Dec. 13, 1955 L. M. WILHOIT ET AL 2,726,723

OIL WELL TOOLS

Filed Sept. 6, 1952

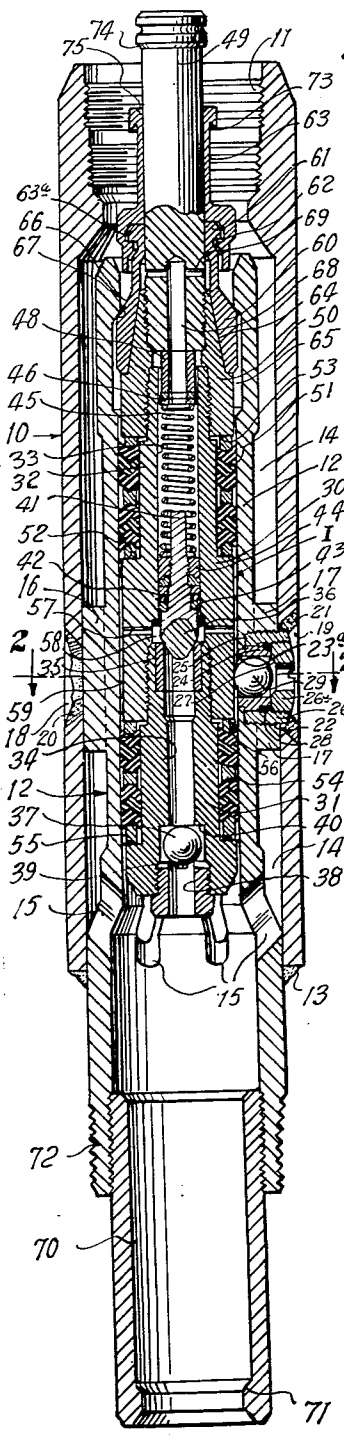


Fig. 1

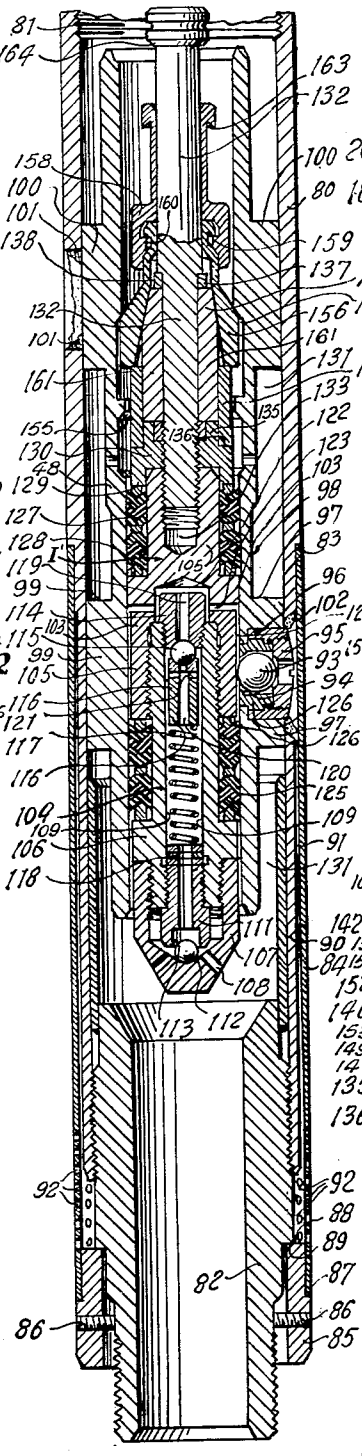


Fig. 3

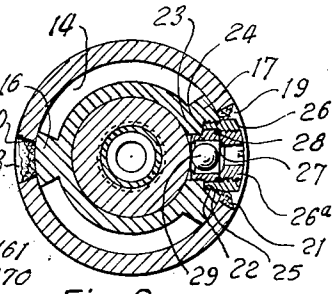


Fig. 2

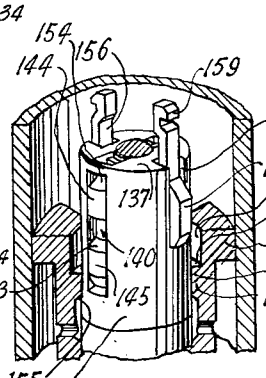


Fig. 4

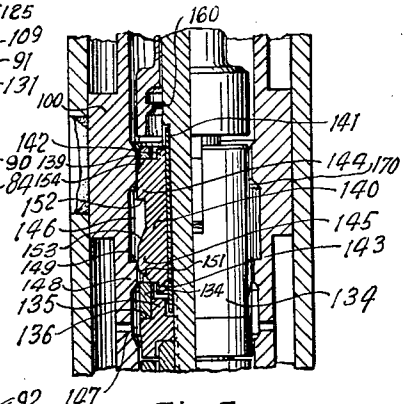


Fig. 5

Lowell M. Wilhoit
Harry B. Schramm
Herbert C. Otis

INVENTORS

BY

ATTORNEY

United States Patent Office 2,726,723 Patented Dec. 13, 1955

2,726,723

OIL WELL TOOLS

Lowell M. Wilhoit, Harry B. Schramm, and Herbert C. Otis, Dallas, Tex.

