May 5, 1959 W. L. LONG ET AL 2,885,006

WELL FLOW CONTROL AND ANCHORING DEVICE

Filed Nov. 3, 1952 3 Sheets-Sheet 1

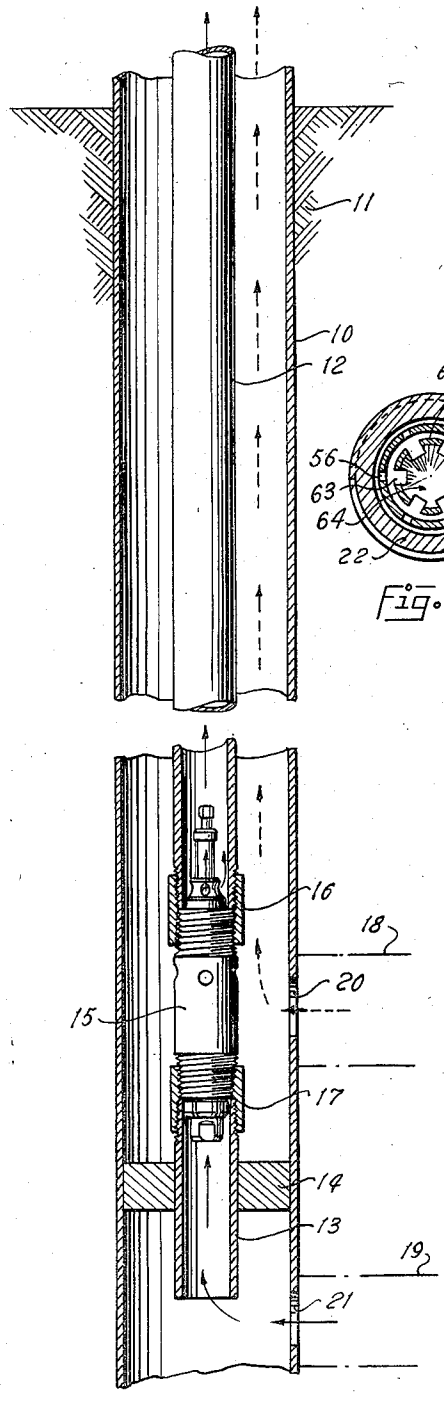


Fig. I

Fig. III

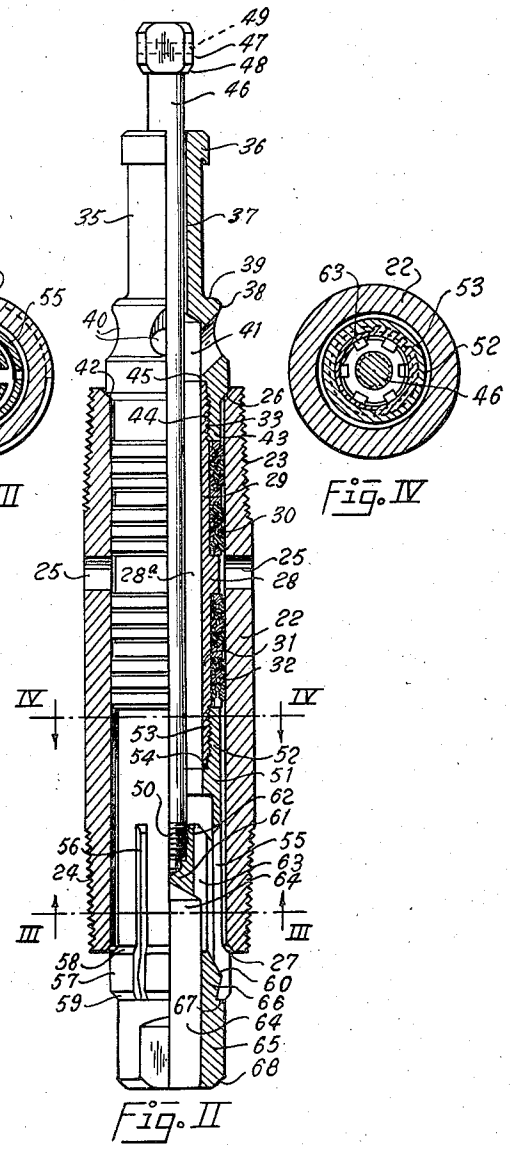


Fig. II

Fig. IV

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WELL FLOW CONTROL AND ANCHORING DEVICE

