

Oct. 10, 1961

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3,003,560

PUMP TOOL FOR REWORKING SUBMARINE WELLS

Filed Sept. 2, 1958

2 Sheets-Sheet 1

FIG. 1.

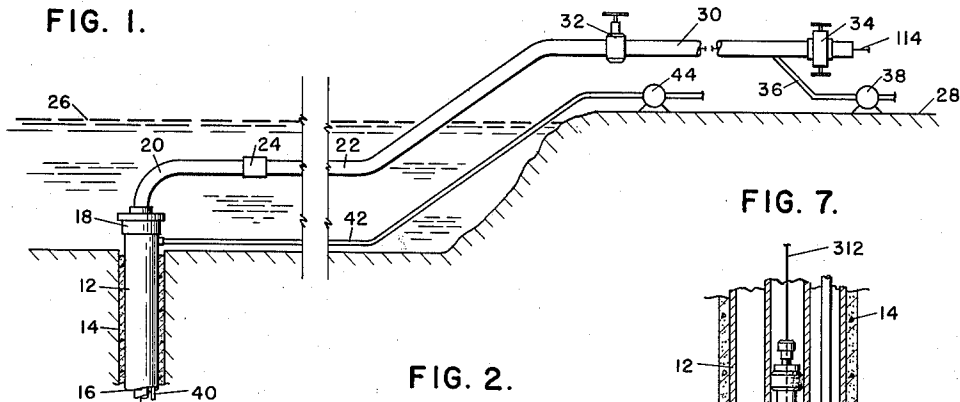


FIG. 2.

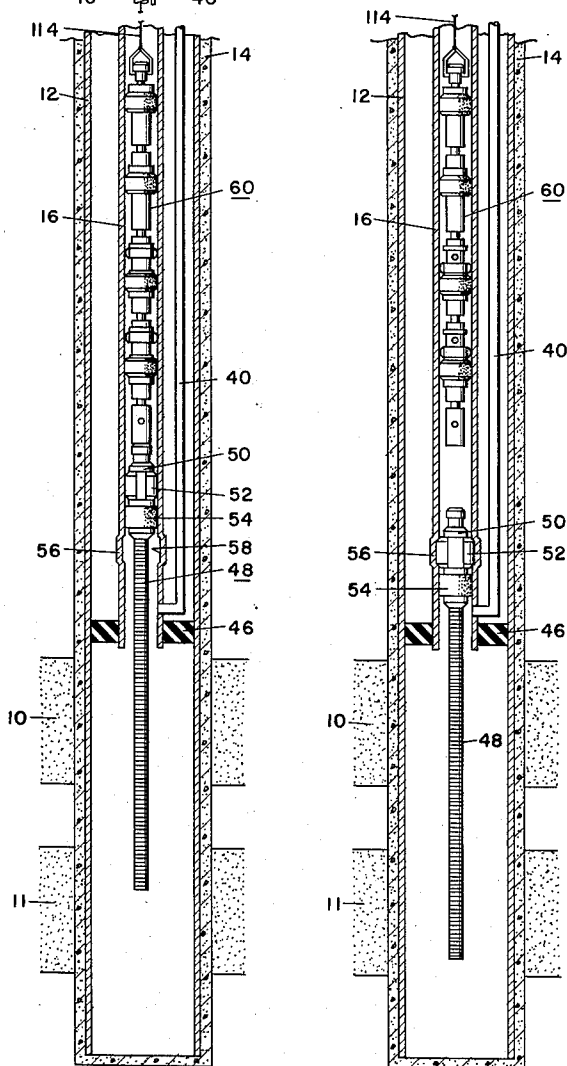
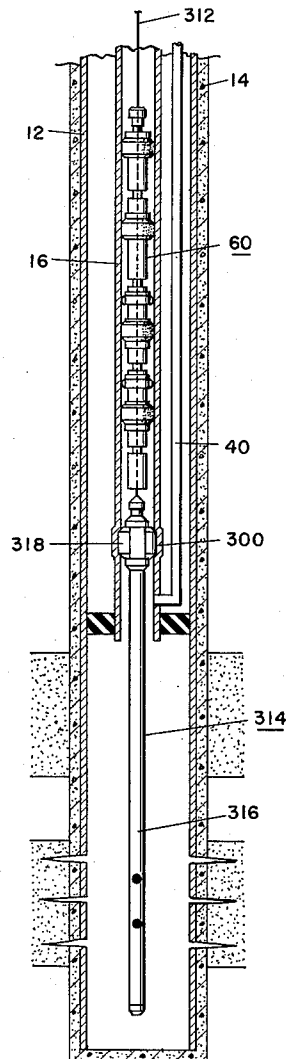


FIG. 7.