Application September 6, 1952, Serial No. 308,202

22 Claims. (Cl. 166—224)

This invention relates to oil well tools and more particularly to a well tool for use in injecting fluids into the flow string or tubing of a well.

One object of the invention is to provide a well tool for use in injecting fluids into the flow string or tubing of a well for the annulus exteriorly of the flow tubing.

Another object of the invention is to provide a chemical injector for flow strings of wells having an insertable and removable injector control mechanism whereby the flow of well fluids through the flow string may be unobstructed when injection of chemical fluids into the flow string is unnecessary.

Still another object of the invention is to provide a chemical injector having a housing and landing nipple permanently connected in the flow string and an injector mechanism which may be selectively placed in and removed from the housing and landing nipple, and wherein the housing and landing nipple are provided with a lateral flow passage from the exterior to the interior thereof valved to control flow through said inlet, the valve being operable by the injector mechanism.

A further object of the invention is to provide an injector mechanism having an adjustable valve whereby the rate of injection of the chemical fluids into the flow string may be predetermined.

A still further object of the invention is to provide a well tool of the character described wherein the landing nipple and injector mechanism are provided with selectively mating positioning and locking members whereby injector mechanisms may be selectively positioned in any selected one of a plurality of housings and landing nipples connected at vertically spaced positions in a well flow conductor.

Additional objects and advantages of the invention will be readily apparent from the reading of the following description of devices constructed in acordance with the invention and reference to the accompanying drawings thereof, wherein:

Figure 1 is a vertical sectional view of the chemical injector showing the injector mechanism in position in the landing nipple and the housing.

Figure 2 is a horizontal sectional view taken on the line 2—2 of Figure 1,

Figure 3 is a vertical sectional view of a modified form of the chemical injector,

Figure 4 is a fragmentary perspective view, with some parts shown in section, of the positioning and locking device of the injector mechanism of the injector illustrated in Figure 3, and

Figure 5 is a fragmentary view, partly in elevation and partly in section, taken at right angles to the view of Figure 3, and showing the positioning members of the positioning and locking device in locating position.

Referring now to the drawings, the numeral **10** designates a housing whose upper end is internally threaded, as at **11**, for connection to a pipe or joint of tubing (not shown) forming a part of the flow string of a well. The

lower end of the housing is rigidly secured to a landing nipple **12** by a weld **13** or in any other suitable manner. The landing nipple is reduced above the lower end of the housing to provide an annular flow passage **14** between the housing and the landing nipple. A plurality of apertures **15** in the wall of the landing nipple provide communication between the central bore of the landing nipple and the annular passage **14** between the nipple and the housing.

The landing nipple is provided with a pair of opposed outwardly extending flanges **16** and **17** which are aligned with a pair of lateral openings **18** and **19**, respectively, in the housing and are rigidly secured to the housing by welds **20** and **21**, respectively, in said openings. The flange **17** is larger than the other flange and is provided with a lateral flow port or bore **22** having its inner portion reduced to form a shoulder **25** in said bore, and a valve seat sleeve **23** disposed in the bore has an external annular flange **24** which abuts the annular shoulder **25** in the bore or port. The valve seat sleeve has an inner valve seat **23***a* at its inner end. A valve seat positioning ring **26** is threaded in the port and is internally threaded to receive a valve retaining ring **26***a* having at its inner end a second or outer valve seat **27**. An O-ring or seal **28** is disposed in an external annular recess between the reduced outer end of the valve seat sleeve **23** and the positioning ring **26** and engages both said sleeve and said ring to seal therebetween. The O-ring is retained in place in the recess by the inner end of the valve retaining ring **26***a*. A ball valve **29** is disposed in the bore of the valve seat sleeve between the inner and outer valve seats to close the bore against fluid flow therethrough in either direction, the ball valve being seated on one or the other of the valve seats in accordance with the direction of flow.

An injector mechanism or choke I may be removably positioned in the landing nipple to cause the ball valve **29** to be moved outwardly to allow flow of fluids from the exterior of the housing into the interior of the landing nipple.

