

May 21, 1963

E. B. LAGUCKI
PUMPABLE WELL TOOL

3,090,440

Filed Aug. 10, 1960

2 Sheets-Sheet 1

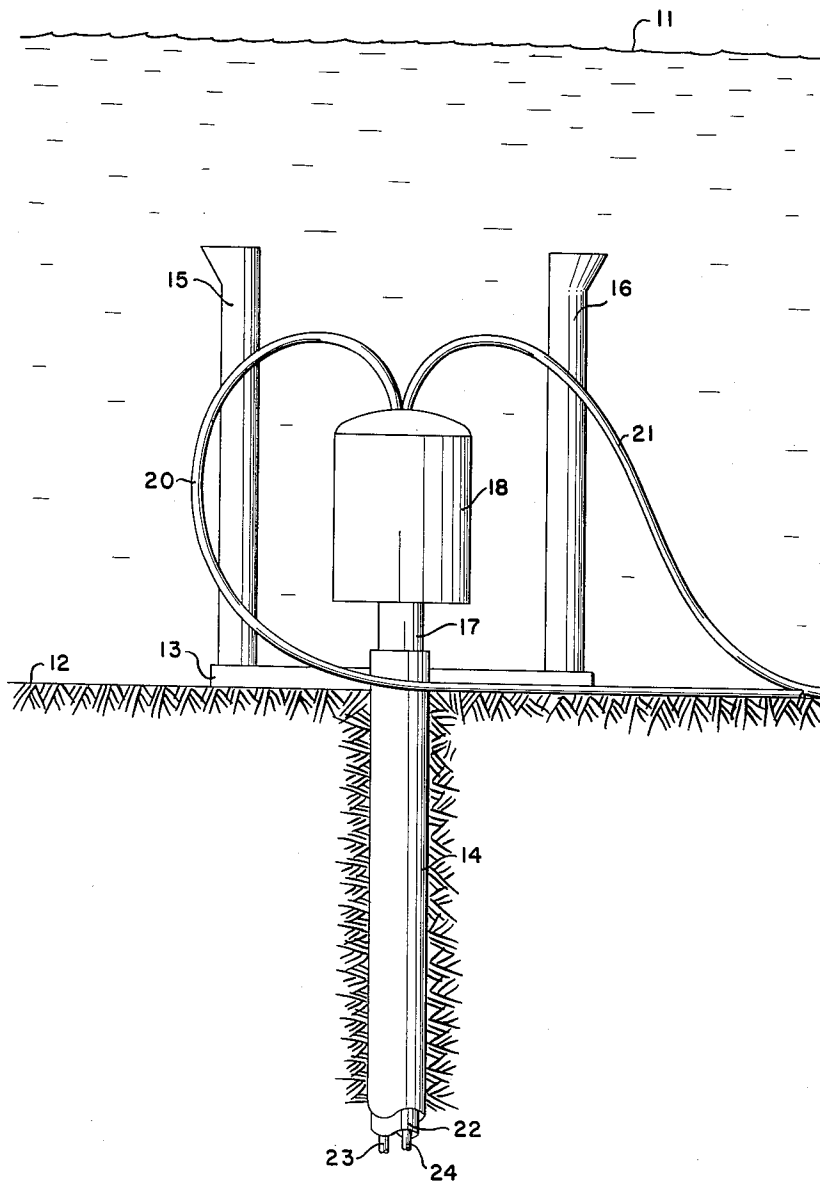


FIG. 1

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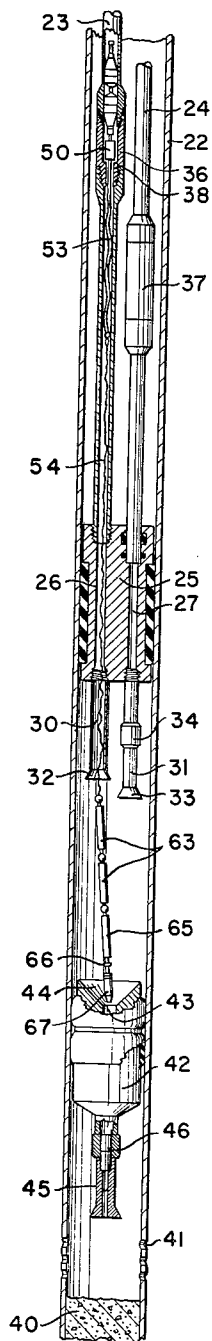


