United States Patent

Pollock, Jr. et al.

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[54] METHOD FOR THROUGH-THE-FLOWLINE TOOL INSTALLATION

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[52] **U.S. Cl.** **166/315**, 166/156

[51] **Int. Cl.** **E21b 23/04**, E21b 43/00

[58] **Field of Search** 166/313, 315, 123, 125, 133, 166/153–156, 193

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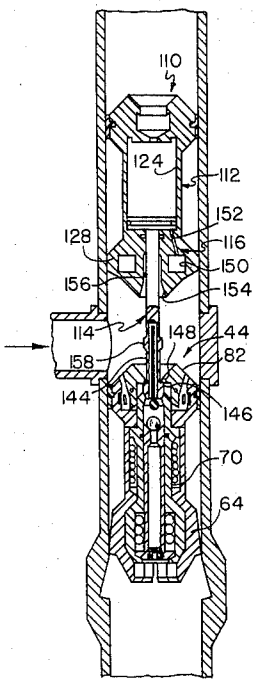
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[57] **ABSTRACT**

There is disclosed a method and apparatus for placing and removing a retrievable tool in a well conduit. The tool is placed by pumping it down the well conduit to a landing area where it is latched in place. The tool is retrieved by pumping a retrieving tool into the conduit into engagement with the retrievable tool and unlatching the retrievable tool with the retrieving tool. The two tools latched together are pumped up the conduit, and the retrieving tool is then disengaged from the retrievable tool when an elevation of lower pressure is reached and both tools are pumped out of the conduit.