The injector mechanism includes a sealing or packing mandrel **30** having a lower section **31** threaded into an upper section **32**, the upper and lower sections having aligned axial bores **33** and **34**, respectively. The upper portion of the bore **34** of the lower section **31** of the packing mandrel is enlarged to receive an annular valve seat **35** which is disposed to be engaged by a valve **36** slidably mounted in the bore **33** of the upper section **32** to close off downward flow through the bore **34** of the lower section of the mandrel. The lower portion of the bore **34** of the lower mandrel section is also enlarged to receive a ball check valve **37** and a retaining bushing **38** threaded in the lower end of the bore. The bushnig **38** is provided with a plurality of lateral slots **39** in its upper end so that fluid may flow downwardly past the ball check valve when it is supported thereon. Upward flow of fluid through the bore is prevented, however, since the ball check valve will be lifted into engagement with the downwardly facing annular seat **40** at the upper end of the enlarged bore to close said bore.

The valve **36** has a stem **41** which extends upwardly in the central bore **33** of the upper section **32** of the mandrel. An O-ring sealing assembly **42** is disposed about the valve stem to prevent passage of fluid between the valve stem and the bore wall of the mandrel. The sealing assembly is held in place on the stem between an annular shoulder **43** on said stem above the valve and a retaining ring **44** threaded on the reduced upper end of said stem.

The valve **36** is biased downwardly toward the valve seat **35** by a compression spring **45** disposed in the

bore 33 of the upper mandrel section and having its opposite ends bearing against the retaining ring 44 and the lowermost of a plurality of spacer rings 46. The spacer rings are held in place by the lower end of an elongate neck member 49 which has such lower end threaded into the upper end of an expander sleeve or lock mandrel 50, which in turn is threaded on the upper end of the upper section 32 of the packing mandrel. The number and thickness of the spacer rings controls the compressive force of the spring.

A chevron packing assembly 51, disposed on the upper section 32 of the packing mandrel between an upwardly facing annular shoulder 52 on said upper section and the downwardly facing lower end 53 of the locking mandrel, seals between the landing nipple and the upper section of the packing mandrel to prevent flow of fluid therebetween. A similar chevron packing assembly 54, disposed on the lower section 31 of the packing mandrel between an upwardly facing annular shoulder 55 on said lower section and the downwardly facing lower end 56 of the upper mandrel section, seals between the landing nipple and the lower section of said packing mandrel to prevent flow of fluid therebetween.

A plurality of lateral ports or openings 57 are formed in the lower portion of the upper section of the packing mandrel, and these ports communicate with the enlarged lower portion 58 of the bore 33 of the upper section adjacent the valve 36 and with the annular space 59 between the injector mandrel and the landing nipple. It will be noted that the lateral port 22 of the landing nipple also communicates with the annular space 59 when the ball valve is displaced outwardly by the injector mandrel, as shown in Figures 1 and 2.

The injector mechanism I is held in place by slips or dogs 60 which swing on hooks 61 at their upper ends engaging over an internal annular flange 62 in the bore of a slip carrier 63 slidably disposed on the neck member 49. The slips are moved outwardly by the downwardly and outwardly beveled surface 64 of the locking mandrel 50 when the latter is moved upwardly relative to the slips. When moved outwardly, the slips enter into an internal annular recess 65 in the bore of the landing nipple and their upper shoulders 66 engage a downwardly facing shoulder 67 at the upper end of the recess in the landing nipple to prevent upward displacement of the injector mechanism out of said landing nipple.

In order to equalize the fluid pressure acting upwardly through the bore 34 of the lower section of the valve 36, the neck member 49 is provided with an axial bore 68 in its lower end and with lateral ports 69 communicating with said axial bore so that the valve may be subjected to fluid pressure from above acting downwardly on the valve, the fluid in the annular passage 14 between the housing and the landing nipple thus having access to the bore 33 of the upper section above the valve 36 to substantially equalize fluid pressures thereacross. Since the area of the sealing assembly 42 is greater than the area of the valve exposed to fluid pressure in the bore of the seat 35, the valve will be normally urged into seating engagement with the seat by the fluid pressure acting on the sealing assembly. This fluid pressure augments the force exerted by the spring 45 acting on the valve.

A sub 70 may be threaded into the lower end of the landing nipple, the sub having a bore substantially equal to and aligned with the bore of the landing nipple. If desired, an internal annular stop flange 71 may be provided in the lower end of the bore of the sub. This sub provides for seating a valve and packing mechanism for closing off all flow through the bore of the housing and landing nipple.

In use, the housing 10 is connected in the flow string of a well by means of the internal threads 11 at its upper end and the external threads 72 at its lower end.

Well fluids will then flow upwardly through the sub 70, the landing nipple and the housing. The pressure of the fluids will move the ball valve 29 into closed position on the valve seat 27 in the lateral port 22 so that no fluid will be allowed to escape through said port 22 to the exterior of the housing.

