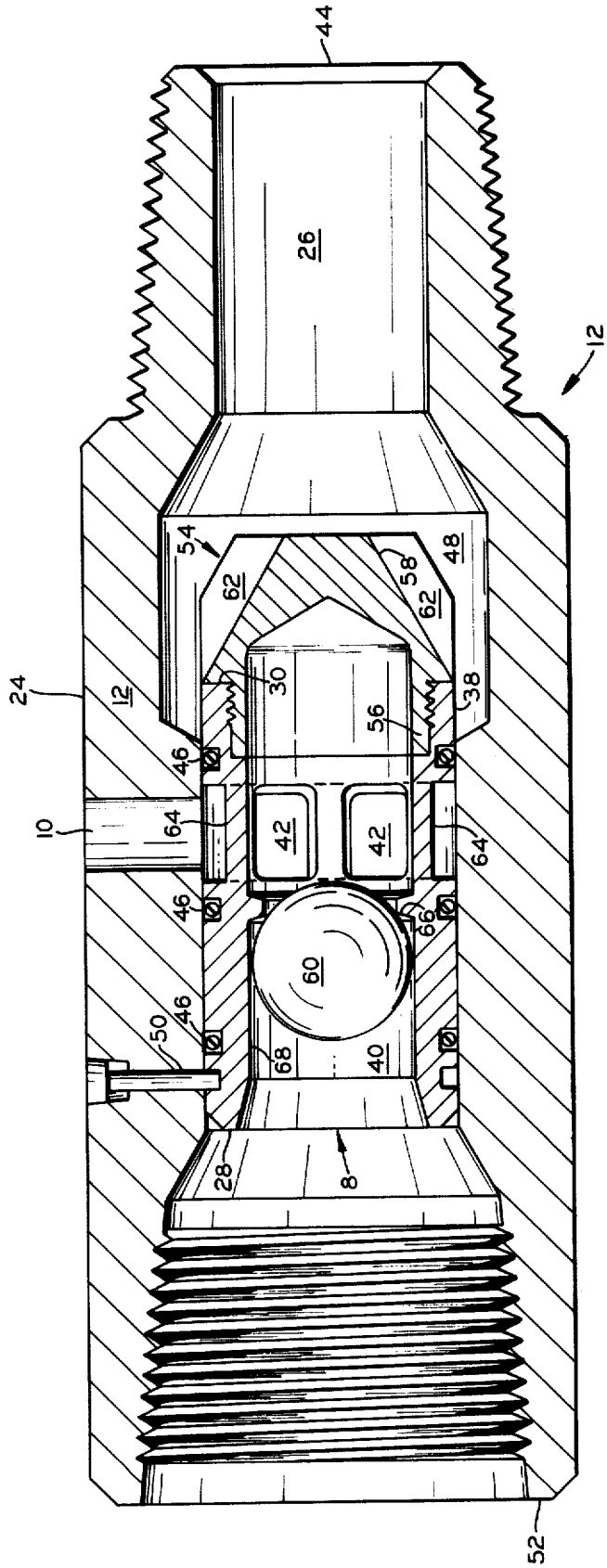
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FIG. 4