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2 Sheets-Sheet 2

FIG. 3.

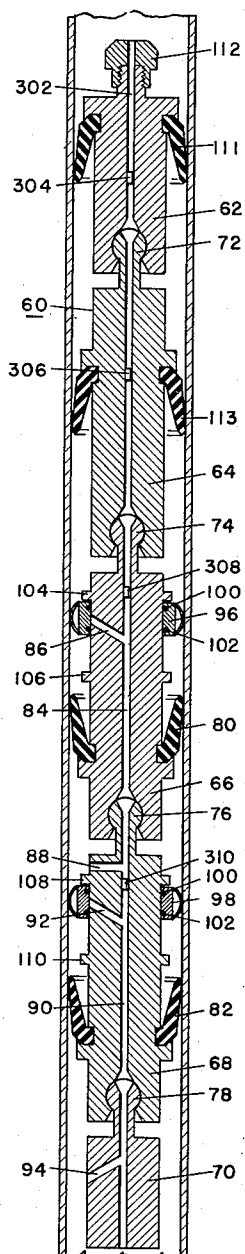


FIG. 4.

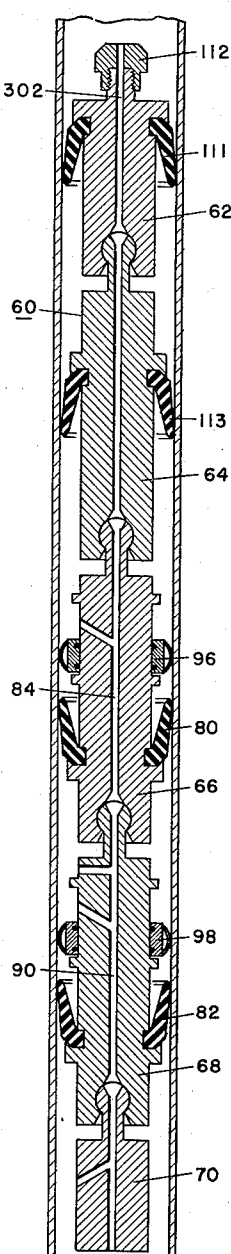


FIG. 5.

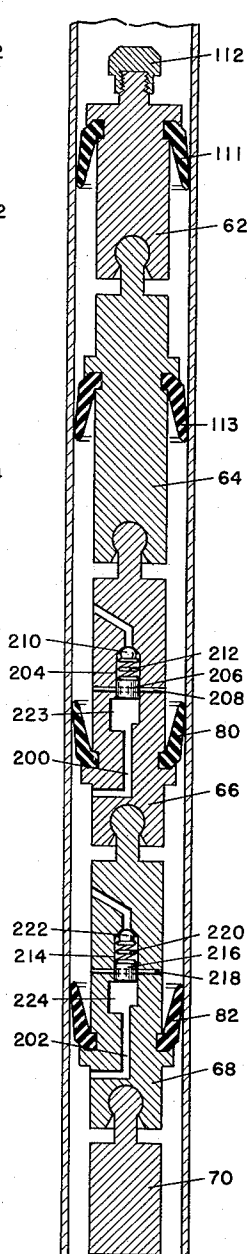
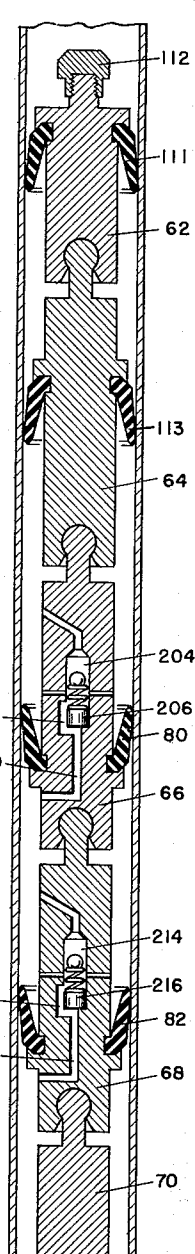


FIG. 6.