5 Claims, 10 Drawing Figures



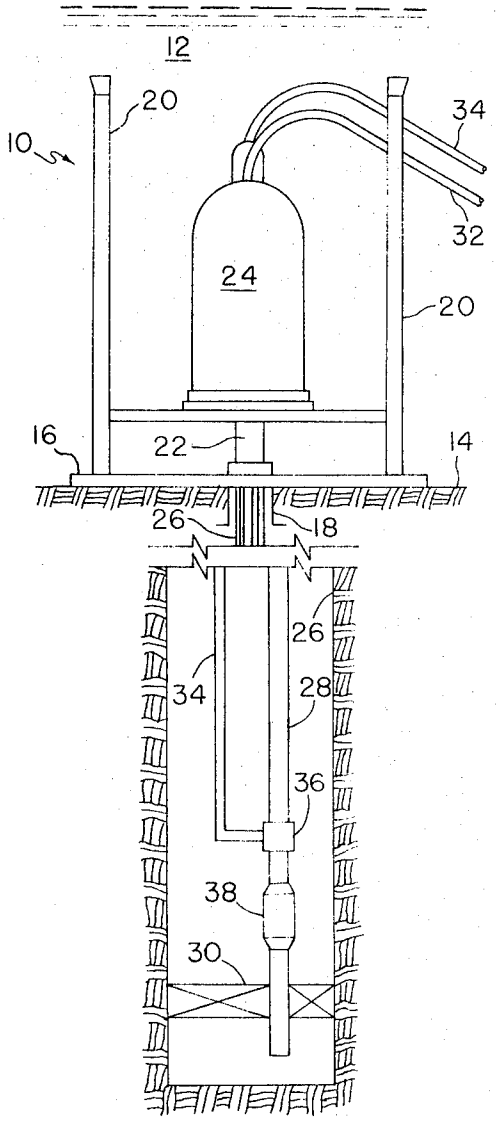


FIGURE 1

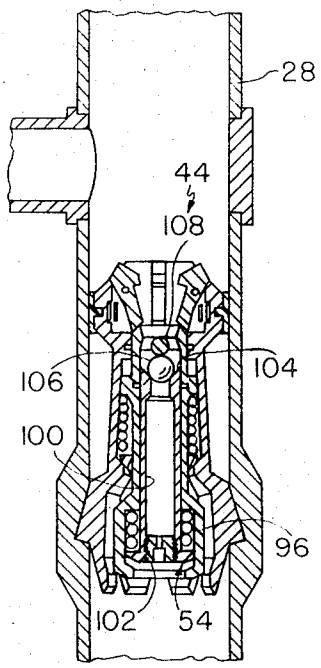


FIGURE 5

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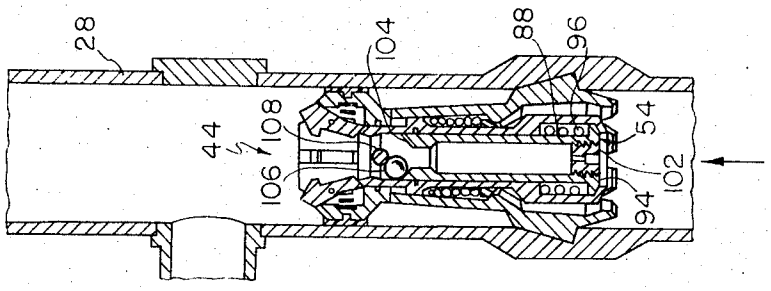


FIGURE 4

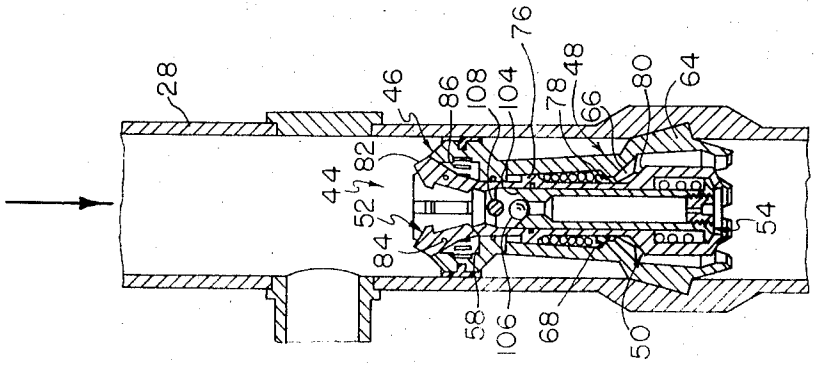


FIGURE 3

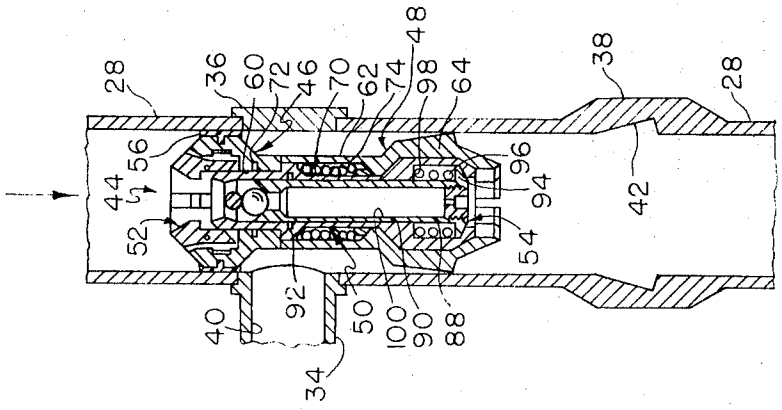


FIGURE 2

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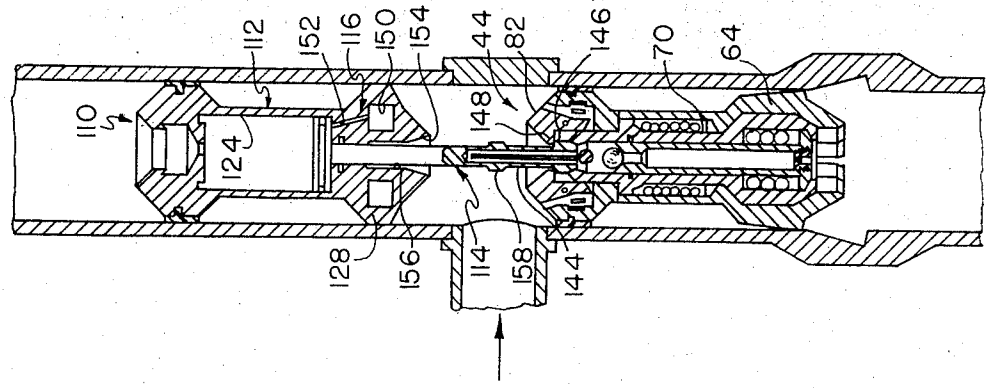