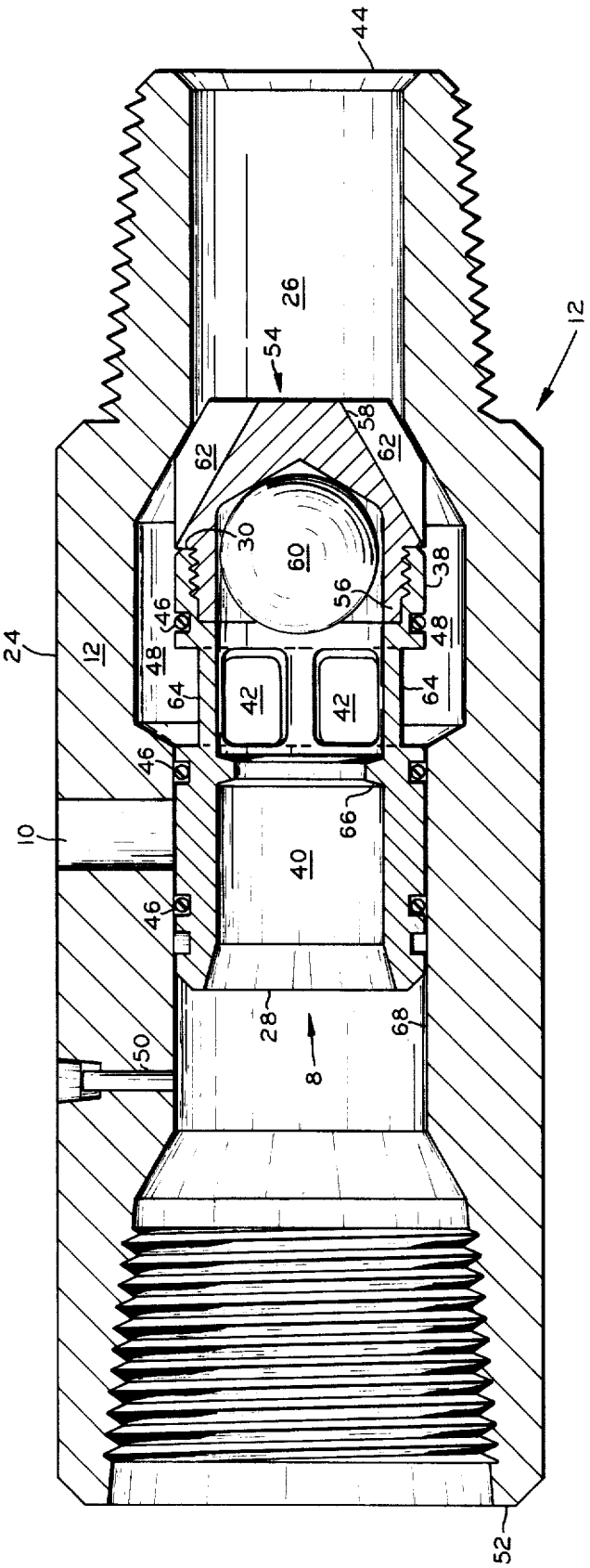
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FIG. 5

METHOD AND APPARATUS FOR WELL BORE WORK

In the art of drilling, working over, and producing wells positioned beneath the surface of a body of water, it is sometimes extremely difficult to guide a conduit into the well bore owing to the current of the water and wind and wave action. After the conduit is positioned in the well bore, it is then often desirable to discharge fluid from substantially only the lower end of the conduit or to move fluid from the well bore through the lower end of the conduit and upwardly through the conduit to the upper end of the conduit for the recovery thereof.

This invention therefore resides in a method and apparatus for reentering and working over a well bore where a fluid diverting element is slidably mounted within a body. The fluid diverting element is movable in response to an actuating element from a first position at which fluid is directed substantially only through a port on the side of the body to a second position at which fluid is directed substantially only through a second end of the body.

Other aspects, objects, and advantages of the present invention will become apparent from a study of the disclosure, the appended claims, and the drawing.

The drawings are diagrammatic views, in partial section, of the apparatus of this nvention.

FIG. 1 shows the apparatus associated with a drill stem;

FIG. 2 shows the body of the apparatus;

FIG. 3 shows the fluid diverting element;

FIG. 3A shows an end view of the fluid diverting element;

FIG. 4 shows the apparatus with the element positioned at the first position; and

FIG. 5 shows the apparatus with the element positioned at the second position.

Referring to FIG. 1, the re-entry tool assembly 2 is associated at one end to a conduit 4 and at the other end to a drill bit 6, for example. The fluid diverting element 8 (see FIG. 3) is at its first position and fluid is being discharged from the port 10 of the body 12 (see FIG. 2) for aligning the bit with the well bore 14 for entry into the well bore 14. In the example application shown in FIG. 1, the well bore is positioned beneath the surface of a body of water 16. Operation of the assembly 2 and associated equipment will be later more fully described.

Referring to FIG. 2, a body 12 of the assembly has first, second, and middle portions 18, 20, 22, walls 24, a longitudinal opening 26 extending therethrough, and the port 10 opening through the walls 24 at the first portion 18 of the body 12.