Filed Nov. 3, 1952 3 Sheets-Sheet 2

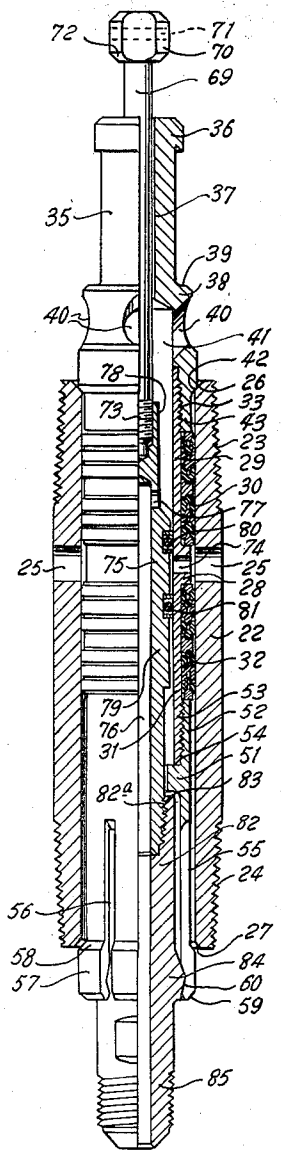


Fig. V

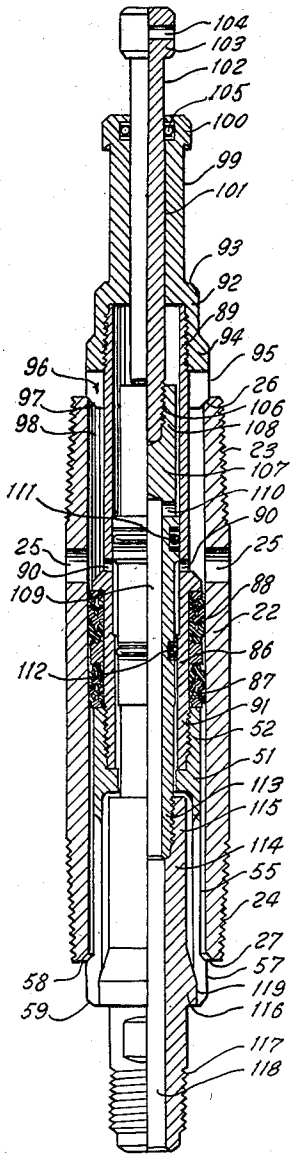


Fig. VI

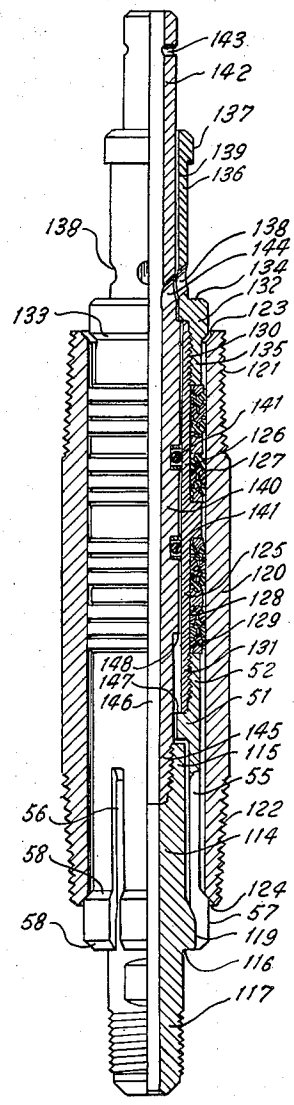


Fig. VII

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WELL FLOW CONTROL AND ANCHORING DEVICE

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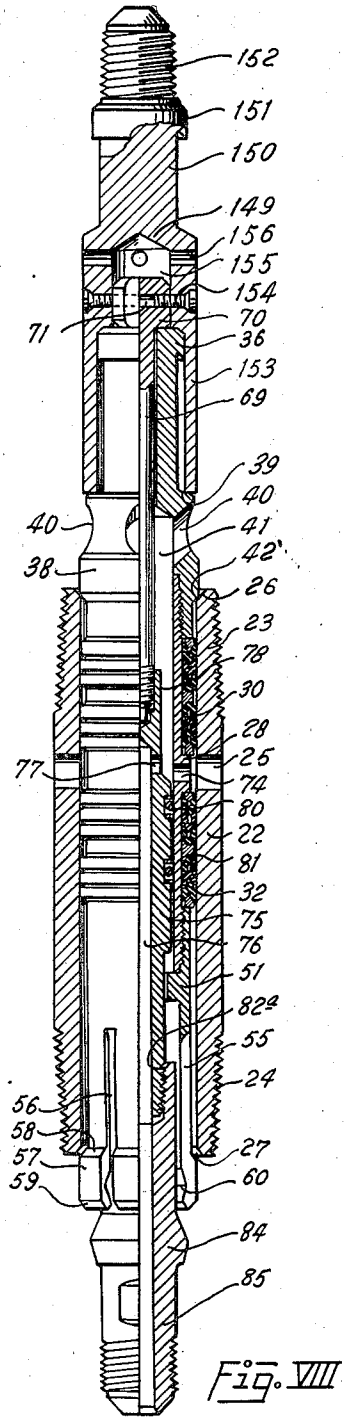


Fig. VIII

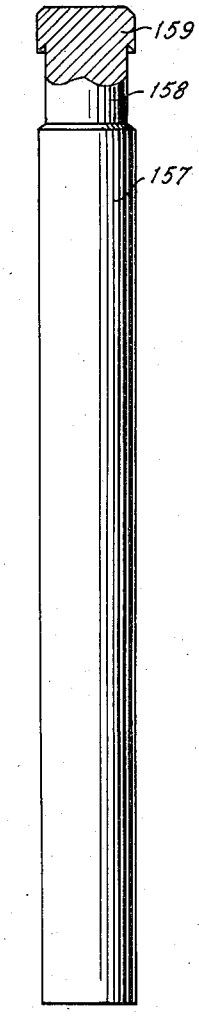


Fig. IX

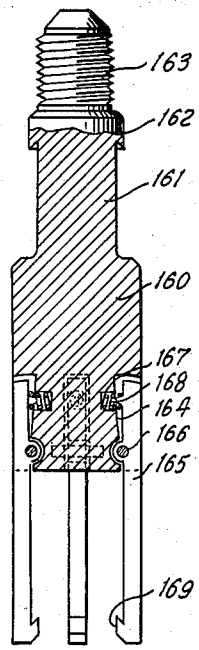


Fig. X

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United States Patent Office 2,885,006
Patented May 5, 1959

2,885,006

WELL FLOW CONTROL AND ANCHORING DEVICE

William L. Long and Temple P. Hoffer, Dallas, Tex., assignors to Pressure Services, Inc., Dallas, Tex., a corporation of Texas

Application November 3, 1952, Serial No. 318,364

13 Claims. (Cl. 166—125)

This invention is concerned with subsurface flow control and anchoring tools to be used in an oil well, and is particularly concerned with a tool which may be removably mounted in the tubing string of an oil well to direct and control the flow of fluids in the well and provides improved means for locating and anchoring standard flow control devices in oil and gas wells.

A primary object of this invention is to provide a subsurface flow control and anchoring tool wherein the locking means therefor are located at the lower end of the nipple and outside of the bore of the nipple, so that sand and other foreign matter in the tubing will not settle on the locking means.