FIGURE 8

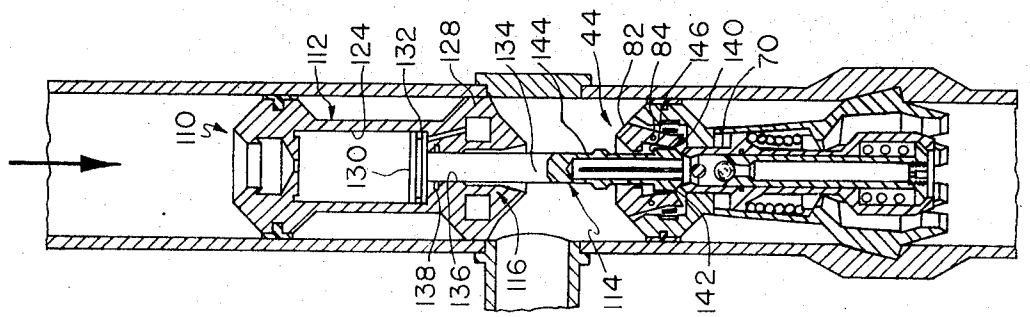


FIGURE 7

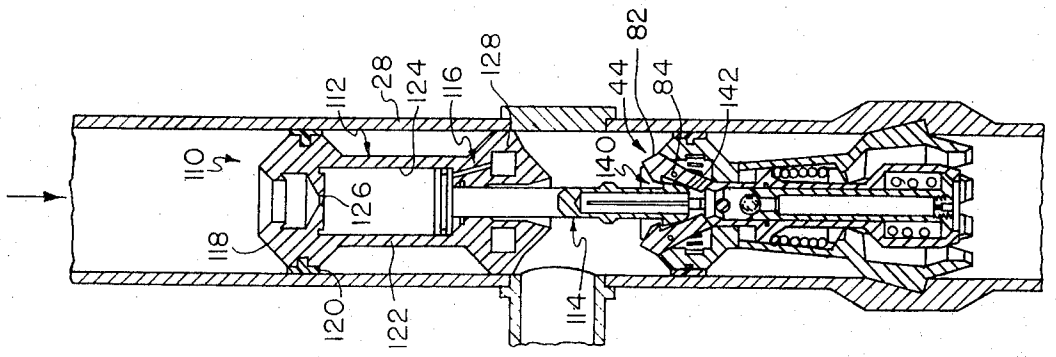


FIGURE 6

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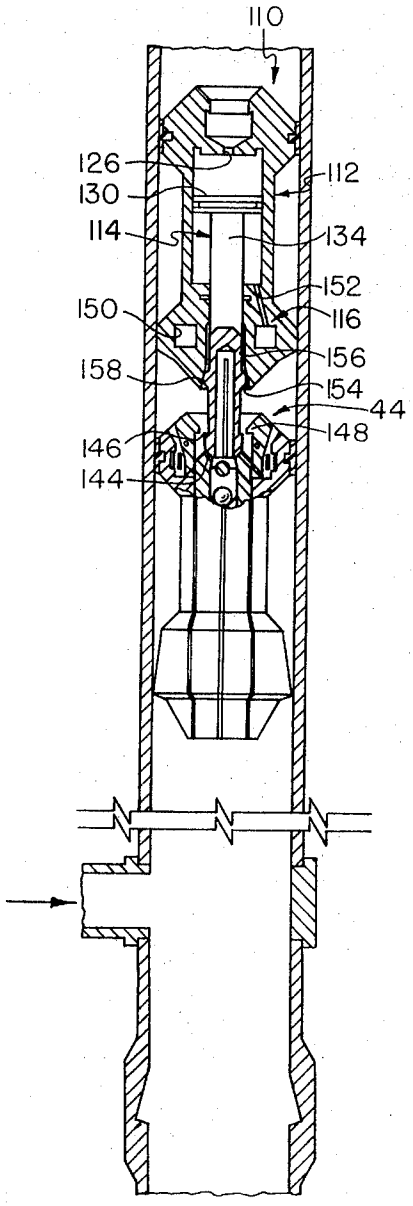