When it becomes desirable to inject fluids, such as chemical treating compositions or the like, into the flow string the injector mechanism I is lowered into the flow string by means of any suitable running tool (not shown) which is connected to the annular grooved flange 74 on the upper end of the neck member 49. The slips 60 and carrier 63 are slidable longitudinally on the locking mandrel 50 and may move upwardly relative to the neck member until the upper end 75 of the slip carrier engages the underside of the annular flange 74 at the upper end of the neck member. In this position, the slips 60 are retracted.

The injector mechanism I is lowered until the slips are positioned adjacent the annular groove 65 of the landing nipple. An external annular flange 63*a* on the slip carrier engages the beveled upper end of the landing nipple 12 to limit downward movement of the injector mechanism in the nipple, slack in the line on which the running tool is suspended indicating that the injector mechanism is positioned in the nipple.

When the slips are thus positioned adjacent the annular recess 65, the line is pulled upwardly to cause upward movement of the locking mandrel relative to the slips. The beveled surface 64 will then move the slips outwardly into the groove, whereupon said slips engage the annular shoulder 67 of the landing nipple to lock the injector mechanism in place in the landing nipple.

The ball valve 29 is held out of engagement with the inner valve seat 23*a* by the injector mandrel to permit flow of fluid pumped between the exterior of the housing and the well casing (not shown) inwardly through the port 22 into the annular space 59 between the injector mandrel and the landing nipple. The fluid may then flow through the lateral openings 57 in the upper mandrel section into the enlarged portion 58 of the bore of said upper mandrel section. The pressure of the fluid will act upwardly against the sealing assembly 42 to force the valve 36 to move upwardly against the force of the spring 45 to open the bore 34 of the lower mandrel section. The fluid will then flow downwardly through the bore 34 past the ball check valve 37 and into the bore of the landing nipple. Here the fluid commingles with the well fluids which flow upwardly through the apertures 15 in the landing nipple into the annular passage 14 between the landing nipple and the housing, and thence upwardly past the slip carrier into the upper sections of the flow string and ultimately to the surface. The rate of flow of the injected fluids can be set by adjusting the compression of the spring 45 before the injector mechanism is lowered into the flow string. The rate of flow can be decreased by adding spacer rings 46 or increased by removing one or more of these rings.

If it is desired to stop the injection of fluids for a certain period of time, it is merely necessary to stop pumping the fluids into the well casing. The valve 36 and the ball valves 37 and 29 will prevent flow of well fluids from the tubing string outwardly through the port 22 into the well casing.

When it is determined that further injection of fluids will not be needed, the injector mechanism may be removed by lowering a pulling tool, such as that shown in the patent to H. C. Otis, 1,898,261, on a line to engage and strike a downward glow on the upper end of the neck member 49 to move the locking mandrel 50 downward. This permits the slips to move inwardly to retracted position, whereupon the pulling tool may engage beneath the shoulder 73 of the slip carrier and lift the entire injector mechanism upwardly.

It will be seen now that a well tool for injecting fluids

into the flow string of a well has been provided which includes a housing **10** having a landing nipple **12** secured therein and connected in the flow string. It will also be seen that an injector mechanism I can be lowered into the landing nipple and locked in place therein by means of the slips **60** which engage the shoulder **67** of the landing nipple when moved into expanded position by the locking mandrel **50**. Moreover, it will be seen that fluids may enter a lateral port in the housing and nipple and flow past a valve **29** into the bore **34** of the injector mandrel, the rate of flow of the fluids into the bore 34 being regulated by the measuring or regulating valve **36**. Moreover, it will be apparent that the injector mechanism may be easily placed in and removed from the landing nipple as needed.

If desired, a plurality of separate conductors (not shown) may be mounted on the exterior of the landing nipple to provide a plurality of upward flow courses bypassing the landing nipple, rather than the single annular passage **14** between the landing nipple and the housing.

A modified form of the well tool is shown in Figures 3 through 5. This form of the well tool includes a housing **80** which has internal threads **81** at its upper end to receive a sub (not shown) by means of which it may be connected to a flow string. The lower end of the housing is internally threaded to receive a lower sub or seating sleeve **82**. The housing is reduced externally at its mid-portion to form a downwardly facing annular shoulder **83** which acts as a stop to limit upward movement of a tubular screen or sleeve **84** whose lower end portion is rigidly held against downward movement by a retaining ring **85** secured to the lower sub **82** by set screws **86**. The retaining ring is provided with an upwardly facing annular shoulder **87** intermediate its ends which abuts the lower end of the sleeve **84**, and the upper annular end surface **88** of the retaining ring abuts a downwardly facing annular shoulder **89** on the lower sub.