Another important object of this invention is to provide a subsurface flow control and anchoring tool wherein the locking means are located at the lower end and outside of the bore of the nipple, so that maximum flow passage is provided through the tool.

Another very important object of this invention is to provide such a tool wherein the flow through the tool is directed around the fishing neck thereon, so that the flow from the well may be utilized to provide a cleaning and flushing action about the fishing neck on the tool, in order that sand and other foreign material in the tubing cannot settle about the upper end of the tool. Thereby standard retrieving tools can be readily engaged with the fishing neck of the tool, and thereby many difficulties, as recited above, are eliminated. It has been a practice in the past to use bailers to remove the foreign material collected on top of the tool before the tools can be removed. This operation will be rendered unnecessary by the use of our invention.

Still another object of our invention is to provide means for equalizing pressure across such a tool prior to removing it from the well, which eliminates the problem of having the tool entangled with a wire line and with the retrieving equipment.

A still further object of our invention is to provide a basic structure in such a tool that may be set and operated in a nipple of standard length and diameter, with standard locking means, so that certain basic components may be utilized by an operator to perform a variety of operations required in dually and singly completing wells. At the present time operators are required to purchase many special tools at great expense to perform various operations in singly and dually completed wells. The present invention, by slight modification, can be made to serve several of these operations, resulting in great economy to the operator.

Other and further objects of our invention will become apparent upon reading the detailed specification hereinafter following and by referring to the drawings, in which suitable structure is shown for carrying out our invention.

In the drawings:

Fig. I shows an elevational view of one of our flow control and anchoring devices mounted in a string of tubing in an oil well which has been dually completed;

Fig. II shows a partially sectionalized elevational view of a form of our tool which may be employed to separate two producing zones in a dually completed well;

Fig. III is a cross-sectional view taken along the line III—III of Fig. II;

Fig. IV is a cross-sectional view taken along the line IV—IV of Fig. II;

Fig. V is a partially sectionalized elevational view of a form of our tool in which is employed an equalizing valve;

Fig. VI is a partially sectionalized elevational view of a modified form of our tool employing an equalizing valve;

Fig. VII is a partially sectionalized elevational view of a form of our tool which may be employed as an anchor in the tubing for supporting a subsurface flow control device of standard manufacture;

Fig. VIII is a partially sectionalized elevational view showing the device of Fig. V with a conventional setting tool attached thereto, and with the equalizing valve therein in open position and the locking means therefor in unlocked position;

Fig. IX shows a partially sectionalized elevational view of a typical sinker bar which may be dropped into the tubing for the purpose of actuating the equalizing valve in our device; and

Fig. X shows a partially sectionalized elevational view of a suitable form of retrieving tool for retrieving our device from the tubing after it has been unlocked.

The various parts of the devices as shown in the drawings are indicated by numeral references, and like parts are indicated by like numerals throughout the various figures of the drawings.

The numeral **10** indicates a string of casing disposed in a bore in the earth **11**, such casing having a string of tubing **12** extending therethrough.

A conventional packer **14** is disposed within the casing and about a section of tubing **13**.

A well apparatus **15**, made in accordance with our invention, is connected to the upper section of tubing **12** by means of a coupling **16**, and to the lower section of tubing **13** by means of a coupling **17**.

The well apparatus **15** is employed for the purpose of separating an upper zone of production **18** from a lower zone of production **19**. The upper zone **18** produces through the port **20** in the casing and through the annulus between the tubing and the casing as indicated by broken arrows, and the lower zone **19** produces through the port **21** in the casing, the section of tubing **13** and the well apparatus **15** and through the tubing **12**, as indicated by the solid arrows.

Fig. I shows a typical mounting of one of our well apparatuses in a string of tubing.

A typical well apparatus is shown in Fig. II, wherein a nipple **22**, having threads **23** on its upper end and threads **24** on its lower end, and a plurality of flow ports **25** through its wall, is adapted for attachment in a string of tubing in the manner shown in Fig. I.

The nipple **22** has an internal beveled shoulder **26** at its upper end and an internal beveled shoulder **27** at its lower end, such beveled shoulders serving the purpose of guiding the tool hereafter described into the nipple.

A packing mandrel **28** is disposed within the nipple **22**, such packing mandrel having a bore **28a** therein. The packing mandrel **28** is cut away, as indicated at **29**, for the purpose of forming a receptacle for the upper V-packing **30**; and the packing mandrel **28** has a cutaway portion, as indicated at **31**, for the purpose of receiving the lower V-packing **32**. The packings **30** and **32** provide a seal between the nipple **22** and the packing mandrel **28**.

The packing mandrel **28** is externally threaded at its

upper end, as indicated at 33, and is externally threaded at its lower end, as indicated at 53.

The setting head 35 has a fishing head 36 thereon, which fishing head is adapted to be engaged with a standard fishing tool for the purpose of retrieving the tool from the well. The setting head 35 has a bore 37 therethrough and a stop head 38 at the lower end thereof. A shoulder 39 is provided on the stop head 38, on which shoulder the skirt of a conventional setting tool may come to rest.

A plurality of angularly disposed flow ports 40 are provided through the wall of the stop head 38 and communicate with the hollow portion 41 of the stop head.

A beveled stop shoulder 42 is provided about the stop head 38 and such shoulder 42 is adapted to mate with and seat upon the beveled shoulder 26 at the upper end of the nipple 22, to thereby limit the movement of the stop head 38 into the nipple 22.

A reduced extension 43 is provided on the lower end of the stop head 38, such extension being internally threaded as indicated at 44, such internal threads mating with the external threads 33 on the upper end of the packing mandrel 28. A shoulder 45 is provided within the stop head 38 to limit the inward movement of the packing mandrel 28 into the stop head.