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PUMP TOOL FOR REWORKING SUBMARINE
WELLS

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Filed Sept. 2, 1958, Ser. No. 758,349

15 Claims. (Cl. 166—70)

This invention relates to oil and gas wells. More particularly, this invention relates to pump tools for pumping members, such as tubular extensions used in carrying out workover operations, into a well through bent tubing.

Often, it is very difficult to lower tools into a well by means of gravity or by wireline. For example, when a well is located offshore, it is necessary that the various tools which are lowered into the well be placed in tubing located onshore and some means devised for transporting these tools through the tubing out to the well. This tubing often has many bends or curves through which the tools must be passed. To get the tools from onshore to the offshore well, a pumping tool is often utilized.

The invention to be described herein is a new and improved pumping tool for use in pumping other members into a well through tubing extending into the well, for example, through tubing extending from the shoreline to the interior of the well. Briefly described, the pumping tool includes a string of members connected together for angular movement with respect to one another. The provision of the means permitting angular movement of the members with respect to one another enables the tool to pass through any bends in the tubing. Pressure actuable means, such as cup packers, are mounted on at least one of the members. The packers permit a differential pressure to be developed so that the tool can be pumped through the tubing. The tool is also provided with a fluid passageway which by-passes the pressure isolating means. Whether or not fluid flows through the fluid by-pass is controlled by a valve. As the tool is pumped into the well, the valve prevents fluid from going through the passageway. After the tool has performed its function of transporting other members into position in the well, the valve is moved to a position to allow fluid to flow through the by-pass passageway. Hence, as the tool is removed from the well, fluid flows through the by-pass, thus equalizing pressure across the packers to permit easy removal of the tool.

The operation of the device, as well as its many other advantages, will be further understood by reference to the detailed description and drawings, in which:

FIG. 1 is a schematic view showing the means for pumping the tool into the well from the shoreline;

FIG. 2 is a schematic elevational view showing the tool being removed after an extension member has been locked into position within the well;

FIG. 3 is an elevational view, partly in section, showing the pumping tool with the valve means in the position assumed as the tool is being pumped into the well;

FIG. 4 is a view similar to FIG. 3, showing the position of the valve as the tool is being removed from the well;

FIG. 5 is a sectional elevational view of another embodiment of a pumping tool with the valve means in position as the tool is being pumped into the well;

FIG. 6 is the embodiment of FIG. 5, showing the position of the valve means as the tool is being removed from the well; and

FIG. 7 shows the embodiment of FIGS. 3 and 4 used for pumping a perforator into the offshore well.

Referring to FIGS. 1 and 2, a borehole is shown penetrating the earth and traversing subsurface formations

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10 and 11. The borehole includes the usual casing 12 which is cemented to the sides of the borehole by means of cement 14.

Production tubing 16 extends into the well and terminates at a point above the bottom of the well. The production tubing 16 extends through a well head 18 and connects with a short radius bend pipe 20. The short radius bend pipe 20 is coupled to a laterally extending conduit 22 by means of a coupling means 24. The well, short radius bend pipe 20, and laterally extending pipe 22 are all below the water line 26.

Pipe 22 extends to the shore 28. A lubricator 30 is connected to the pipe 22. Valves 32 and 34 are provided at the extremities of lubricator 30.

Extending from the lubricator 30 is a conduit 36. Fluid may be pumped into the lubricator 30, laterally extending pipe 22, bend 20, and production tubing 16 by means of pump 38.

Connected to the lower portion of production tubing 16 is a circulating flow line 40. The flow line 40 extends up to the well head 18 where it is attached to a laterally extending conduit 42 which leads to a pump 44 located onshore.

Packing means 46 are provided in the well near the lower extremity of the production tubing 16 and below the junction of production tubing 16 and circulating line 40.

FIG. 1 shows a tubular extension member 48 which has been pumped into position within the well. The tubular extension 48 includes an extension hanger 50 containing locking dogs 52. A packer 54 is also included about the extension hanger 50. The extension member 48 is locked into position within the production tubing 16 by the provision of a landing nipple 56 provided in the production tubing 16. The landing nipple 56 includes a recess 58 for receiving the locking dogs 52. The extension member 48 is made of flexible material so that it can be passed through the short radius bend pipe 20.

The flexible extension member 48 has been pumped into the desired position by use of the new and novel pumping tool indicated generally by the numeral 60.