The exterior diameter of the housing is still further reduced from a point spaced slightly below the shoulder **83** throughout the length of the lower portion **90** of said housing, and the inner diameter of the sleeve **84** is of greater diameter than the exterior diameter of the reduced lower portion of the housing so that an annular passage **91** is formed therebetween. A plurality of apertures or ports **92** are provided in the lower end portion of the screen or sleeve to permit flow of fluid from exteriorly of the housing in the well casing into the annular passage **91** between the sleeve and housing.

A landing nipple **98** is mounted in the bore of the housing **80**, being positioned axially therein by a pair of opposed external wings or flanges **97** and **99** on the lower portion of said nipple and similar pair of external spaced lugs or flanges **100** near the upper end of the nipple. The landing nipple is rigidly secured to the housing by welds **101** and **102** about apertures in the housing aligned with one of the spacer lugs **100** and the flange or wing **97**, respectively. The wing **97** is larger than the wing **99** and has a port **96** formed therein to provide communication between the exterior of the housing and the interior of the nipple. A ball valve **93** is disposed between two opposed valve seats **94** and **95** in the port **96** in the flange **97** of the landing nipple, and this ball valve serves the same purpose as the valve **29** of the form of the well tool of Figure 1.

The choke or injector mechanism I' of the modified form includes a sealing or packing mandrel **103** having a lower section **104** threaded into an upper section **105**. The lower section has an external annular flange **106** near its lower end and a cap **107** having a plurality of openings **108** is threaded onto the lower end of said mandrel section below the flange. The openings **108** communicate with the bore **109** of the lower mandrel section through a valve seat member **111** threaded in the lower end of said bore. A ball check valve **112** is disposed in the cap adjacent a downwardly facing valve seat **113** provided on the lower end of the valve seat member, and is adapted to engage said seat to prevent upward flow of fluid through the bore of the lower mandrel section.

An upper valve seat member **114** is threaded in the upper end of the lower mandrel section and a ball valve **115** is adapted to engage said seat to close off flow through the bore **119** of the seat member. The ball valve **115** is supported on a movable sleeve member **116** slidably disposed in the bore **109** of the lower mandrel section and biased upwardly by a spring **117** bearing against the lower end of the sleeve member. The compression of the spring is adjustably controlled by spacer rings **118** disposed in the bore of the mandrel section on the upper end of the valve seat member **111**. The slidable sleeve member **116** is provided with a bore **120**, and has a plurality of lateral ports **121** formed below the upper end of said member to provide for downward passage of fluid past the ball valve **115** to the bore of the sleeve and thence downwardly through the mandrel section past the ball check valve **112** and through the openings **108** of the cap.

The bore **119** of the valve seat **114** communicates with an axial bore **122** in the lower end of the upper mandrel section **105** and, through lateral ports **123** formed in said mandrel section, with the annular space **124** between the upper mandrel section and the landing nipple. A chevron packing assembly **125** disposed about the lower mandrel section **104** between the annular flange **106** thereof and the lower annular end of the upper mandrel section prevents flow of fluid in either direction through the annular space **124** between said lower mandrel section and the landing nipple. A similar chevron packing assembly **127** is disposed about the upper reduced portion of the upper mandrel section between the upwardly facing annular shoulder **128** at the lower end of the reduced upper portion of said mandrel section and the lower end of a depending annular skirt or flange **129** of a packing clamping ring **130** telescoping over the upper end of the upper mandrel section, and this packing prevents flow of fluid in either direction through the annular space **124** between the upper section and the landing nipple.

It will thus be apparent that fluid under pressure, such as chemical treating compositions or the like, will flow from the well casing through the ports **92** in the screen or sleeve **84**, the annular space **91**, and past the ball valve **93** into the annular space **124** in the landing nipple. The fluid is then directed through the lateral ports **123** in the upper mandrel section to the bore **122** of said upper section and downwardly through the bore **119** of the valve seat **114** to unseat the valve **115**. The fluid will then flow through the ports **121** and bore **120** of the sleeve member **116** and continue downwardly through the bore **109** of the lower mandrel section, past the ball check valve **112** and through the openings **108** in the cap **107** into the bore of the housing **80**, where the fluid then will mingle with fluids flowing upwardly through the sub **82** and through the annular passage or space **131** between the housing and the landing nipple.

The mechanism for positioning and locking the injector includes a neck or stem **132** whose lower end is threaded in a bore **133** in the upper end of the upper section **105** of the packing mandrel. The packing clamping ring **130** is also threaded on the lower end of the rod, and acts as a lock nut holding the neck connected to the packing mandrel. A positioning barrel **134** has its lower end telescoped over a reduced upstanding annular flange **135** at the upper end of the packing clamping ring and its lower end rests on the annular shoulder **136** of the packing clamping ring exteriorly of the flange. The barrel has an inturned flange **137** at its top end against the upper surface of which an annular shoulder **138** on the neck **132** bears to hold the barrel immovably in place between the packing clamping ring and said annular shoulder.