A locking stem 46 extends through the bore 37 of the setting head 35, such locking stem having an enlarged head 47 thereon. The locking stem 46 slidably extends through the bore 37 and closes such bore to the flow of fluid therethrough, so that fluid flowing upwardly in the flow passage (comprised of the bore 64, passages 63 and bore 28*a*) is diverted through the flow ports 40. The head 47 has a stop shoulder 48 on the lower circumference thereof, such shoulder 48 being adapted to engage with the upper end of the fishing head 36, thereby limiting the inward movement of the stem 46 into the bore of the setting head 35.

A threaded hole 49 is provided through the locking stem head 47, such hole being provided for the purpose of receiving shear screws which engage the locking stem head 47 to a conventional running tool which will be hereinafter described.

The stem 46 is threaded at its lower end as indicated at 50.

The locating prong head 51 has an internally threaded extension 52 thereon, such threaded extension being screwed to the threads 53 on the lower end of the packing mandrel 28. The shoulder 54 on the inner side of the locating prong head 51 limits the movement of the lower end of the packing mandrel 28 into the locating prong head extension 52.

A plurality of locating prongs 55 extend downwardly from the locating prong head 51, such locating prongs 55 being spaced apart by cutout slots 56 therebetween. The prongs 55 are thus made resilient for the purposes which will be hereinafter described.

Each of the locating prongs 55 has a head 57 on the lower end thereof, each of such heads having a beveled upper surface 58 and a beveled lower surface 59. The heads 57 each have a recess 60 therein.

The locking mandrel 61 has an internally threaded extension 62 thereon which is threaded to the threads 50 on the lower end of the stem 46. A plurality of passages 63 are cut through the upper end of the locking mandrel 61 to permit the flow of fluid therethrough from the bore 64 of the locking mandrel.

An enlarged head 65 is provided on the locking mandrel 61, such head having a portion 66 thereon which is adapted to engage with the recesses 60 in the prong heads 57 for the purpose of preventing the prongs 55 from springing inward and thereby locking and setting the flow control device in the nipple 22 after it has been run into the tubing in the manner which will be hereinafter described.

A shoulder 67 is formed on the head 65 for the purpose of engaging with the lower end of the prong head 57, so as to prevent the upward movement of the locking mandrel after it has been set. The lower end of the head 65 is beveled as indicated at 68, in order to guide the head over obstructions in the tubing while being run.

The flow control device shown in Fig. II, and described above, is removably locked in the nipple 22, which in turn is mounted in the tubing string in the manner shown in Fig. I. By the employment of such device in dually completed wells, the upper and lower zones 18 and 19 are separated and the production therefrom kept separate as required by law. Furthermore, a well can be circulated to kill the well, by admitting well fluid or mud to the interior of the tubing through the ports 25 in the wall of the nipple 22, when the flow control device is removed. The device can also be used to inject acidizing fluid into the lower zone separate from the upper zone. It can also be employed to test the lower zone independently of the upper zone.

In the operation of the device shown in Fig. II, seating nipple 22 is placed in the tubing string and connected thereto by the use of couplings such as 16 and 17. A conventional running tool, such as that indicated by the numeral 149 in Fig. VIII, the construction and operation of which will be hereinafter described, is placed on top of and over the setting head 35, so that the lower end of the skirt 153 rests on the shoulder 39. When so disposed over the head 35, the locking stem 46 is pushed downward and the head 47 is connected to the running tool by means of shear screws such as those shown at 154.

With stem 46 thus pushed downward, the locking dog 66 is pushed downward out of engagement with the heads 57 on the locating prongs 55. The running tool is then connected to conventional stroke jars which are in turn connected to a wire line and the assembly is then lowered into the tubing.

When the heads 57 on the locating prongs 55 reach and rest upon the upper end of the seating nipple 22, the jars are actuated and the resilient locating prongs are sprung inward and caused to slide through the seating nipple 22. The downward movement of the assembly into the sleeve 22 is arrested when beveled surface 42 strikes beveled surface 26 and further movement of the assembly into and through the nipple is prevented. When this position is reached, the heads 57 on the locating prongs 55 are below the lower end of the nipple 22 and are allowed to spring outward underneath the lower end of the nipple.

After the assembly is so run into the nipple 22, the wire line is manipulated to jar the running tool upwardly. As the running tool is pulled upwardly, the locking stem 46 is likewise jerked upwardly. This moves the locking mandrel 61 upwardly and brings the locking head 66 into the recess 60 in the head 57 of the locating prongs 55, thus preventing the inward collapse of the locating prongs.

The control device is thus locked in the seating nipple against upward and downward movement. The stem 46 and the locking mandrel 61 are held against downward movement by the head 66 being disposed in the recess.

The continued jarring upward on the stem 46 shears the screws holding the setting tool to the head 47, so that the running tool may be removed from the tubing by means of the wire line connected thereto. The setting operation of the control device is thus completed.

The means of removal of the control device from the seating nipple 22 will be hereinafter described.

When the flow control assembly is thus disposed in the nipple, a flow of fluid is permitted through the bore 64, the passages 63, the bore 28*a*, and the flow ports 40. It is thus seen that the flow is thus directed about the setting head 35, so that such flow will prevent the settling of sand and other foreign matter in the tubing upon and about the setting head.

It is also to be noted that the locking means, consisting of the heads 57 on the prongs 55, are disposed below and outside of the seating nipple 22, so that there is no restriction of flow through the device by disposing the locking means inside of the nipple, as has been the practice in the past.

Furthermore, the locking means are disposed below the seating nipple so that no foreign matter in the well may settle upon them and prevent them from operating.

Fig. V shows a form of our well apparatus in which an equalizing valve is incorporated.

In such device a locking stem 69 has a head 70 thereon with shear screw holes 71 therein, and a stop shoulder 72 is provided on the lower side of such head. A threaded portion 73 is provided on the lower end of the stem 69. The tubular packing mandrel 28 is the same in construction as that shown and described in Fig. II, save and except that it is provided with a plurality of flow passages or ports 74 through its wall.