FIG. 2

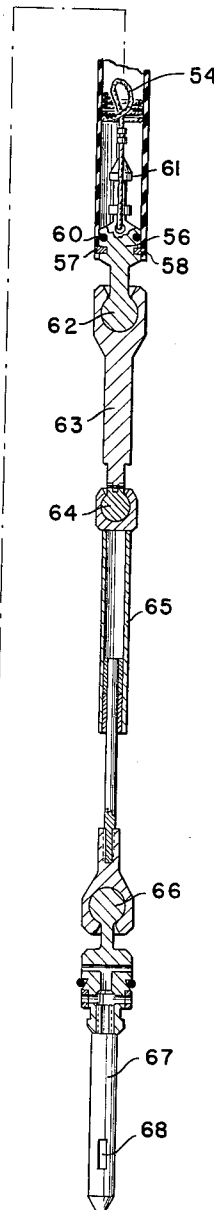
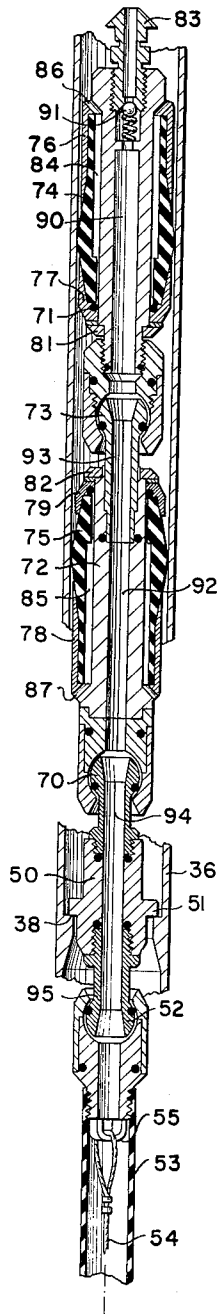


FIG. 3

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PUMPABLE WELL TOOL

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4 Claims. (Cl. 166-155)

This invention relates to a well tool adapted to be pumped up or down a string of tubing positioned in a well and pertains more particularly to a tool adapted to be pumped down a well tubing to engage, connect to, manipulate and/or operate a device positioned within a well.

A recent development in the oil industry is the drilling and completion of wells at an offshore location where the wellhead assembly and production control units are positioned beneath the surface of a body of water and preferably close to the bottom of the body of water. With wellhead assemblies positioned on an ocean floor, a hazard to the navigation of boats in offshore waters is removed. Additionally, considerable savings are realized in that it is not necessary to erect a protective stationary platform around the wellhead in the manner in which they are employed to protect well casing and wellhead assemblies extending above the surface of the water. It has also been found necessary to position a wellhead assembly on the ocean floor in water depths where it is not feasible to erect a stationary platform around a wellhead assembly.

However, the placement of wellhead assemblies on the ocean floor raises a new set of problems with regard to carrying out work-over operations, maintenance or other operations in a completed well. Major work-over operations call for the use of a barge positioned on the surface of the water above the well together with equipment for going down and entering the wellhead assembly and the tubing or casing strings connected thereto, and in some circumstances may result in the entire removal of the wellhead assembly to the surface during work-over operations. In order to carry out some of the more simple work-over or maintenance operations, such as perforation of well casing, the opening of a packer, the removal of a valve, the cleaning of paraffin from a tubing string, etc., it has been necessary to develop an entirely new line of well tools which can be pumped through a production tubing string from some remote location, oftentimes a mile or more from the well, and enter the well, passing down the tubing string therein to be subsequently positioned therein for carrying out some preselected operation. After completing the operation the tool in the tubing string within the well is subsequently removed, generally by reverse circulation.