The barrel has two opposed lateral windows **139** through which positioning keys **140** are adapted to project (Figures 4 and 5). The keys are located within the bar-

rel and are biased outwardly by leaf springs **141** disposed between the backs of the keys and the neck **132**. The keys have upper and lower lugs **142** and **143**, respectively, which are adapted to engage the inner wall of the barrel to prevent the keys from being displaced completely from said barrel. The keys have selector bosses **144** and **145** which are adapted to project into shaped annular grooves **146** and **147** formed in the landing nipple. The grooves are separated by an annular flange **148** which provides a flat annular top surface **149** which may be beveled slightly at its innermost edge. The lower shoulder **151** of the lower selector boss **145** is beveled inwardly and downwardly so that the engagement of the beveled lower shoulder **151** with the upper edge of the flange **148** forces the key inwardly and allows it to move past said flange. The flat lower surface **152** of the upper selector boss **144**, however, catches on the flat top surface **149** of the flange so that the key cannot move further downwardly. The keys **140**, therefore, limit the downward movement of the injector mechanism in the landing nipple. The beveled upper surfaces **153** and **154** of the selector bosses force the keys inwardly as they engage the beveled lower surface **155** of the flange **148** as they move upwardly past the flange so that the keys permit upward movement and removal of the injector mechanism.

The injector mechanism is locked against upward displacement from the landing nipple by a pair of dogs or slips **156** which are disposed in opposed recesses **157** formed in the barrel between the positioning keys. The slips are swingably carried by a slip carrier or sleeve **158** slidably mounted on the neck **132**, being suspended by hooks **159** at their upper ends engaging over an internal flange **160** formed in the bore of the lower enlarged portion of the slip carrier. A pair of camming blocks **161** are held in place in the barrel between the inturned flange **137** at its upper end and the upstanding annular flange **135** on the packing clamping ring, and these blocks cam the slips outwardly into the annular groove **146** when the barrel and camming blocks are moved upwardly relative to the slip carrier and slips.

In use, the housing **80** is connected in the flow string of the well. The well fluids then flow upwardly through the landing nipple and the housing, and the pressure of such fluids moves the ball valve **93** outwardly to the valve seat **95** so that none of the well fluids escape outwardly through the port **96** to the exterior of the housing.

When it is desired to inject chemical fluids into the flow string, the choke or injector mechanism I' is lowered into the flow string by means of a suitable running tool (not shown) suspended on a line. The running tool is connected to the annular grooved flange **164** on the upper end of the neck member **132** in the same manner as with the previous form. The slips **156** and the carrier **158** are slidable longitudinally relative to the neck member and camming blocks so that the slips may move to retracted position. The springs **141** bias the selector keys **140** outwardly, however, so that the downward movement of the injector mechanism is stopped when the surface **152** of the upper selector boss **144** engages the upper surface **149** of the flange **148** in the landing nipple. The slips may then be set by lifting the line to cause upward movement of the neck member **132** and camming blocks **161** relative to the slips and the carrier. The slips now project to the annular groove **146** and prevent upward movement of the injector mechanism from the landing nipple. The barrel **134** and all associated parts move upwardly until the slips engage the downwardly facing shoulder **170** at the upper end of the annular groove **146**. In this position, the selector bosses of the positioning keys are cammed inwardly to the position shown in Figure 5, and sand or other extraneous matter is excluded from between said keys and the neck member.

The ball valve **95** is displaced outwardly by the upper section of the packing mandrel to permit flow of fluid into the landing nipple in the manner previously described. The rate of flow of the fluid or chemicals can be adjusted by varying the compression of the spring **117**, which may be accomplished by adding or removing spacer rings **118** to compress or release the spring.

When it is desired to remove the injector mechanism, a pulling tool such as has been previously described is employed to drive the neck member **132** downwardly to allow the slips to move to retracted positions. The pulling tool is then moved to engage beneath the undercut flange **163** at the upper end of the slip carrier and the injector is then pulled upwardly, the keys and slips being cammed inwardly by the beveled shoulders of the grooves **146** and **147** as they move upwardly.

This modified form of the invention not only provides for positioning the injector mechanism in a landing nipple which is not provided with any substantial restriction in its bore, so that there is a substantially full opening through said landing nipple, but also provides a screened lateral inlet from outside the housing into the bore of the landing nipple, and a modified valve structure for controlling admission of fluids or chemicals to the bore of the landing nipple. The selector keys of the locking mechanism also provide means by which an injector mechanism may be selectively positioned in any one of several full opening landing nipples and housings made up in the flow tubing at different elevations in the well bore. The shape and size of the bosses on the selector keys and the shape and size of the flanges **148** and the grooves **146** and **147** in the landing nipple will control the selective positioning of the injector mechanism in each of the locations.