The valve mandrel 75 has a bore 76 therein and a plurality of flow passageways 77 through its wall. An internally threaded extension 78 is provided on the valve mandrel 75, and such threaded extension receives the threaded portion 73 of the stem 69.

An enlarged annular section 79 is provided on the valve mandrel 75, and an upper packing ring 80 and a lower packing ring 81 are disposed about the section 79. The packing rings are so disposed that they straddle the flow ports 74 when the assembly is in locked position, as shown in Fig. V.

The locking mandrel 82 is threadedly connected to the lower end of the valve mandrel 75, as indicated at 82*a*, and the upper end of locking mandrel 82 provides a shoulder 83 which engages with a complementary shoulder on the locking prong head 51.

A locking knot 84 is provided on the locking mandrel 82 and is adapted to engage with the heads 57 on the locking prongs 55 to retain the prongs in engagement with the lower end of the nipple 22, in the manner which was described in connection with Fig. II.

A threaded extension 85 is provided on the lower end of the locking mandrel 82 for the purpose of connecting thereto a conventional subsurface flow control device, if desired.

The equalizing valve arrangement provided for in Fig. V is for the purpose of equalizing pressures across the tool before pulling it from the tubing, in order to prevent the flow control assembly from being blown up the tubing when it is released from the nipple.

The assembly shown in Fig. V is run into the well and connected to the tubing in the same manner as was described in connection with Fig. II.

It is to be noted, however, that when the locking stem 69 is in down position, as shown in Fig. VIII, flow ports 25, 74 and 77 are in communication with each other, and the tool is run into the well in such position.

When the locking stem 69 is jerked upwardly, in order to lock the flow control assembly in the nipple 22, the valve mandrel 75 is moved upwardly and the flow ports 77 and flow ports 74 are moved out of communication with each other and are separated by the packing ring 80. Thus the pressure outside of the nipple 22 is isolated from the pressure inside of the bore 76 and bore 41. Thus, the upper zone of production is separated from the lower zone of production when the tool is set in the nipple in the tubing string.

Prior to pulling the flow control assembly from the nipple, a sinker bar, similar to that shown in Fig. IX, indicated by the numeral 157, is released into the tubing and allowed to fall therein. Such sinker bar strikes the top of the locking stem 69 and drives it downwardly, thus bringing the flow ports 77 into communication with the flow ports 25 and 74. The pressure in the casing on the outside of the nipple 22 and the pressure in the tubing are thus allowed to equalize. After the pressures have been thus equalized, the sinker bar 157 may be fished from the tubing by conventional fishing tools which engage with the head 159 and the neck 158 of the sinker bar. The flow control assembly is then removed from the tubing in the manner which will be hereinafter described in connection with all of the devices shown in the drawings.

In Fig. VI is shown a modified form of flow control device with an equalizing valve arranged therein. In such modified form a packing mandrel 86 is provided with a recess 87 therein for the purpose of receiving the V-packing 88. An externally threaded upper extension 89 is provided on the packing mandrel 86 and a plurality of flow ports 90 are provided through the wall thereof. An externally threaded lower extension 91 is provided on the packing mandrel 86, which threaded extension 91 is connected to the threaded extension 52 on the locking prong head 51.

A stop head 92 is provided, having a shoulder 93 on which the skirt of a running tool may come to rest.

An internally threaded skirt 94 is provided on the stop head 92, and such skirt is sectioned so as to provide a plurality of legs 95 thereabout, between which legs 95 there are flow passages 96 which communicate with the flow passage 98 between the nipple 22 and the upward extension 89 of the packing mandrel 86.

The legs 95 have beveled lower ends, as indicated by the numeral 97, which beveled ends are arranged to engage with the beveled surface 26 of the nipple 22 and thus prevent further downward movement of the flow control assembly into the nipple.

The stop head 92 has a neck portion 99 with a fishing neck 100 on the upper end thereof; and the neck 99 has a bore 101 therethrough through which the setting stem 102 slideably passes.

The setting stem 102 has an enlarged head 103 thereon, which head has threaded holes 104 therein for the purpose of receiving shear screws to connect the said head to a running tool.

A packing ring 105 is provided between the stem 102 and the bore 101.

The lower end of the stem 102 is threaded, as indicated at 106, and such threaded end is screwed to the internally threaded upper extension 108 of the valve mandrel 107.

The valve mandrel 107 has an internal bore 109 and flow ports 110 through its wall, which flow ports communicate with bore 109.

An upper packing ring 111 is arranged about the valve mandrel 107; and a lower packing ring 112 is arranged about said valve mandrel, the said packing rings 111 and 112 sealing between the valve mandrel 107 and the inner wall of the packing mandrel 86.

It is to be noted that when the assembly is in the position shown in Fig. VI, the packing ring 111 separates the flow passages 110 and the flow passages 90.

The valve mandrel 107 has an externally threaded lower extension 113 which is screwed to the internally threaded upper extension 115 of the locking mandrel 114.

A locking knot 116 is provided on the locking mandrel 114, for the purpose of engaging with the heads 57 of the locking prongs 55 and holding such heads in engagement with the lower end of the nipple 22.

A threaded extension 117 is provided on the lower end of the locking mandrel 114 for the purpose of attachment of subsurface flow control devices of conventional design.

A bore 118 is provided through the locking mandrel 114 which communicates with the bore of the valve mandrel 109.

The locking heads 57 on the locking prongs 55 are the same in construction as that shown and described in Fig. II, save and except that there is no recess 60 on the inner side thereof and the lower inner surface is

straight, as indicated at 119. The recess 60 may be eliminated in this form because it is not necessary to provide a detent to prevent the locking mandrel from moving downward. The frictional engagement of the packing with the stem 102 and the packing mandrel 86 is sufficient to hold the locking head up.