FIG. 3 shows in detail the structure of the pumping tool 60, with the parts in the position assumed as the tool is being pumped into the well. The tool 60 includes a string of members 62, 64, 66, 68, and 70, which are connected together for angular movement with respect to one another. These members may be connected together, for example, by a universal type joint, such as the knuckle joints 72, 74, 76, and 78. The spacing between the knuckle joints and the diameters of the members are such that the tool 60 will pass through the bends in the tubing, such as bend 20 of FIG. 1. For example, if the production tubing 16 has an inside diameter of 2½ inches, a spacing between the knuckle joints of 10 inches and a diameter for the members of about 2 inches has been found very satisfactory.

In order to pump the tool 60 through the tubing and into the well, it is necessary that at least one pressure actuable means be provided. In the embodiment of FIG. 3 the pressure actuable means includes a pair of packers 80 and 82 mounted on mandrels 66 and 68, respectively. Cup packers 80 and 82 face upwardly, as seen in FIG. 3.

A fluid passageway 84 extends from fluid inlet 86 located above the packer 80 to fluid outlet 88 located between the cup packers 80 and 82. A second fluid passageway 90 extends from fluid inlet 92 located above the cup packer 82 to a fluid outlet 94 located below packer 82. Hence, fluid passageways 84 and 90 provide fluid by-passes around packers 80 and 82, respectively.

In order for the tool 60 to be properly pumped from

the shoreline to within the well, it is necessary that a valve means be provided for closing the fluid passageways 84 and 90 as the tool is pumped into the well. After the pumping tool 60 has properly positioned the extension member in the landing nipple 56 of tubing 16 (see FIGS. 1 and 2), it is necessary that the pressure across each of the packers 80 and 82 be equalized. This is accomplished by the movement of the valve means so as to permit fluids to by-pass the packers 80 and 82.

The valves shown in FIG. 3 are friction slide valves 96 located above packer 80, and 98 located above packer 82. Friction slide valves 96 and 98 are substantially annular in shape. The outside diameter of the valves are large enough so that they are substantially always in frictional contact with the inside diameter of the tubing as the pumping tool 60 is moved through the tubing. Hence, as the pumping tool is being flowed toward the well, the friction of valves 96 and 98 with the tubing 16 forces annular slide valves 96 and 98 upwardly, as seen in FIG. 3, to close the fluid by-pass inlets 86 and 92, respectively. O-rings 100 and 102 are provided on the inside diameters of the slide valves 96 and 98 to provide fluid-tight engagement with the mandrels 66 and 68, respectively. Circular stops 104 and 106 are provided about mandrel 66 to limit the upward and downward movement of slide valve 96. Similarly, circular stops 108 and 110 are provided about mandrel 68 to limit the upward and downward movement of slide valve 98.

A fishing neck 112 is provided at the upper extremity of the pumping tool 60. Attached to the fishing neck is a wireline 114 (see FIGS. 1 and 2) used, among other things, to remove the pumping tool 60 from the well after the extension member has been properly positioned within production tubing 16.

In the operation of the embodiment shown in FIGS. 3 and 4, the pumping tool 60 and extension member 48 are placed in the lubricator 30. Pump 38 is then operated to apply pressure through tubing 22, tubing 20, and production tubing 16. At the same time, pump 44 is operated to apply suction to tubing 42 and flow line 40. The tool 60 and extension member 48 are then pumped into position within the nipple 56 on production tubing 16. After the extension member 48 has been properly positioned, tension is applied to wireline 114 to remove the pumping tool 60 from the well. As tension is applied to the wireline 114, the slide valves 96 and 98 are moved downwardly because of the frictional contact with production tubing 16 to engage cylindrical stops 106 and 110, respectively (see FIG. 4). Thus, as the tool 60 is removed to the surface, the fluids contained in the tubing will by-pass packers 80 and 82 through fluid passageways 84 and 90, respectively. The tool 60 is thus easily removed without having to overcome a pressure differential which would be developed across packers 80 and 82 if it were not for the provision of fluid by-passes 84 and 90. The removal of the tool 60 may be further facilitated by the application of fluid pressure simultaneously with the placing of tension on wireline 114. For this purpose, downwardly facing cup packers 111 and 113 are provided about mandrels 62 and 64, respectively. Pressure is then applied to remove the pumping tool 60 by applying pressure directly through line 42 by pump 44, and applying suction through production tubing 16, tubing 20, and tubing 22 by means of pump 38. Alternatively, the tool 60 may be pumped directly out of the well without the use of the wireline 114, if desired.