FIGURE 9

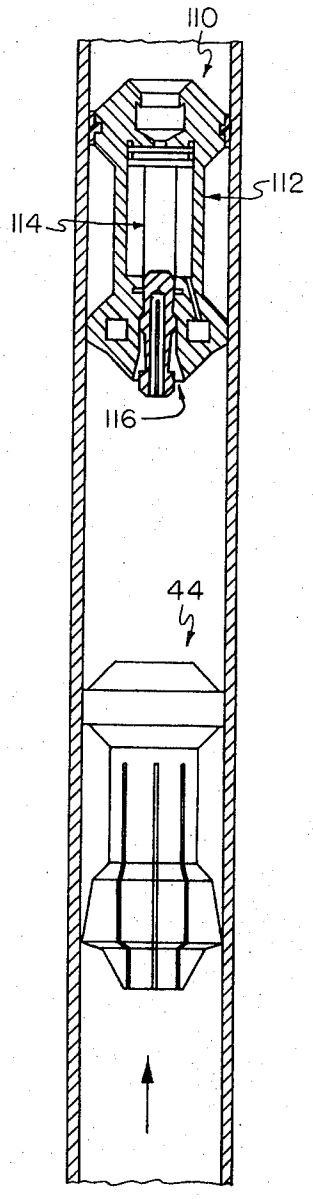


FIGURE 10

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METHOD FOR THROUGH-THE-FLOWLINE TOOL INSTALLATION

BACKGROUND OF THE INVENTION

This invention relates to method and apparatus for rumming well tools into and out of a well conduit. Although the invention has particular application to offshore wells, it will be apparent that the invention is not so limited.

Well tools are conventionally run into and retrieved running a tubing string by wire line equipment. Even on land based wells, this technique is somewhat onerous because of the time and expense necessary to set up the necessary equipment. In an offshore environment where a plurality of wells are produced from a single platform, wire line placement of well tools is considerably more difficult since flow lines leading from the surface are inclined or arcuate. In offshore wells completed with a submerged wellhead, the running of wire line tools is exceptionally difficult and expensive.

Proposals have been made in the prior art to place well tools by locating the well tool in the conduit and applying fluid pressure thereto to move the tool down the flowline to the well. These proposals have provided means for applying fluid pressure in the opposite direction to retrieve the well tool. Exemplary of these proposals are the disclosures in U.S. Pats. No. 3,308,880, No. 3,363,693 and No. 3,378,080.

While these proposals have been successful in placing and retrieving tools through the flowline, there exists room for improvement in techniques for hydraulically placing and retrieving well tools.

Well tools proposed by the prior art which are capable of placement and retrieval through the flowline are typically elongate devices which are incapable of traversing a sharp bend in the flowline. Consequently, care must be taken in underwater completions to avoid sharp bends in the flowline. It is consequently established practice for through-the-flowline tools to provide five foot radius bends in the flowline immediately adjacent the submerged wellhead. Bends of this character are shown in U.S. Pat. No. 3,308,880. Although the use of such bends provides considerable flexibility for the underwater flowline and accommodate passage of conventional through-the-flowline tools, these items constitute an expensive component of the submerged wellhead.

SUMMARY OF THE INVENTION

It is accordingly an object of the invention to provide method and apparatus for placing and retrieving well tools through a flowline having relatively sharp bends therein.

Another object of the invention is to provide method and apparatus for placing and retrieving well tools through curved flowlines.

A further object of the invention is to provide a well tool which is capable of traversing sharp bends in a flowline.

Another object of the invention is to provide a retrieving tool for unlatching a well tool from within a well conduit which is capable of disengagement from the well tool within the conduit.