The structure provided by Fig. VI enables the tool to be used to plug off the lower zone in a dually completed well, and at the same time permits the inside of the tubing above the flow control device to communicate through ports 25, the passageway 98 and the flow ports 96 with the annulus between the casing and the tubing. Such a tool is required when it is necessary to treat the upper zone of a well with acid separate from the lower zone, and also when it is desired to take the bottom-hole pressure of the upper zone separate from the lower zone.

It is believed apparent that when the tool shown in Fig. VI is set in the position shown therein, and the nipple 22 is connected in the tubing in the manner shown in Fig. I, the upper zone is isolated from the lower zone, because there can be no flow through the bores 118 and 109 and about the stem 102.

The tool shown in Fig. VI is connected and run into the tubing in the same manner as was described in connection with Fig. II.

The ports 90 and 110 are brought into communication by dropping a sinker bar into the tubing in the same manner as was described in connection with Fig. V, in order to equalize the pressures across the tool before pulling it from the tubing.

In some instances the pressure in the tubing below the flow control device may be greater than the pressure above it when the flow control device shown in Fig. VI is used, and provision is therefore made to balance the forces inside the device created by pressure differentials across the device.

In the flow control device shown in Fig. VI the outside area of the packing ring 111 is equal to the sum of the inside area of the packing ring 105 and the outside area of the packing ring 112. Pressure from below the device acts on the packing rings 105 and 112 to tend to move the stem 102 and valve mandrel 107 upwardly. The same pressure acts downwardly on the packing ring 111, so that upwardly and downwardly acting pressures are equalized. Therefore, the stem 102 and valve mandrel 107 may be easily pushed downward to bring the ports 90 and 110 into communication to equalize the pressure across the device, even though the pressure below the device greatly exceeds the pressure above it.

In Fig. VII there is shown a device made in accordance with our invention which may be used as a pack-off and anchoring device for conventional bottom hole pressure regulators, safety shutoff valves and other flow control devices, which may be attached beneath and screwed on to the bottom of the anchoring tool.

In such form, shown in Fig. VII, a nipple 120 is provided with threads 121 on its upper end and threads 122 on its lower end, which nipple may be connected in a tubing string in the manner shown in Fig. I.

The nipple 120 is provided with a beveled surface 123 on its upper end and a beveled surface 124 on its lower end for the purpose of providing engaging surfaces for the upper end of the tool disposed therein and a locking shoulder at the lower end of such tool.

Packing mandrel 125 has an upper packing recess 126 and a lower packing recess 128, for the purpose of receiving the packing elements 127 and 129 respectively.

The packing mandrel 125 has an externally threaded upper end 130 and an externally threaded lower end 131.

The stop head 132 has a beveled shoulder 133 on the lower face thereof, which shoulder 133 comes into engagement with the shoulder 123 when the pack-off device is moved into the nipple 120, to thus limit further movement of the pack-off device into the nipple.

An upper shoulder 134 is provided on the stop head 132 for the purpose of receiving the skirt of a running tool and providing a stop therefor.

An internally threaded lower extension 135 is provided on the stop head 132, which threaded extension is engaged with the threaded extension 130 of the packing mandrel 125.

A neck portion 136 extends upwardly from the stop head 132, and such neck portion has a fishing head 137 on the upper end thereof and a bore 139 therethrough.

A plurality of angularly disposed flow passages 138 are provided through the neck 136.

A main mandrel 140 is slideably disposed in the packing mandrel 125 and has packing rings 141 disposed thereabout and between the main mandrel and the packing mandrel 125.

The main mandrel 140 has an upwardly extending neck portion 142, such neck portion having threaded shear screw holes 143 in the upper end thereof for the purpose of receiving shear screws to attach a running tool to such neck. The main mandrel 140 has a bore 146 extending therethrough, and a plurality of angularly disposed flow passages 144 extend through the wall thereof, such flow passages registering with and communicating with the flow passages 138 and the bore 146 when the tool is in set position, as shown in Fig. VII.

An externally threaded extension 145 is provided on the lower end of the main mandrel 140, which threaded extension is screwed to the extension 115 of the locking mandrel 114.

A stop shoulder 147 is provided on the locking prong head 51 for the purpose of limiting the downward movement of the main mandrel 140 when the external shoulder 148 on the main mandrel 140 engages the shoulder 147.

The tubular locking mandrel 114 is the same in construction and operation as the locking mandrel 114 described in Fig. VI, and has a threaded extension 117 on the lower end thereof for the purpose of attachment thereto of a conventional pressure regulating device, with which the bore 146 of the flow control assembly may communicate.

It will be noted that fluid may flow through the bore 146 and through the stem 142, and fluid may also flow through the angularly disposed ports 144 and 138 and about the neck 136, so that no sand or debris in the tubing can collect about said neck.

The tool shown in Fig. VII is run and set in the nipple 120 in the same manner as the tool is run and set as described in connection with Fig. II, and it may be released and pulled from the sleeve 120 with conventional pulling tools as will be hereinafter described.

In Fig. VIII is shown a conventional running tool 149 attached to the flow control device as shown in Fig. V, in the position in which the running tool is attached for setting the flow control device in the nipple 22 after the nipple has been incorporated in a tubing string, as shown in Fig. I.

The running tool 149 has an upwardly extending neck 150, which neck has a fishing head 151 thereon. A threaded extension 152 extends upwardly from the fishing head 151, such threaded extension being provided for the purpose of attachment of a conventional jar connected to a wire line on which the tools are run into the tubing.

The running tool 149 has a downwardly extending skirt 153 thereon, the lower end of which skirt rests on the shoulder 39 when the running tool is attached to the head 70 on the stem 69.

A plurality of shear screws 154 pass through the wall of the running tool 149 and into the holes 71 in the head 70, thereby frangibly attaching the running tool to the head 70.

A plurality of passages 156 are provided through the wall of the running head and communicate with the bore 155 thereof in order to equalize the pressure between the outside of the running head and the interior portion 155.