It is an object of the present invention to provide apparatus adapted to be pumped down a well tubing string and engage, operate or manipulate a well device positioned in the well.

A further object of the present invention is to provide apparatus adapted to be pumped down a well tubing string with a portion of the apparatus being discharged from the lower open end of the tubing string to engage, operate or manipulate a well device positioned in a well casing.

Another object of the present invention is to provide an apparatus adapted to be pumped down a well tubing string to a seat therein, with a portion of said apparatus adapted to be disconnected from the main body of the apparatus and travel a considerable distance downwardly to engage a well device.

A still further object of the present invention is to provide an apparatus adapted to be pumped down a well tubing string running along an ocean floor and curving downwardly into a well.

Another object of the present invention is to provide an apparatus adapted to be pumped down a well tubing string, connect to a well device within the well, and sub-

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sequently be pumped up the well tubing string to the surface.

Still another object of the present invention is to provide an apparatus adapted to be pumped down a well tubing string to seat therein with a portion of the apparatus adapted to be disconnected therefrom and travel a considerable distance downwardly and later be retrieved with the apparatus and removed from the well tubing by operations carried out from a remote location.

These and other objects of this invention will be understood from the following description taken with reference to the drawing, wherein:

FIGURE 1 is a schematic view in partial longitudinal section illustrating a wellhead assembly positioned on the ocean floor;

FIGURE 2 is a diagrammatic view taken in longitudinal cross-section, of one arrangement of equipment within a well together with the apparatus of the present invention;

FIGURE 3 is a diagrammatic view taken in longitudinal cross-section, of one form of the tool of the present invention.

Referring to FIGURE 1 of the drawing, a wellhead assembly is shown as positioned below the surface 11 of a body of water and preferably on the ocean floor 12. The wellhead apparatus comprises a platform 13 secured to the top of a conductor pipe or surface casing 14 which in turn extends into the earth below the body of water and is preferably cemented therein in a conventional manner. The wellhead assembly may also be provided with two or more vertically-positioned guide columns 15 and 16 which are fixedly secured at their lower ends to the platform 13. A well casinghead 17 is mounted on the top of the conductor pipe 14 with a control equipment housing 18 closing the top of the casinghead and/or any casing and tubing suspension equipment employed on the wellhead assembly, as well as the various control valves and other control equipment normally used on the top of a well of this type.

Emerging from the housing 18 are a pair of flow lines 20 and 21 which preferably bend in long sweeping curves from a vertical position down to a substantially horizontal position so that they can run along the ocean floor 12 to a remote location where fluid from the well, and normally from other wells, is collected and metered and treated. Such a collection station may be several miles away. During the production of the well, normally only one of the flow lines 20 or 21 is employed in transporting fluid away from the well. The well may be provided with one or more strings of well casing 22 suspended within the conductor pipe 14. The flow lines 20 and 21, in the particular installation illustrated, are in communication with a pair of tubing strings 23 and 24 depending within the well. However, in all other installations utilizing a single tubing string, the second flowline may be in communication with the annular space between the tubing string and the adjacent well casing.

In FIGURE 2 the two tubing strings 23 and 24 contained within the well casing 22 are shown as being secured at their lower ends to a suitable packer 25 having flow passages 26 and 27 therethrough, the passages 26 and 27 having an inner diameter preferably equal to that of the tubing strings 23 and 24. If desired, short nipples 30 and 31 may be threadedly connected to the bottom of the packer 25 in axial alignment with the flow passages 26 and 27, respectively. The nipples 30 and 31 are preferably flared at their lower ends 32 and 33 to facilitate entry of an object being pulled into their lower ends. Additionally, if desired, one of the nipples, say 31, may be provided with a removable check valve 34 adapted to close the lower end of one of the tubing strings during certain operations carried out within the well.

Suitable stop elements are provided near the bottom of

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at least one and preferably both of the tubing strings 23 and 24. In the particular arrangement of equipment shown in FIGURE 2, the stop elements take the form of landing nipples 36 and 37, each nipple having a seating shoulder 38 formed on the inner wall thereof for stopping any tool of slightly larger diameter from passing the shoulder 38 and dropping out the end of the tubing string.