In summary, a method of pulling a retrievable tool latched in a conduit in accordance with this invention comprises moving a retrieving tool through the conduit into engagement with the retrievable tool, unlatching the retrievable tool from the conduit with the retrieving tool, disengaging the retrieving tool from the retrievable tool and applying fluid pressure to the tools for moving the tools upwardly through the conduit toward the surface.

The retrieving tool of this invention comprises a carrier movable through the conduit, latch means extendable out of the carrier for connection to the retrievable tool and means responsive to decreasing pressure in the conduit for unlatching the latch means from the retrievable tool.

The retrievable tool of this invention comprises first latch means for securing the tool to the conduit, a first reciprocable element having a passage therethrough for manipulating the first latch means, second latch means for holding the first element in a position to hold the first latch means in the latched position, and means for moving the first reciprocable element and thereby manipulating the first latch means comprising a second reciprocable element in the passage of the first element and providing a flow path therethrough, and check valve means in the flow path preventing fluid flow through the tool in one direction.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view diagramatically illustrating an underwater wellhead assembly;

FIGS. 2 and 3 illustrate a sequence of placing a well tool such as a storm choke in the tubing string;

FIG. 4 illustrates the normal operating position of the storm choke of FIGS. 1 and 2;

FIG. 5 illustrates the closed position of the storm choke upon high rates of fluid flow upwardly through the well conduit; and

FIGS. 6–10 illustrate the sequence of retrieving the well tool of this invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Attention is directed to FIG. 1 wherein there is shown a wellhead assembly **10** positioned below the surface of a body of water **12** on the floor **14** thereof. The wellhead assembly **10** comprises a platform **16** secured to the top of a conductor pipe or surface casing **18**. The wellhead assembly **10** may be equipped with a plurality of vertically positioned guide columns **20** which are secured at their lower ends to the platform **16**. A casing head **22** is mounted on top of the surface pipe **18** and has a housing **24** secured thereto. The housing **24** closes the top of the casing head **22** and contains suitable casing and tubing suspension equipment employed in the wellhead assembly **10** as well as control valves of various types.

A casing string **26** is cemented inside the surface casing **18** with a tubing string **28** being disposed in the casing **26** with a suitable packer **30** being used in a conventional manner. A flowline **32** is connected through the housing **24** and casinghead **22** to the tubing string **28** and leads to a production platform or other suitable storage facility. It will be noted that the wellhead assembly **10** is not equipped with the conventional 5 foot radius bend as has been the practice heretofore. The flowline **32** may consequently be subjected to sharp bends and may be connected to the housing **24** by a suitable ell. A control conduit **34** leads from the housing **24** into the well and connects to a fitting **36** to provide control fluid for retrieving a well tool.

It will be apparent to those skilled in the art that this invention may be used in a multiple completion well with control fluid being passed through one of the remaining tubing strings and a suitable crossover. Techniques of this type are shown in U.S. Pat. No. 3,363,693 and No. 3,378,080.

Referring to FIGS. 2 and 3, the tubing string **28** is provided with a landing nipple **38** below the port **40** in the fitting **36**. The landing nipple **38** is illustrated as comprising a recess **42** to provide a landing area for a well tool **44**.

Although many different types of well tools may be positioned and retrieved by the use of this invention, for example separator sleeves, blanking plugs, sidedoor chokes, gas lift valves and the like, the well tool **44** is illustrated as a storm choke. As is known in the art, storm chokes allow the passage of fluid toward the surface at moderate rates of flow and close when the flow rate exceeds a predetermined value.

One of the inherent limitations of a storm choke is its ineffectiveness in wells that make sand. In such circumstances, sand accumulates in and on the storm choke during normal projection flow rates thereby rendering the device inoperative to close the tubing string at high flow rates. For this reason, storm chokes are not typically installed in wells making sand. Sand accumulation necessary to inactive a storm choke may occur rather quickly or over a substantial period of time. The ability to readily remove a storm choke from a wall widens the

applicability of these devices to wells making sand. Indeed, merely moving the storm choke through the tubing string may be suffice to dislodge sand therefrom. Whether storm chokes are replaced at frequent intervals or whether they are merely cycled through the tubing string depends on circumstances of each producing well.