It will be noted that the stem 69 is pushed downward so that the head 70 rests on the upper side of the fishing head 36. The valve mandrel 75 and locking mandrel 82 are likewise pushed downward, so that the flow port 77 is in communication with the flow ports 25 and 74, thus equalizing the pressure on the outside of the sleeve 22 and the interior of the packing mandrel 28 and the interior of the valve mandrel 75. The locking knot 84 is out of engagement with the prongs 55, so that the prongs may flex inward and slide through the nipple 22. When the heads 57 on the locking prongs 55 have passed beyond the lower end of the nipple, they will spring outwardly into engagement underneath and outside of the nipple.

After the flow control assembly is pushed through the nipple 22 to the position shown in Fig. VII, the setting tool 149 may be jerked upwardly, thus bringing the locking knot 84 into engagement with the insides of heads 57 on the locking prongs 55, thus retaining the locking prongs 55 against inward movement, thus retaining the locking prong heads 57 in engagement with the underside of the nipple 22. Further jerking upwardly on the setting tool 149 will break the shear screws 154 and allow the setting tool 149 to be removed from the tubing, thus leaving the flow control device in locked position in the nipple.

The conventional running tool 149 may be employed for the purpose of setting all of the various forms of the flow control assembly shown in the drawings. It is attached by means of shear screws to the upward extension or head on the setting stem on each of the forms shown, in the same manner as is disclosed in Fig. VIII, and each of the respective flow control devices are moved through and set in its respective nipple in the same manner as was described in connection with Fig. VIII.

When it is desired to unlock either of the flow control devices from its respective nipple, in order to remove the flow control device from the nipple and from the tubing, the sinker bar, as shown in Fig. IX, may be released in the upper end of the tubing and the falling force thereof will strike the upward extension of the stem in each of the flow control devices and knock it downward, thus actuating the equalizing valve as elsewhere described. Use of the sinker bar permits the pressure across the tool to be equalized before it is unlocked from the nipple, and eliminates the danger of the tool being blown up the hole and becoming entangled with the conventional wire line and retrieving tools. Conventional retrieving tools may be used for unlocking and removing the tool from the nipple after the pressure is equalized.

Of course, where there is no differential in pressure across the tool, as when it is used as a subsurface anchor, it can be unlocked and removed from the well by conventional retrieving tools run into the tubing on a wire line.

A conventional retrieving tool, suitable for retrieving the flow control device from the nipple, is shown in Fig. X and indicated by the numeral 160. Such retrieving tool has a neck portion 161 with a fishing head 162 thereon. It also has an upper threaded portion for the purpose of attaching same to a wire line, as indicated by the numeral 163.

Recesses 164 are provided in the sides of the body of the fishing tool in which the arms 165 are disposed, such arms being pivoted to the retrieving tool by means of pivot pins 166. Holes 167 are provided in the recesses 164 for the purpose of receiving springs 168, which springs are engaged with the upper ends of arms 165. Hooks 169 are provided on the ends of arms 165, such hooks being for the purpose of engaging the fishing head on either of the flow control tools herein disclosed and described. Such arms 165 may be sprung outward when the retrieving tool 160 is lowered onto the fishing head and spring over same to engage the under side thereof, so that the flow control device may be removed from the nipple. Also, the retrieving tool may be used for the purpose of engaging with the head 159 of the sinker bar 157 for the purpose of retrieving it from the tubing.

The arms 165 are so arranged that the solid portion of the retrieving tool 160, at the lower end thereof, will engage the head of the locking stem of the tool being removed from the well and push it downward to engagement with the fishing head thereon at the same time that the hooks 169 come into engagement with the underside of the fishing head. Thus the locking knot on the locking mandrel is pushed out of engagement with the locking prongs, so that the flow control device may be easily pulled upward through the nipple in which it is disposed, by virtue of the fact that the locking prongs are free to spring inward and slide along the inner wall of the nipple.

It is to be understood that other and further modifications and changes may be made in the invention as disclosed and still remain within the spirit and scope of the invention and the appended claims.

We claim:

1. In a well apparatus; a nipple adapted to be incorporated in a string of tubing and having a flow port through the wall thereof; a tubular member slideably disposed in said nipple and having a passage through the wall thereof normally in communication with the said flow port; packing means disposed above and below the said flow port and passage and being arranged between the interior wall of the nipple and the exterior wall of the tubular member so as to separate the area outside of the tubing from the area inside of the tubing; a hollow head carried by the upper end of said tubular member engageable with the upper end of said nipple to limit downward movement of the tubular member in the nipple, said hollow head having one or more flow passages through the side wall thereof; a plurality of resilient locking prongs carried by the lower end of the tubular member and arranged to engage with the lower end of the nipple to prevent upward movement of the tubular member in the nipple; a hollow valve mandrel slideably disposed in the tubular member and having a passageway through its wall communicating with the hollow portion thereof and with the hollow portion of the head; a stem attached to the upper end of said valve mandrel and extending centrally through the head; packing means about the mandrel and sealingly engaging the inner wall of the tubular member above and below the passage in the wall of the tubular member, the upper of said packing means being positioned between the passage in the tubular member and the passageway in the wall of the mandrel, the said passageway being normally out of communication with the port and flow passage when the valve mandrel is in raised position, but being arranged to communicate with the port and flow passage when the valve mandrel is moved downwardly in the tubular member.

2. Claim 1, with the addition of a locking knot carried by the lower end of said valve mandrel and arranged to engage the locking prongs to prevent their inward movement while engaged with the lower end of the nipple.