The longitudinal opening 26 of the body 12 has a first diameter (D_1) at the first portion 18, a second diameter (D_2) at the second portion 20 and a third diameter (D_3) at the middle portion 22 of the body 12. The third diameter D_3 is larger than said first and second diameters D_1, D_2 for purposes that will be later more fully described.

Referring to FIG. 3, a fluid diverting element 8 has first and second ends 28, 30; first, second, and middle portions 32, 34, 36; walls 38; a longitudinal opening 40 extending through the element 8; and a port 42 opening through the element walls 38 at the middle portion 36 of the element 8.

Referring to FIGS. 4 and 5, the fluid diverting element 8 is positioned in the longitudinal opening 26 of the body 12 and is slidably movable in the body 12 between a first position (see FIG. 4) at which the ports 10, 42 are in fluid communication one with the other and the second and middle portions 20, 22 of the longitudinal opening 26 of the body 12 are sealed for passing fluid through substantially only the ports 10, 42 at the first position and a second position (see FIG. 5) at which the port 42 and longitudinal opening 40 of the element 8 are in fluid communication with substantially only the second and middle portions 20, 22 of the longitudinal opening 26 of the body 12 and the port 10 of the body 12 is substantially sealed for discharging fluid substantially only through the second end 44 of the assembly 2.

Referring to FIGS. 4 and 5, annular sealing elements 46, such as O-rings, for example, are preferably positioned in the annulus 48 between the element 8 and the body 12 for sealing the annulus at these locations at both the first and second positions of the element 8.

If the sealing elements are maintained on the body 12, at least two of the sealing elements 46 are utilized and positioned at locations A and B as shown in FIG. 2. The seals 46 can be maintained on the element 8 in which positions at least 3 of the elements are utilized and positioned at locations C, D, and E as shown on FIG. 3. It is preferred that the three sealing elements 46 be utilized as shown on FIGS. 4 and 5 in order to maintain the apparatus of simple construction.

A retaining means 50, such as, for example, a shear pin, is associated with the fluid diverting element 8 and the body 12 for releasably maintaining the element 8 at the first position as will later be more fully described with respect to the operation of the apparatus.

Where the retaining means 50 is a shear pin, the shear pin 50 extends through the body wall 24, preferably at a location between the port 10 of the body 12 and the first end 52 of the assembly 2 and into the walls 38 of the element 8 at the first position of said element as shown in FIG. 4.

The size of material from which the shear pin 50 is constructed is dependent upon the preselected force desired for movement of the element 8 from the first to the second position and can easily be determined by one skilled in the art. One particularly useful shear pin is an aluminum rod having a tensile strength of about 42,000 psi.

Referring to FIG. 3, a cap 54, for example, seals the second end 30 of the fluid diverting element 8 for directing fluid from port 42 through the annulus 48 at the middle and second portions 22, 20 of the body at the second position of the element 8.

The cap 54 has first and second end portions 56, 58. The first end portion 56 of the cap 54 is releasably connected to the second end 30 of the diverting element 8 by mating threads for example, for removing a free-dropped actuating element 60 and returning the diverting element 8 to the first position. The second end portion 58 of the cap 54 preferably has a plurality of lugs 62 extending outwardly therefrom which are of dimensions sufficient for preventing the cap from passing into the second portion 20 of the body 12 and maintaining the apparatus of simple construction. Other means can be provided such as a stop shoulder extending inwardly from the body wall 24, but such means to maintain the element 8 within the body 12 at the second position

would be subject to erosion and damage and would result in waste to rebuild or construct as opposed to the lugs **62** of the cap **54**.

As shown in FIG. 3A, it is preferred that there be about **4** lugs positioned about the cap **54** at substantially equal arcuate distances one from the other to provide a stable seating of the element **8** on the body **12**.

In order to assure relatively unrestricted flow through the apparatus at the second position of the element **8**, it is preferred that the annulus defined by the body walls **24**, the lugs **62**, and the cap **54** have a minimum total cross-sectional area at least as great as the total cross-sectional area of port **42**.