The storm choke **44** has as major components a body or carrier **46** having latches **48** thereon, a reciprocable element **50** for manipulating the latches **48**, second latch means **52** for holding the reciprocable element **50** in a position to retain the latches **48** in the expanded position, and an actuator **54** for moving the reciprocable element.

The body **46** is provided with a two-way seal **56** adjacent the rear end thereof for sealably engaging the interior of the tubing string **28**. The body **46** also provides a rearwardly facing recess **58** and a central passage **60**. The latches **48** are carried by the body **46** and extend toward the front of the choke **44**. The latches **48** may be of any desired type and are illustrated as comprising a plurality of spring fingers **62** having outwardly facing lugs **64** thereon. The interior of the latches **48** are provided with first and second cam faces **66, 68**.

The reciprocable element **50** comprises a mandrel or sleeve **70** extending through the passage **60** in the body **46** with a seal **72** disposed therebetween. The mandrel **70** is biased by a spring **74** operating against an integral flange **76** on the mandrel **70** and reacting against an annular ring **78** slidably disposed about the mandrel **70**. The annular ring **78** presses against the cam face **68** to bias the latches **48** into the latching position as shown in FIG. **3** when the reciprocable element **50** is moved downwardly with respect to the body **46**. It will accordingly be seen that the spring **74** normally biases the reciprocable element **50** toward the position shown in FIG. **3**.

The latches **48** may normally be biased toward the expanded position shown in FIG. **3** and are retracted upon upward movement of the element **50** by coaction of a cam face **80** on the element **50** with the cam face **66**. It will be seen that the well too **44** comprises means for latching the tool in a landing area in the conduit **28** with means being provided to manipulate the latches **48** into an expanded and a retracted position.

Disposed in the recess **58** is the second latch means **52** comprising a plurality of latch elements **82** pivoted about pins **84** and biased toward the center of the tool **44** by suitable springs **86**. As revealed by a comparison of FIGS. **2** and **3**, depression of the sleeve **70** allows the lower ends of the latch elements **82** to pivot inwardly to hold the reciprocable element **50** in the depressed position shown in FIG. **3**. The latch elements **82** are designed to hole the reciprocable element **50** in the depressed position until the second latch means **52** are physically manipulated by a retrieving tool. It will accordingly be seen that the well tool **44** is securely latched in the tubing string **28**.

The actuating element **54** comprises a second reciprocable mandrel or tube **88** slidably positioned in the passage **90** of the sleeve **70**. Suitable seals **92** are provided therebetween. A flange **94** is provided on the mandrel **88** and coacts with a spring **96** and a shoulder **98** on the element **50** to normally bias the mandrel **88** downwardly with respect to the element **50**.

The mandrel **88** provides a flow path **100** therethrough with a removable choke bean **102** threadably engaged in one end thereof. The other end of the mandrel **88** provides a valve seat **104** cooperating with a ball **106** to provide a check valve preventing fluid flow from the top to the bottom of the well tool **44**. A retainer comprising a pin **108** in the end of the sleeve **70** is provided to prevent loss of the ball **106**.

The well tool **44** is placed in the flow line **32** by a suitable manifold or receiver (not shown) and fluid pressure is applied thereto for moving the tool **44** through the flowline **32** and through the tubing string **28** to the landing nipple **38**. It will be apparent that fluid pressure acting against the ball **106** maintains the check valve closed thereby developing a force tending to depress the actuator **54** and the reciprocable element **50**. The reciprocable element **50** and the spring **74** and the inherent bias in the latches **48** tend to move the latches **48** outwardly into a latching position. As the well tool **48** enters the landing nipple, the lungs **64** are free to move outwardly into the recess **42** and thereby prevent further downward movement of the tool **44**. In order to lock the tool **44** in the landing nipple **38**, additional pressure is applied through the flow line **32** by suitable equipment. As the pressure adjacent the rear of the tool **44** builds up, the spring **74** is compressed and the reciprocable element **50** is depressed. As the upper end of the sleeve **70** passes under the free end of the latch elements **82**, the latch elements **82** are biased inwardly to retain the element **50** in the position shown in FIG. **3**.