The well casing 22 of FIGURE 2 is shown as being closed at its lower end by a cement plug 40 and being provided above the plug 40 with a series of perforations 41 through the wall of the casing 22 opposite the producing formation. Positioned above the perforations 41 in the well casing 22 is a packer assembly 42 adapted to close the well casing. The packer assembly is provided with a flow passage 43 therethrough with a guide cone 44 formed at the top of the flow passage 43 for guiding various pieces of small-diameter equipment therethrough. The bottom of the packer assembly 42 is provided with a nipple 45 containing a ball-check valve or bottom-hole choke 46 which is readily removable by a suitable tool, but normally closes the flow passage 43 against downward movement of a pressure fluid which might tend to fracture the producing formation in an undesirable manner.

In order to carry out various operations within a well casing, such for example as removing the ball-check valve 46 from the bottom of the packer assembly 42, a well tool in accordance with the present invention has been provided. The well tool of the present invention employs a body member or mandrel 50 (FIGURE 3) having a shoulder 51 of a diameter small enough to pass through the tubing string 23 (FIGURE 2) yet large enough to contact and be stopped by the stop element or seating shoulder 38 in the landing nipple 36. The mandrel 50 is connected, preferably by means of a flexible joint 52 to the top of a flexible cable housing 53 which contains a considerable length, say 40 or 70 feet of a small-diameter flexible cable 54 made of any suitable material, such as braided wire or a plastic material, such as nylon. The upper end of the cable 54 is permanently secured to any suitable part of the apparatus such as an anchor ring 55 while the lower end of the cable 54 is connected to a closure member 56. The closure member 56 is releasably held within the bottom of the cable housing 53 in any suitable manner as by spring fingers or by shear pins 57 and 58. An O-ring seal 60 is preferably provided on the closure element 56 for closing the space between the closure 56 and the cable housing 53 in a fluid-tight manner. For emergency purposes the top of the closure 56 is generally provided with a fishing neck 61. The cable housing 53 may be made of any suitable flexible material such as two-wire braided rubber or plastic hose of a diameter small enough to pass through the tubing string 23 and the landing nipple 36. A flexible cable housing is desired so that the entire tool may be pumped through a fairly sharply curved flow line (FIGURE 1) without becoming wedged therein.

Secured to the lower end of the closure member 56, as by means of a flexible joint 62 is one or more weight bars 63 for providing weight so that the closure member 56 falls freely through the well tubing and casing. Preferably secured to the lower end of the weight bar, as by a flexible joint 64, is a set of telescoping jars 65. The bottom of the jars 65 is in turn connected, as through a flexible joint 66 to a tool 67 attached to the lower end thereof for engaging, manipulating, connecting to or being disconnected from any suitable tool, device or instrument to be placed or withdrawn from the well at a point below the lower open end of a tubing string 23. One form of tool is provided with an internal latch 67 and probe 68 which are adapted to engage and connect to a device to be run into the well and to be remotely disengaged from the device after the device has been positioned in the well. Alternatively, the tool and its latch 67 may be run into a well to connect on to a device so that the de-

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vice is withdrawn from the well when the tool is circulated to the surface again. In many cases the weight of the closure member 56 together with the latch 67 is sufficient to cause these elements to fall freely without the use of a weight bar.

In order to propel the body mandrel 50 and its attachment secured therebelow down through a well tubing, a tool carrier of any suitable type may be connected to the upper end of the body mandrel 50, as by a swivel joint or a flexible joint 70. A preferred design of the tool carrier is shown in copending patent application, Serial No. 45,036, filed July 25, 1960. The tool carrier comprises a central mandrel 71 and 72 connected together by a flexible joint 73. Mounted on the central mandrel 71—72 are a pair of sealing elements or packers 74 and 75 which are held thereon by suitable sealing-element or packer-retaining cups or rings 76 and 77, 78 and 79, respectively. The sealing elements 74 and 75 and their retaining cups 76, 77, 78 and 79 are held in position on the mandrel 71—72 by retaining nuts 81 and 82. Preferably the mandrel 71—72 is provided with a flexible linkage 73 such as a ball-and-socket joint 73 at a point between the sealing elements 74 and 75 so as to facilitate movement of the tool carrier in curved sections of a well tubing or pipe.