3. In a well apparatus, a nipple having a flow port through its wall; a tubular member slideably carried in the nipple; such member having a flow passage in its wall normally in communication with the flow port; a hollow valve mandrel slideably disposed in the tubular member and having a flow passageway through its wall, said flow passageway being normally out of communication with the flow passage and flow port; a sealing ring arranged about the valve mandrel and engaging the inner wall of the tubular member and separating the flow port and the flow passageway when the valve mandrel is in raised position; a sealing ring about the valve mandrel

below the flow port and separating the flow port from the interior of the tubular member below the said sealing ring; a hollow head carried by the upper end of the tubular member and having side openings therethrough, said side openings being normally in communication with the flow port, said head resting on the upper end of the nipple; a stem slideably extending longitudinally through the head, and being attached to the upper end of the valve mandrel, whereby external force may be applied to the stem to lower the valve mandrel in the tubular member to bring the flow port and flow passageway into communication; a sealing ring about the stem and sealing between the inner wall of the head and the stem; resilient locking means carried by the lower end of the tubular member and engaged with the lower end of the nipple; the contacting area of the first named sealing ring being equal to the sums of the contacting areas of the second and third named sealing rings.

4. Claim 3, with the addition of an enlarged hollow head carried by the lower end of the valve mandrel, said head being engaged with the resilient locking means to prevent their inward movement.

5. In a well apparatus, a nipple; a tubular member slideably disposed in the nipple; packing arranged about the tubular member and sealing between the inner wall of the nipple and the exterior wall of the tubular member; a hollow head carried by the upper end of the tubular member and engaged with the upper end of the nipple, said head having flow passages through the wall thereof; a hollow cylindrical member slideably disposed in the tubular member, the hollow cylindrical member having flow ports through the wall thereof through which the hollow portion of the cylindrical member communicates with the flow passages in the hollow head; packing arranged about the cylindrical member below the flow ports and sealing between the inner wall of the tubular member and the exterior wall of the cylindrical member; a stem carried by the upper end of the cylindrical member and extending longitudinally through the head; resilient locking means carried by the lower end of the tubular member and engaged with the lower end of the nipple.

6. Claim 5 with the addition of a locking head carried by the lower end of the cylindrical member and engaged with the resilient locking members to prevent their inward movement.

7. In a well apparatus, a nipple having a flow port through its wall; a tubular member slideably disposed in the nipple; packing about the tubular member above the flow port and being arranged to seal between the interior wall of the nipple and the exterior wall of the tubular member; packing about the tubular member below the flow port and being arranged to seal between the interior wall of the nipple and the exterior wall of the tubular member; the said packings separating the area outside of the nipple from the area inside of the tubular member when the nipple is incorporated in a string of tubing; a hollow stop head carried by the upper end of the tubular member and having flow ports through its wall, said stop head being engaged with the upper end of the nipple; resilient locking means carried by the lower end of the tubular member and engaged with the lower end of the nipple; a stem slideably extending longitudinally through the stop head; and a locking head carried by the lower end of the stem, said locking head being engaged with the resilient locking means to prevent their inward movement.

8. Claim 7 with the addition of a flow passage through the locking head, said flow passage communicating with the interior of the tubular member.

9. Claim 7 wherein the resilient locking means are a plurality of elongated flexible prongs spaced apart by slots, said prongs having enlarged heads thereon engaged with the lower end of the nipple outside of the nipple.

10. In a well apparatus; a nipple adapted to be incorporated in a string of tubing; a flow control device slidably disposed in the nipple; said flow control device including a tubular member; a hollow head on the upper end of said tubular member arranged to engage the upper end of the nipple to limit downward movement of the flow control device in the nipple; a stem slidably extending through the said head; resilient locking means carried by the lower end of said tubular member, said locking means being arranged to engage with the lower end of said nipple to prevent upward movement of the flow control device in the nipple; means carried by the stem and engageable with the locking means to hold same in engagement with the nipple; a flow passage through the flow control device; flow ports through the side of said head communicating with the said flow passage; said stem closing the flow passage above the flow ports to divert the upward flow of fluid in the passage through the flow ports.

11. In a well apparatus, a nipple adapted to be incorporated in a string of tubing; a flow control device slidably disposed in said nipple; said flow control device including a tubular member; means carried by the upper end of the tubular member and engageable with the nipple for limiting the downward movement of the flow control device in the nipple; means carried by the lower end of the tubular member and engageable with the nipple for limiting the upward movement of the flow control device in the nipple; a flow passage through the flow control device, said flow passage being open to permit the flow of fluid therethrough in upward or downward direction; an extension of the flow control device extending above the nipple; one or more flow ports through the side wall of said extension and communicating with the flow passage; a control member slidably extending through the tubular member and extension for operating the upwardly limiting means; said control member closing the flow passage in the extension above the flow ports, whereby fluid passing through the flow passage is directed through the flow ports and about the extension.

12. In a well apparatus; a nipple adapted to be incorporated in a string of tubing; a flow control device slidably disposed in said nipple; said flow control device including a tubular member; means carried by the upper end of the tubular member and engageable with the nipple to limit downward movement of the flow control device in the nipple; releasable means carried by said tubular member and engageable with the nipple to limit upward movement of the flow control device in the nipple; means for actuating the releasable means; a flow passage through the flow control device, said flow passage being open to permit the flow of fluid therethrough in upward or downward direction; an extension of the flow control device extending above the nipple; one or more flow ports through the side wall of said extension and communicating with the flow passage; and means closing the flow passage in the extension above the ports to divert the upward flow of fluid in the passage through the flow ports while the downward limiting means is engaged with the nipple, whereby fluid passing through the flow passage is directed through the ports and about the extension on the flow control device.

13. In a well apparatus, a nipple adapted to be incorporated in a string of tubing; a flow control device slidably disposed in the nipple; said flow control device including a tubular member; a hollow head on the upper end of the tubular member engageable with the upper end of the nipple to limit downward movement of the flow control device in the nipple; resilient means carried by the tubular member and engageable with the nipple to prevent upward movement of the flow control device in the nipple; means for actuating the resilient means; a flow passage through the flow control device, said flow passage being open to permit the flow of fluid therethrough in upward or downward direction; said head having one or more ports through its side wall

communicating with the flow passage; and means closing the flow passage above the ports to divert the upward flow of fluid in the passage through the flow ports when the head is engaged with the nipple, whereby flow may be directed about the head.

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