In order to maintain the element **8** of high strength yet provide for the passage of relatively large volumes of fluid through its port **42**, it is preferred that there be a plurality of ports formed on the middle portion **36** of the element **8**. Further, it is preferred that an annular groove **64** be formed about the outer surface of the element **8** and open into the ports **42** formed thereon for assuring the flow of fluid from port **42** through port **10** at the first position of the element **8** when the ports **42** and **10** are arcuately displaced one from the other.

The element **8** can be moved from the first to the second position by dropping a free-falling actuating element **60** or running an element on a wire line or conduit, for example. It is preferred, however, that the actuating element **60** be a deformable ball **60** and that the diverting element **8** having an annular seat **66** extending into the longitudinal opening **40** from an inner surface **68** of the element **8**. In this construction, the annular seat **66** has an inside diameter less than the diameter of the ball **60** for seating the ball thereon and passing the ball therethrough. Further, it is preferred that the second portion **34** of the element **8** have a length greater than about the diameter of the deformable ball **60** in order to prevent the restriction of flow through port **42**.

In the method of this invention, the assembly **2** is connected to a conduit **4**, for example, with the element **8** maintained at the first position by, for example, the shear pin **50**. The conduit **70** is moved downwardly through the body of water **16** to an elevation adjacent the elevation of the well bore **14**.

As viewed from an underwater television camera, by a diver, or other means, if the end **72** of the conduit is not aligned with the well bore **14**, fluid is passed downwardly through the conduit **4** and substantially only outwardly from the body port **10**. The force of the fluid being discharged from the side of the conduit string moves the lower end **72** of the conduit **4** into vertical alignment with the well bore **14** at which alignment the conduit **4** is lowered into the well bore **14** and to a desired location in the conduit as shown by broken lines on FIG. **1**.

The deformable ball **60** is thereafter dropped into the bonduit for actuating the assembly **2**, closing the port **10**, and opening the end **72** of the conduit into fluid communication along the length of the conduit **4**. Fluid is thereafter discharged from substantially only the end **72** of the conduit for drilling purposes, for example, or into the conduit **4** via substantially only the end **72** recovering fluid during workovers or producing the well, for example.

An example of the material of the ball and relative dimensions of the inside diameter of the seat **66** and the outside diameter of the deformable ball are as follows:

Material of ball:

Solid Hycar butadiene/acrylonitrile copolymer rubber of 80 Shore A hardness

Outside diameter: 2 ⅝ inches

I.D. of seat **66**: 2.078 inches

In an example movement of the deformable ball **60**, the ball first seats on the annular seat **66** which terminates flow through ports **10, 42**. Fluid pressure can be increased on the ball by pumping fluid into the upper end of the conduit **4**. At a first preselected force on the ball, the shear pin **50** is severed and the element **8** is moved to the second position. Fluid is pumped into the conduit **4** and the pressure is increased to place a second preselected force on the deformable ball **60** which causes the ball to deform, pass through the seat **66**, and be moved into the second portion **34** of the element **8**. With the ball at this position, fluid in the conduit is in communication with port **42** and fluid can be passed through the conduit, the annulus **48** and into or from the end **72** of the conduit **4**.

Other modifications and alterations of this invention will become apparent to those skilled in the art from the foregoing discussion and accompanying drawing, and it should be understood that this invention is not to be unduly limited thereto.

What is claimed is:

1. A reentry tool assembly, comprising:

a body having first, second, and middle portions, walls, a longitudinal opening extending therethrough, and a port opening through the walls at the first portion, said longitudinal opening being of a first diameter at the first portion, a second diameter at the second portion and a third diameter at the middle portion, said third diameter being larger than said first and second diameters;

a fluid diverting element having first and second ends, first, second, and middle portions, walls, a longitudinal opening extending through the element, and a port opening through the element walls at the middle portion, said element being slidably movable in the body between a first position at which the ports are in fluid communication one with the other and the second and middle portions of the longitudinal opening of the body are sealed and a second position at which the port and longitudinal opening of the element are in fluid communication with the second and middle portions of the longitudinal opening of the body, the port of the body is sealed, and the element is within the body;

first means for sealing the second end of the fluid diverting element and passing fluid from the element port through the annulus between the element and the middle and second portions of the body at the second position of the element; and

second means for releasably maintaining the element at the first position.