Since the possibility always exists that any tool attached to the tool carrier may become stuck in a well, the tool carrier is preferably provided with a fishing head 83 whereby a retrieving tool (not shown) may be run through the tubing string 23 (FIGURE 2) to latch on to the fishing head 83, thereby permitting removal of the tool carrier and the tool connected thereto. The retrieving tool may take the form of another tool carrier having latching means carried at its lower end to connect on to the fishing head 83 of the tool carrier stuck within the well. As illustrated, the packer retaining elements or cups 76 and 77 surround the ends of the packer or sealing element 74 while at the same time being axially spaced from each other on the central mandrel 71 so that the packer element 74 is against, or may be expanded against, the inner wall of a tubing 23 to form a seal thereagainst. Preferably, the sealing elements 74 and 75 are formed having an internal diameter slightly larger than that of mandrel 71—72 so that undercut portions or annular spaces 84 and 85 are formed between the mandrel and the sealing elements.

Fluid ports 86 and 87 are provided through the walls of the packer retaining cups 76 and 78 near the closed ends thereof so that fluid passageways are formed through the packer retaining cups in communication between the spaces outside the packer and the annular spaces 84 and 85. The packers or sealing elements 74 and 75 are made of any suitable inflatable resilient material such as rubber, synthetic rubber, rubberized fabrics or certain plastic material which may be expanded under the application of fluid pressure. The portion of the sealing element 74 in contact with the inner wall of the tubing string may have a thickened cross-section so as to provide for some wear on the seal as it is propelled through the tubing. In addition, the sealing element 74 may be bevelled to substantially a point, as illustrated, if desired.

During use of the tool carrier of FIGURE 3, a pressure fluid enters ports 86 and flows into the annular space 84 within the packer element 74 so that the packer element 74 is forced against the inner wall of a tubing string thus causing the packer element to act as a piston and be forced downwardly through the tubing string by application of continued pressure from above. This action takes place since a pressure differential exists across the upper sealing element 74 whereas no pressure differential exists across the sealing element 75 on downward travel of the tool carrier, since the fluid pressure on either side of the lower sealing element is the same and there is therefore no tendency for the sealing element 75 to expand against the wall of the tubing. Thus it may be seen that, on the downward travel of the present tool carrier, the upper seal-

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ing element 74 maintains a tight fit against a tubing at all times, while the lower sealing element 75 merely acts as an inoperative piston which would not contact the tubing wall with any force to form a seal thereagainst and hence would not be subject to wear as the tool carrier passes downwardly through the tubing string.

In returning a tool carrier, with or without its accompanying tool, to the top of a well, circulation of the driving fluid in the tubing string is reversed so that the pressure fluid would move upwardly through it. Thus, the action of the sealing elements 74 and 75 would be reversed with the sealing element 75 acting as the piston and the sealing element 74 acting as a follower. It is apparent that the present tool carrier would be operative even if the position of the sealing elements 74 and 75 were reversed.

The tool carrier is also provided with a longitudinal fluid passageway, preferably in the form of an axial bore 90. A spring-loaded check valve 91 is preferably positioned in the bore 90 within the tool carrier, the valve 91 being adapted to open preferably at a pressure greater than that needed to expand the sealing element 74 against the wall of the tubing. The lower portion of the mandrel 72 is also provided with a bore 92 which communicates with the bore 90 in the upper mandrel 71 through a flow passage or bore 93 in the flexible joint 73. The flexible joint 70 in turn is provided with a flow passage or bore 94 so that the interior of cable housing 53 is subjected to upstream pressure within a tubing string when the pressure fluid passes the check valve 91. The flexible joint 52 is also provided with a flow passage 95. By maintaining pressure fluid within the flexible cable housing 53 during the pumping of the apparatus of the present invention down a well tubing string, sufficient rigidity is imparted to the cable housing to prevent it from hanging up as it passes through curved sections of the flow line or well tubing 21 as shown in FIGURE 1.