The foregoing description of the invention is explanatory only, and changes in the details of the construction illustrated may be made by those skilled in the art, within the scope of the appended claims, without departing from the spirit of the invention.

What I claim and desire to secure by Letters Patent is:

1. A well tool comprising: an elongate hollow housing connectable in a well flow string, said housing having a lateral port, an elongate hollow landing nipple concentrically disposed in said housing and having its upper and lower ends communicating with the interior of said housing, said nipple being of substantially smaller diameter than said housing whereby an annular passage is formed therebetween, said nipple having an extension projecting laterally therefrom to said housing and having a bore communicating with the port of the housing and the interior of said landing nipple, a two-way check valve in said bore movable by fluid pressures to prevent flow of fluid in either direction through said bore, and a removable choke disposed in said landing nipple having sealing means for sealing between said choke and said landing nipple above and below said bore, said choke and said landing nipple forming an annular space between said sealing means, said choke displacing said valve to permit fluid flow from the exterior of said housing into said annular space, said choke having a passage communicating with the annular space between the choke and landing nipple and with the interior of said landing nipple below said bore whereby fluid may flow from exteriorly of the housing to the interior of said landing nipple and downwardly into the interior of said housing and thence upwardly through said annular passage between the nipple and housing.

2. A well tool comprising: an elongate hollow housing connectable in the flow string of a well, said housing having a lateral port, an elongate hollow landing nipple concentrically disposed in said housing and having its ends communicating with the interior of said housing, said nipple being of substantially smaller diameter than said housing whereby an annular passage is formed therebetween, said nipple having an extension projecting laterally therefrom to said housing and having a bore communicating with said lateral port and the interior of said landing

nipple, a two-way check valve in said bore movable by fluid pressures to prevent flow of fluid in either direction through said bore, a removable choke disposed in said landing nipple having sealing means for sealing between said choke and said landing nipple above and below said bore, said choke and said landing nipple forming an annular space between said sealing means, said choke displacing said valve to permit fluid flow from the exterior of said housing into said annular space, said choke having an axial passage communicating with said annular space and the interior of said landing nipple below said bore whereby fluid may flow from said annular space to the interior of said landing nipple downwardly into the interior of said housing and thence upwardly through said annular passage, and pressure responsive means in said axial passage of said choke for regulating the rate of fluid flow through said axial passage.

3. A well tool comprising: an elongate hollow housing connectable in the flow string of a well, said housing having a lateral port, an elongate hollow landing nipple concentrically disposed in said housing and having its upper and lower ends communicating with the interior of said housing, said nipple being of substantially smaller diameter than said housing whereby an annular passage is formed therebetween, said nipple having an extension projecting laterally therefrom to said housing and having a bore communicating with said port and the interior of said landing nipple, a two-way check valve in said bore movable by fluid pressures to prevent flow of fluid in either direction through said bore, a removable choke disposed in said landing nipple having sealing means for sealing between said choke and said landing nipple above and below said bore, said choke and said landing nipple forming an annular space between said sealing means, said choke displacing said valve to permit fluid flow from the exterior of said housing into said annular space, said choke having a passage communicating with said annular space and with the interior of said landing nipple below said bore whereby fluid may flow from said annular space to the interior of said landing nipple downwardly into the interior of said housing and thence upwardly through said annular passage, a second valve movably mounted in said passage of said choke, and means biasing said second valve toward closed position, the fluid pressure in said annular space tending to open said second valve against the force exerted by the biasing means whereby the rate of flow of fluid from said annular space into said passage of said choke varies in accordance with the fluid pressure in said annular space.

4. A well tool comprising: an elongate hollow housing connectable in the flow string of a well, said housing having a lateral port, an elongate hollow landing nipple concentrically disposed in said housing and having its ends communicating with the interior of said housing, said nipple being of substantially smaller diameter than said housing whereby an annular passage is formed therebetween, said nipple having an extension projecting laterally therefrom to said housing and having a bore communicating with said port and with the interior of said landing nipple, a two-way check valve in said bore movable by fluid pressures to prevent flow of fluid in either direction through said bore, a removable choke disposed in said landing nipple having sealing means for sealing between said choke and said landing nipple above and below said bore, said choke and said landing nipple forming an annular space between said sealing means, said choke displacing said valve to permit fluid flow from the exterior of said housing into said annular space, said choke having a passage communicating with said annular space and the interior of said landing nipple below said bore whereby fluid may flow from said annular space to the interior of said landing nipple downwardly into the interior of said housing and thence upwardly through said annular passage, and a check valve in said passage of said choke for preventing back flow of fluid through said passage of said choke into said annular space.