Referring now to FIGS. **4** and **5**, the landed well tool **44** is illustrated as a storm choke and functions to allow flow therethrough toward the surface at moderate rates of flow and closes at abnormally high rates of flow. The flow bean **102** is selected to produce a pressure drop across the actuator **54** at a predetermined abnormally high rate of flow sufficient to compress the spring **96** and thereby advance the mandrel **88**. Upward movement of the mandrel **88** causes the retainer **108** to position the ball **106** in sealing relation with the seat **104** thereby closing the flow path **100** as shown in FIG. **5**.

It will accordingly be seen that production through the tubing string **28** is halted upon the occurrence of abnormally high rates of flow. Production may be re-established if the pressure below the storm choke **44** subsides sufficiently to allow the spring **96** to expand into the position shown in FIG. **4**. Production may also be established by retrieving the well tool **44** and reinserting the same.

An important feature of this invention resides in the method and apparatus for retrieving the well tool **44**. Referring now to FIGS. **6–10**, there is shown a retrieving tool **110** having as major components a body or carrier **112**, movable means **114** for connection to the well tool **44** and means **116** responsive to decreasing pressure in the tubing string **28** for unlatching the movable means **114** from the tool **44**. In operation, the retrieving tool **110** is pumped down the tubing string **28** until the movable means **114** engages and connects to the well tool **44**. The well tool **44** is unlatched from the tubing string **28** by the retrieving tool **110**. The retrieving tool **110** and well tool **44** are then pumped upwardly through the tubing string **28**, the pressure responsive means **116** acting to disengage the retrieving tool **110** from the well tool **44**. It will be apparent that when the tools **44, 110** are separated, they have the capability of negotiating bends of smaller radius than when the tools are connected together.

The body **112** comprises a piston like head **118** having a two directional seal **120** thereon for sealably engaging the inside of the tubing string **28**. A cylindrical extension **122** provides a bore **124** in fluid communication with the rear end of the body **112** through a port **126**. The front of the body **112** provides a head **128**.

The movable means **114** comprises a piston **130** operative in the bore **124** and sealed thereagainst by a suitable piston ring **132**. A piston rod **134** extends through a passage **136** in the head **128** with a seal **138** being provided for the piston rod **134**. The free end of the piston rod **134** provides cam and latch means **140** for unlatching the well tool **44** and for connecting the well tool **44** to the retrieving tool **110**. The cam and latch means **140** is provided with cam surfaces **142** for engaging the latch elements **82** below the pivot pins **84** to bias the latch elements **82** outwardly into the position shown in FIG. **7**.

The cam and latch means **140** is illustrated as comprising a plurality of individual spring members **144** machined from the end of the piston rod **134**. Each of the spring members **144** comprises a shoulder **146** coacting with an oppositely facing shoulder **148** on each of the latch elements **82** as shown in FIG. **8**.

The pressure responsive means **116** is illustrated as comprising a chamber **150** in the head **128** of the body **112** communicating with the bore **124** through a passage **152**. The pressure responsive means **116** also comprises cam means pro-

vided by the head **128** comprising a conical cam face **154** and a cylindrical retention surface **156** cooperating with a protuberance **158** on each of the spring members **144**.

It is desirable for the retrieving tool **110** to disengage automatically from the well tool **44**. THe pressure responsive means **116** is so designed and the chamber **150** is accordingly prefilled with a pressurized fluid through a suitable filling port (not shown). As the retrieving tool **110** rises in the tubing **28**, the hydrostatic pressure applied to the piston **130** through the port **126** decreases. The pressure in the chamber **150** is selected to bias the piston **130** upwardly some distance above the landing nipple **38** but below the casinghead **22**. Although any suitable depth for disengagement may be used, a practical area for disengaging the tools **44**, **110** is at about a thousand feed below the casinghead **22**.