As an example of the use of the apparatus of the present invention it will be assumed that it is desired to retrieve the ball-check valve 46 from the nipple 45 of the packer 42 which is fixedly positioned within the well casing 22 (FIGURE 2). The entire apparatus shown in FIGURE 3 is connected together and inserted into the flow line 21 at a distant point, such for example, at a production platform or from an installation on shore. A source of fluid pressure (not shown) is then connected to the flow line 21 in back of the tool which has been inserted in the line and fluid is pumped through the line 21 in back of the pumpable tool of the present invention until it has passed over the curved section of the flow line and enters the wellhead assembly where it passes down tubing string 23. The tool carrier and its tool will continue to pass down through the tubing string 23 until the body mandrel 50 seats in the landing nipple 36, which action is ascertained at the surface by build-up of pressure in the line. Pumping pressure is then increased (say from 750 p.s.i. to 1500 p.s.i.) until the shear pins 57 and 58 (FIGURE 3) shear in the rope socket closure nipple 56. If spring clips are employed instead of shear pins 57 and 58 to hold the closure member 56 in the cable housing 53, the tension on the clips may be adjusted so that the closure member 56 breaks loose from the bottom of the cable housing 53 when the body mandrel 50 hits with a jar on the seat within the landing nipple 36. After pins 57 and 58 are sheared the weight of the closure member 56, weight bar 63, jars 65 and engaging tool 67 causes the cable or nylon rope 54 to uncoil and drop down out of the cable housing 53. The latching tool 67 together with the jars 65 and weights 63 drop downwardly and pass through the bore 43 in the packer 42 until the latching mechanism 67 engages and connects to the ball-check valve 46 in the nipple 45. In some cases it is sufficient for the latching tool 67 to be secured directly to the closure member 56 without using weight bars 63 or jars 65. However, in many locations the jars 65 provide the additional impact

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to insure engagement of the latching tool 67 with the ball check valve 46 to be retrieved.

Once the latching tool 67 has become connected to the ball-check valve 46, flow through the tubing strings is reversed so that flowing pressure fluid passes down through tubing string 24 and up through tubing string 23 where it would expand the lower sealing member 75 of the tool carrier and force the tool carrier and body mandrel 50 and cable housing 53 upwardly through the tubing string while the weights 63, jars 65 and latching device 67 were pulled out of a packer 42 and up into the bottom of the lower end of the tubing string 23 to trail the tool carrier as it moves upwardly through the tubing string. Although the present system has been described with regard to using dual tubing strings 23 and 24 (FIGURE 2), it is apparent that instead of pumping a pressure fluid down one tubing string 23 and up the other 24, or in the opposite direction, a single tubing string 23 could be employed with flow of fluid being down through tubing string 23 and up through the annular space between the tubing string and the inside wall of the well casing 22, and in the opposite direction. It is also obvious that the apparatus of the present invention may be employed for setting many other devices or retrieving various devices from a well, the only limiting factor being that the devices in their retracted position must be of a size to pass through the tubing string 23. By using the apparatus of the present invention it is possible to retrieve or insert various devices in the well that are a considerable distance below the lower ends 32 and 33 of the tubing strings 23 and 24. Although the landing nipple 36 is shown as being positioned some distance above the packer 25, it is to be understood that the landing nipple 36 and its seat 38 could also be positioned below the packer 25 in place of nipple 30.

I claim as my invention:

1. A well tool adapted to be pumped down one of at least two strings of pipe positioned within a well, said string of pipe having a lower open end and having stop means positioned therein to prevent the passage of a well tool therethrough, said well tool comprising a body member of a diameter small enough to pass through said pipe string, at least a portion of said body member being of a size to engage and be stopped by the stop means of said pipe string, a tool carrier secured to the top of said body member, said tool carrier having sealing element means carried thereon of substantially the same diameter as the pipe string for propelling the well tool through the pipe string in a stream of fluid flowing therethrough, a flexible cable housing secured to the lower end of said body member, releasable closure means carried by the lower end of said cable housing, a length of small-diameter weight supporting cable normally stored and carried within said cable housing, one end of said cable being secured to said cable housing and the other end being secured to said closure means and extendible from said cable housing, and tool means connected to the bottom of said closure means for engaging a device positioned within said well.