2. An apparatus, as set forth in claim **1**, wherein the first means is a cap having first and second end portions, said first end portion being releasably connected to the second end of the fluid diverting element and said second end portion having a plurality of lugs extending outwardly therefrom which are of dimensions sufficient for preventing the cap from passing into the second portion of the body.

3. An apparatus, as set forth in claim **2**, wherein there are at least four lugs positioned about the cap at substantially equal arcuate distances one from the other.

4. An apparatus, as set forth in claim 2, wherein the annulus defined by the walls of the body, the lugs, and the cap have a minimum total cross-sectional area at least as great as the total area of the port of the element.

5. An apparatus, as set forth in claim 1, wherein there are a plurality of ports formed on the middle portion of the element.

6. An apparatus, as set forth in claim 1, wherein an annular groove is formed about the outer surface of the element and opened into the element port.

7. An apparatus, as set forth in claim 1, wherein there are at least two annular sealing elements positioned in the annulus between the element and the body on opposed sides of the port of the body.

8. An apparatus, as set forth in claim 1, wherein the second means comprises a shear pin extending through the body walls at a location between the port of the body and a first end of the body and into the walls of the element at the first position of said element.

9. An apparatus, as set forth in claim 1, including a deformable ball;

an annular seat extending into the longitudinal opening about an inner surface of the element at the first portion of the element, said annular seat having an inside diameter less than the diameter of the ball for seating of the ball thereon and passing the ball therethrough; and

said second portion of the element having a length greater than about the diameter of the deformable ball.

10. An apparatus for reentry into a well bore, as at the bottom of the sea which comprises

1. a tubing adapted to be lowered to sea bottom and into a well bore into the ground under the sea,
2. a lateral port at the lower end of said tubing adapted to discharge therefrom laterally a fluid under pressure from within said tubing,
3. an opening at the bottom of said tubing adapted to discharge downwardly out the bottom thereof a fluid under pressure from within said tubing,
4. means in one position closing the said opening at the bottom of said tubing and while in said position permitting fluid to egress from said lateral port, said means in another position closing said lateral port and permitting fluid to egress from said opening at the bottom of said tubing and
5. means actuated by an increase in the pressure in said tubing the move said first mentioned means from said one position to said another position.

11. An apparatus according to claim 10 wherein the first mentioned means includes a hollow, releasably-held, slidable, ported body adapted to receive therein from the tubing above said first mentioned means a resilient plugging element adapted to plug the hollow body against pressure in said tubing above said body, said body responsive to pressure increase in said tubing being released and sliding in said tubing to close said lateral port and open said opening at the bottom of said tubing.

12. A method for positioning an open bottomed drill string for entry into a well bore in the surface of the ground under water which comprises:

providing in the lower end of said pipe a section containing a lateral port and within said section a fluid diverting means adapted to move within said section to close the end of the pipe and open the lateral port when in its upper position and to open the end of the pipe and close the lateral port when in its lower position,

securing said fluid diverting means in its upper position so that it will remain in said position until it is desired to allow it to move to its lower position,

lowering the pipe string downward through said water until the end of the pipe string is at an elevation adjacent the surface opening of the well bore,

pumping fluid into said pipe string and out through said lateral port in an amount sufficient to cause the lower end of the pipe string to be propelled into alignment with the well bore,

and then applying sufficient force to the fluid diverting means in said lateral port section of the pipe to force it to move from its upper position to its lower position thereby closing the lateral port and opening the end of the pipe string so that fluid may be pumped out the bottom opening of the pipe string only.

13. A method according to claim 12 wherein the fluid diverting means is moved from its upper to its lower position by raising the fluid pressure on the fluid diverting means by blocking off said fluid diverting means at a point above the lateral port until the pressure is such that the fluid diverting means breaks loose from its secured upper position.

14. A method according to claim 13 wherein the fluid diverting means is blocked off by a deformable ball which will pass through the upper portion of said fluid diverting means to the lower portion of said means after the pressure exceeds the amount necessary to force the fluid diverting means to break loose from its upper position, said fluid diverting means being designed so that said ball when in the lower portion of said fluid diverting means will not prevent fluid from flowing out the bottom end of the pipe string.

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