A second embodiment of pump tool is shown in FIGS. 5 and 6 wherein like parts to the embodiment shown in FIGS. 3 and 4 are referred to by like numerals. Instead of the annular friction slide valve, however, a spring biased ball valve is included in the fluid by-passes.

Referring to FIG. 5, fluid passageway 200 and 202 by-pass the upwardly facing cup packers 80 and 82, respectively. By-pass 200 has a first portion 204 of greater diameter. A piston 206 is shear pinned at the lower ex-

trinity of the portion of greater diameter 204 by means of shear pin 208. A ball valve 210 is spring biased by coil spring 212 against the inlet to the chamber 204. Similarly, by-pass 202 has a first portion 214 of greater diameter. A piston 216 is shear pinned to the lower portion of chamber 214 by shear pin 218. Coil spring 220 normally biases ball valve 222 against the fluid inlet to chamber 214.

Each of the fluid by-passes 200 and 202 is also provided with a second portion 223 and 224, respectively, of still greater diameter, which are adjacent the chambers 204, 214, respectively.

Using the pump tool shown in FIGS. 5 and 6, the tool is used to pump the other member, such as the extension member 48 shown in FIGS. 1 and 2, into the well in a manner similar to the pump tool shown in FIGS. 3 and 4. Referring again to FIG. 1, the pump tool is placed in the lubricator 30 and then pumped through the tubing into the well. The pump pressure used is not great enough to shear the shear pins 208 and 218.

After the extension member has been properly positioned within the production tubing 16, additional pressure is applied against the pistons 206 and 216 to shear the shear pins 208 and 218. Pistons 206 and 216 will then be permitted to fall into the larger chambers 222 and 224, respectively. Since the diameters of pistons 206 and 216 are smaller than the diameters of the chambers 222 and 224, the fluid will by-pass the packers 80 and 82 as the pump tool is removed by the wireline to the surface. As in the embodiment of FIGS. 3 and 4, the embodiment of FIGS. 5 and 6 may be pulled upwardly with respect to the fluid by means of the wireline, or may have tension applied to the wireline while pumping simultaneously, or the tool may be pumped back up to the surface without the use of a wireline.

The new device described herein may be used for pumping various members into a well other than the tubing extension shown in FIGS. 1 through 6.

FIG. 7 shows a gun perforator which has been run through the production tubing 16 and landed in the bottom of the production tubing 16 upon a landing nipple 300. For use in running gun perforators of the type shown in FIG. 7, the pump tool 60 of FIGS. 3 and 4 is provided with a longitudinally extending passageway 302. Each of the members 62, 64, 66, 68, and 70 is provided with a longitudinally extending passageway, with the passageways in intercommunication. When the tool is used for placing extension members, such as extension member 48, in a well, the longitudinally extending passageways are plugged by plugs 304, 306, 308, and 310.

Referring to FIG. 7 again, when it is desired to run a gun perforator into the well, the plugs are removed from the tool and a conductor cable 312 is run through the longitudinally extending passageways 302 and connected to the electrical equipment within the gun perforator 314.

The lower portion 316 of perforator gun 314 is made of flexible material so that it will pass through the bends in the tubing. Portion 316 may be made expendable and leave the upper portion 318 of tubing perforator 314 remaining on landing nipple 300 after the desired perforations have been made within the producing formation.

After the perforations have been made, the pump tool 60 and portion 318 of the gun perforator are removed by tension applied to cables 312 and/or pump pressure applied down side flow line 40 and up production tubing 16.

We claim:

1. An elongated device for use in pumping members through tubing extending into a well comprising: a plurality of members connected together for angular movement with respect to one another to permit passage of the tool through any bends in the tubing; a cup packer mounted on each of two adjacent members, said packers being faced in such a direction as to be actuated by

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the pumping of the fluid to move the device into the well; an annular friction slide mounted for slidable movement about each of two adjacent members, the slide valves being substantially always in frictional contact with the tubing during movement through the tubing, the two adjacent members each having a fluid by-pass extending from a point spaced from the face-side of the cup packer on the particular member to the other side, and stops mounted on the two adjacent members so that the slide valves are movable by frictional contact with the tubing to a position to close the by-passes as the device is being pumped into the well and to a position to open the by-passes as the device is removed from the well.