2. A well tool adapted to be pumped down one of at least two strings of pipe positioned within a well, said string of pipe having a lower open end and having stop means positioned therein to prevent the passage of a well tool therethrough, said well tool comprising a body member of a diameter small enough to pass through said pipe string, at least a portion of said body member being of a size to engage and be stopped by the stop means of said pipe string, a tool carrier secured to the top of said body member, said tool carrier having sealing element means carried thereon of substantially the same diameter as the pipe string for propelling the well tool through the pipe string in a stream of fluid flowing therethrough, a flexible cable housing secured to the lower end of said body member, an axial flow passageway through said tool carrier and said body member and said cable housing, pressure-responsive check valve means normally closing

said flow passageway to fluid pressure above said tool carrier, releasable closure means carried by the lower end of said cable housing, a length of small-diameter weight supporting cable normally stored and carried within said cable housing, one end of said cable being secured to said cable housing and the other end being secured to said closure means and extendible from said cable housing, and tool means connected to the bottom of said closure means for engaging a device positioned within said well.

3. A well tool adapted to be pumped down one of at least two strings of pipe positioned within a well, said string of pipe having a lower open end and having stop means positioned therein to prevent the passage of a well tool therethrough, said well tool comprising a body member of a diameter small enough to pass through said pipe string, at least a portion of said body member being of a size to engage and be stopped by the stop means of said pipe string, a tool carrier secured to the top of said body member, said tool carrier having sealing element means carried thereon of substantially the same diameter as the pipe string for propelling the well tool through the pipe string in a stream of fluid flowing therethrough, a flexible cable housing secured to the lower end of said body member, an axial flow passageway through said tool carrier and said body member and said cable housing, pressure-responsive check valve means normally closing said flow passageway to fluid pressure above said tool carrier, said valve means being adapted to open under a pressure greater than that needed to actuate the tool carrier, releasable closure means carried by the lower end of said cable housing, connector means releasably securing said closure means to said cable housing, a length of small-diameter weight supporting cable normally stored and carried within said cable housing, one end of said cable being secured to said cable housing and the other end being secured to said closure means and extendible from said cable housing, and tool means connected to the bottom of said closure means for engaging a device positioned within said well, said closure means and tool means having a weight sufficient to fall freely through said well and engage at least a portion of a device therein.

4. A well tool adapted to be pumped down one of at least two strings of pipe positioned within a well, said string of pipe having a lower open end and having stop means positioned therein to prevent the passage of a well tool therethrough, said well tool comprising a body member of a diameter small enough to pass through said pipe

string, at least a portion of said body member being of a size to engage and be stopped by the stop means of said pipe string, a tool carrier secured to the top of said body member, said tool carrier having sealing element means carried thereon of substantially the same diameter as the pipe string for propelling the well tool through the pipe string in a stream of fluid flowing therethrough, a flexible joint in said tool carrier, a flexible cable housing secured to the lower end of said body member, an axial flow passageway through said tool carrier and said body member and said cable housing, a pressure-responsive check valve means normally closing said flow passageway to fluid pressure above said tool carrier, said valve means being adapted to open under a pressure greater than that needed to actuate the tool carrier, releasable closure means carried by the lower end of said cable housing, shear pin connector means releasably securing said closure means to said cable housing, a length of small-diameter weight supporting cable normally stored and carried within said cable housing, one end of said cable being secured to said cable housing and the other end being secured to said closure means and extendible from said cable housing, a weight bar, a flexible joint connecting the top of said weight bar to the bottom of said closure means, a set of jars, a flexible joint connecting the top of said jars to the bottom of said weight bar, a flexible joint connected to the bottom of said jars, and tool means connected to the flexible joint on the bottom of said jars for engaging a device positioned within said well, said tool means being provided with latching elements for selectively engaging and disengaging at least a portion of said device in the well.

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