The overall operation of the retrieving tool **110** should now be apparent. The retrieving tool **110** is inserted in a suitable receiver or manifold (not shown) connected to the flowline **32**. Pressure is applied to the flowline **32** to propel the retrieving tool **110** through the flowline **32** and into the tubing string **28**. As will be apparent, the pressurized fluid in the chamber **150** will position the movable means **114** in the retracted position shown in FIG. **10** during movement of the tool **110** through the flowline **32** and through part of the tubing string **28**. As the retrieving tool **110** passes downwardly through the tubing string **28**, the hydrostatic pressure applied against the piston **130** through the port **126** gradually overcomes the pressure applied on the opposite side of the piston by the fluid in the chamber **150**. As this depth is passed, the piston **130** moves downwardly with respect to the body **112** into the attitude shown in FIG. **6**. When the retrieving tool **110** contacts the well tool **44** as shown in FIG. **6**, additional pressure is applied through the flow line **32** to advance the retrieving tool **110** thereby enabling the cam surfaces **142** to bias the latch elements **82** out of engagement with the mandrel **70**.

Pressure is then applied through the control conduit **34** to move the retrieving tool **110** upwardly into the relationship shown in FIG. **8**. It will be seen that the mandrel **70** moves upwardly causing retraction of the latch elements **64** from the landing nipple **38**. Pressure is applied through the control conduit **34** and the flowline **32** is opened. There is consequently a sizeable pressure drop across the retrieving tool **110**, as compared to the pressure drop across the well tool **44**, thereby propelling the retrieving tool **110** together with the well tool **44** upwardly through the tubing string **28**. As the retrieving tool **110** passes into the unlatching zone, pressure in the chamber **150** is sufficient to bias the piston **130** upwardly against hydrostatic pressure in the tubing string **28**. The piston rod **134** is thereby withdrawn into the body **12** forcing the protuberances **158** against the conical cam surface **154** thereby collapsing the spring members **144** toward the axis thereof. The shoulders **146** thereupon pass inside the shoulders **148** as shown in FIG. **9**.

Continued pumping through the control conduit **34** causes the retrieving tool **110** and the well tool **44** to pass separately through the casinghead **22** and the flowline **32** into a suitable receiver or manifold (not shown) at the storage location. It will be apparent that the reduced length of the separate tools, as compared to the overall length of the connected tools, enables the tools **110**, **44**, to negotiate bends of substantially shorter radius than the prior art. Consequently, great pains and expense need not be made to eliminate short bends from the flowline **32**. As will be appreciated, this is of particular importance in offshore underwater completions but is of considerable utility in other environments.

We claim as our invention:

1. The method of pulling a retrievable tool latched in a landing area in a well conduit comprising the steps of:

moving a retrieving tool downwardly through the conduit into engagement with the retrievable tool;

connecting the retrieving tool to the retrievable tool;

unlatching the retrievable tool from the landing area with the retrieving tool;

raising the connected tools to a higher elevation in the well conduit;

disconnecting the retrieving tool from the retrievable tool; and

applying fluid pressure to the tools for moving the same upwardly through the conduit toward the surface.

2. The method of claim **1** wherein the moving step comprises connecting the retrieving tool to the retrievable tool upon engagement therewith and further comprising, after the unlatching step, raising the retrieving tool and the retrievable tool together from the landing area.

3. The method of claim **2** wherein the conduit comprises a port, a control conduit connected thereto, the landing area being below the port and wherein

the raising step comprises raising the tools together to a location above the port.

4. The method of claim **3** wherein the pressure applying step comprises passing fluid through the control conduit into the conduit for flowing the tools through the conduit.

5. The method of claim **3** wherein the retrieving tool is on one side of the port and the retrievable tool is on the other side thereof during the unlatching step and wherein the raising step comprises

applying fluid pressure through the conduit between the retrieving tool and the retrievable tool; and

maintaining pressure in the conduit above the retrieving tool less than the pressure in the conduit below the retrievable tool.

* * * * *