2. An elongated device for use in pumping members through tubing extending into a well comprising: a plurality of members connected together for angular movement with respect to one another to permit passage of the tool through any bends in the tubing; a first cup packer mounted on one member and a second cup packer mounted on a second member adjacent said one member, said cup packers being faced in such a direction to be actuated by the pumping of the fluid to move the device in one direction; a third cup packer mounted on a third member and a fourth cup packer mounted on a fourth member adjacent said third member, said packers being faced in such a direction as to be actuated by the pumping of the fluid to move the device in the other direction; an annular friction slide valve mounted for slidable movement about each of the third and fourth members, the slide valves being substantially always in frictional contact with the tubing during movement through the tubing, the third and fourth members each having a fluid by-pass extending from a point spaced from the face-side of the cup packer on the particular member to the other side, and stops mounted on the third and fourth members so that the slide valves are movable by frictional contact with the tubing to a position to close the by-passes as the device is being pumped into the well and to a position to open the by-passes as the device is removed from the well.

3. An elongated device for use in pumping members through tubing extending into a well comprising: a plurality of members, each connected to adjacent members by knuckle joints, the spacing between the knuckle joints and diameters of the members being such that the elongated device will pass through bends in the tubing; a first cup packer mounted on one member and a second cup packer mounted on a second member adjacent said one member, said cup packers being faced in such a direction as to be actuated by the pumping of the fluid to move the device in one direction; a third cup packer mounted on a third member and a fourth cup packer mounted on a fourth member adjacent said third member, said packers being faced in such a direction as to be actuated by the pumping of the fluid to move the device in the other direction; an annular friction slide valve mounted for slidable movement about each of the third and fourth members, the slide valves being substantially always in frictional contact with the tubing during movement through the tubing, the third and fourth members each having a fluid by-pass extending from a point spaced from the face-side of the cup packer on the particular member to the other side, and stops mounted on the third and fourth members so that the slide valves are movable by frictional contact with the tubing to a position to close the by-passes as the device is being pumped into the well and to a position to open the by-passes as the device is removed from the well.

4. An elongated device for use in pumping members through tubing extending into a well comprising: a plurality of members connected together for angular movement with respect to one another to permit passage of the tool through any bends in the tubing; a cup packer mounted on each of two adjacent members, said packers being faced in such a direction as to be actuated by the pumping

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of the fluid to move the device into the well; the two adjacent members each having a fluid by-pass extending from a point spaced from the face-side of the cup packer on the particular member to the other side, the by-pass having a first portion of greater diameter and an adjacent second portion of still greater diameter; a piston shear-pinned at one extremity of said first portion of greater diameter; and a spring biased ball valve held by the piston against the fluid inlet to the first portion of greater diameter so that the device can be pumped into the well, additional pressure applied against the pistons to shear the shear pins, and the pistons moved into the second portions of still greater diameter in the by-passes to permit the fluids in the tubing to flow through the by-passes as the device is removed from the well.

5. An elongated device for use in pumping members through tubing extending into a well comprising: a plurality of members connected together for angular movement with respect to one another to permit passage of the tool through any bends in the tubing; a first cup packer mounted on one member and a second cup packer mounted on a second member adjacent said one member, said cup packers being faced in such a direction as to be actuated by the pumping of the fluid to move the device in one direction; a third cup packer mounted on a third member and a fourth cup packer mounted on a fourth member adjacent said third member, said packers being faced in such a direction as to be actuated by the pumping of the fluid to move the device in the other direction; the third and fourth members each having a fluid by-pass extending from a point spaced from the face-side of the cup packer on the particular member to the other side, the by-pass having a first portion of greater diameter and an adjacent second portion of still greater diameter; a piston shear-pinned at one extremity of said first portion of greater diameter; and a spring biased ball valve held by the piston against the fluid inlet to the first portion of greater diameter so that the device can be pumped into the well, additional pressure applied against the pistons to shear the shear pins, and the pistons moved into the second portions of still greater diameter in the by-passes as the device is removed from the well.

6. An elongated device for use in pumping members through tubing extending into a well comprising: a plurality of members, each connected to adjacent members by knuckle joints, the spacing between the knuckle joints and diameters of the members being such that the elongated device will pass through bends in the tubing; a first cup packer mounted on one member and a second cup packer mounted on a second member adjacent said one member, said cup packers being faced in such a direction as to be actuated by the pumping of the fluid to move the device in one direction; a third cup packer mounted on a third member and a fourth cup packer mounted on a fourth member adjacent said third member, said packers being faced in such a direction as to be actuated by the pumping of the fluid to move the device in the other direction, the third and fourth members each having a fluid by-pass extending from a point spaced from the face-side of the cup packer on the particular member to the other side, the by-pass having a first portion of greater diameter and an adjacent second portion of still greater diameter; a piston shear-pinned at one extremity of said first portion of greater diameter; and a spring biased ball valve held by the piston against the fluid inlet to the first portion of greater diameter so that the device can be pumped into the well, additional pressure applied against the pistons to shear the shear pins, and the pistons moved into the second portions of still greater diameter in the by-passes to permit the fluids in the tubing to flow through the by-passes as the device is removed from the well.

7. A pump tool in accordance with claim 3 wherein the members have an opening extending longitudinally there-through so that, if desired, conductor cables can be passed through the openings.

8. An elongated device for use in pumping members

through tubing extending into a well comprising: a plurality of members connected together for angular movement with respect to one another to permit passage of the device through any bends in the tubing; at least one cup packer connected to the device, said packer being connected to one of the members, said cup packer being faced in such a direction as to be actuated by the pumping of the fluid to move the device into the well; a friction slide valve mounted on said member to which the cup packer is connected and at a point spaced from the face side of the cup packer, the slide valve being substantially always in frictional contact with the tubing during movement through the tubing, the device having a fluid bypass extending from a point spaced from the face side of the cup packer to the other side; and stops on said one of the members engageable by the slide valve mounted so that the slide valve is movable by frictional contact with the tubing to a position to close the bypass as the device is being pumped into the well and to a position to open the bypass as the device is removed from the well.

9. An elongated device for use in pumping members through tubing extending into a well comprising: a plurality of members connected together for angular movement with respect to one another to permit passage of the device through any bends in the tubing; at least one cup packer connected to the device, said packer being connected to one of the members, said cup packer being faced in such a direction as to be actuated by the pumping of fluid to move the device into the well; said member to which the cup packer is connected having a fluid bypass extending from a point spaced from the face side of the cup packer to the other side, the bypass having a portion of greater diameter with a valve therein with frangible means normally holding the valve closed so that the device can be pumped into the well, additional pressure applied to break the frangible means to permit the fluids in the tubing to flow through the bypass as the device is removed from the well.

10. A pump tool for use in pumping other members into a well through tubing extending into the well comprising: a string of members connected together for angular movement with respect to one another to permit passage of the tool through any bends in the tubing; at least one of said members having a cup packer mounted thereon; a fluid passageway in said tool which bypasses

said cup packer; and a valve mechanism for controlling fluid flow through said fluid passageway, the valve mechanism being adapted to assume a first position to prevent fluid from going through the passageway as the tool and other members are pumped into the well and also adapted to assume a second position to allow fluid to flow through the passageway as the tool is removed from the well.

11. A pump tool in accordance with claim 10 wherein the valve mechanism is a friction slide valve in contact with the tubing, and a stop on the tool located so that the friction slide valve contacts the stop and covers the fluid passageway entrance as the tool is pumped into the well and moves away from the fluid passageway entrance as the tool is removed from the well.

12. A pump tool in accordance with claim 11 wherein the friction slide valve is annular.

13. A pump tool in accordance with claim 10 wherein the fluid passageway which bypasses the packer includes a portion of greater diameter, and the valve mechanism is a valve connected to the sides of the fluid passageway with frangible means to normally close the fluid passageway.

14. A pump tool in accordance with claim 13 wherein the fluid passageway which bypasses the packer includes a second portion of even greater diameter adjacent said portion of greater diameter, and the valve mechanism includes a spring biased ball valve normally held in a closed position by a piston shear pinned to one extremity of said portion of greater diameter so that the packer can be bypassed by shearing the shear pins to move the piston into the second portion of even greater diameter.

15. A pump tool in accordance with claim 10 wherein the members each have an opening extending longitudinally therethrough, said openings communicating with each other so that, if desired, conductor cables can be passed through the openings.

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