5. A well tool comprising: an elongate hollow housing connectable in the flow string of a well, said housing having a lateral port, an elongate hollow landing nipple concentrically disposed in said housing and having its upper and lower ends communicating with the interior of said housing, said nipple being of substantially smaller diameter than said housing whereby an annular flow passage is formed therebetween, said nipple having an extension projecting laterally therefrom to said housing and having a bore communicating with said port and with the interior of said landing nipple, a two-way check valve in said bore movable by fluid pressures to prevent flow of fluid in either direction through said bore, a removable choke disposed in said landing nipple having sealing means for sealing between said choke and said landing nipple above and below said bore, said choke and said landing nipple forming an annular space between said sealing means, said choke displacing said valve to permit fluid flow from the exterior of said housing into said annular space, said choke having a passage communicating with said annular space and the interior of said landing nipple below said bore whereby fluid may flow from said annular space to the interior of said landing nipple downwardly into the interior of said housing and thence upwardly through said annular flow passage, pressure responsive means in said passage of said choke for regulating the rate of fluid flow through said passage, and a check valve in said passage of said choke for preventing back flow of fluid through said passage of said choke into said annular space.

6. A well tool comprising: an elongate tubular housing connectable in the flow string of a well, said housing having a lateral port, an elongate tubular landing nipple concentrically disposed in said housing and having its upper and lower ends communicating with the interior of said housing, said nipple being of substantially smaller diameter than said housing whereby an annular passage is formed therebetween, said nipple having an extension projecting laterally therefrom to said housing and having a bore communicating at one end with said housing port and at its other end with the interior of said landing nipple, a valve in said bore movable by fluid pressures into closing engagement with spaced opposed valve seats in said bore to prevent flow of fluid in either direction through said bore, a removable choke disposed in said landing nipple having sealing means engaging the interior of the nipple for sealing between said choke and said landing nipple above and below said bore and forming an annular space around the choke between said sealing means, said choke having means displacing said valve from engagement with one of the seats in the bore to permit fluid flow from the exterior of said housing into said annular space, said choke having an axial passage with a lateral inlet communicating with said annular space and with the interior of said landing nipple below said choke whereby fluid may flow from said annular space to the interior of said landing nipple and downwardly into the interior of said housing and thence upwardly through said annular passage, a second valve movably mounted in said axial passage of said choke, means biasing said second valve toward closed position, the fluid pressure in said annular space tending to open said second valve against the force exerted by the biasing means whereby the rate of flow of fluid from said annular space into said passage of said choke varies in accordance with the fluid pressure in said annular space, and a check valve in said passage of said choke for preventing flow of fluid back through said passage of said choke into said annular space.

7. A well tool comprising: an elongate tubular housing connectable in the flow string of a well and having a lateral port, an elongate tubular landing nipple disposed in said housing and having its upper and lower ends communicating with the bore of said housing, said nipple

being of substantially smaller diameter than said housing whereby a flow passage is formed therebetween, said nipple having an extension projecting laterally therefrom to said housing with a bore therein communicating with said port and with the interior of said landing nipple, a valve in said bore movable by fluid pressures between spaced seats to prevent flow of fluid in either direction through said bore, a removable choke disposed in said landing nipple having sealing means for sealing between said choke and said landing nipple above and below said bore, said choke and said landing nipple forming an annular space between said sealing means, said choke having means displacing said valve from one of the seats to permit fluid flow from the exterior of said housing into said annular space, said choke having a passage communicating with said annular space and with the interior of said landing nipple below said bore whereby fluid may flow from said annular space to the interior of said landing nipple downwardly into the interior of said housing and thence upwardly through said flow passage, and locking means on said choke engageable with said landing nipple for removably locking said choke in position in said landing nipple.

8. A well tool comprising: an elongate hollow housing connectable in the flow string of a well, said housing having a lateral port, an elongate hollow landing nipple disposed in said housing and having its upper and lower ends communicating with the interior of said housing, said nipple being of substantially smaller diameter than said housing whereby a flow passage is formed therebetween, said nipple having an extension projecting laterally therefrom to said housing and having a bore therein communicating with said port and with the interior of said landing nipple, a valve in said bore movable by fluid pressures between spaced opposed seats to prevent flow of fluid in either direction through said bore, a removable choke disposed in said landing nipple having sealing means for sealing between said choke and said landing nipple above and below said bore, said choke and said landing nipple forming an annular space between said sealing means, said choke having means displacing said valve from one of the opposed seats to permit fluid flow from the exterior of said housing into said annular space, said choke having a passage communicating with said annular space and with the interior of said landing nipple below said bore whereby fluid may flow from said annular space to the interior of said landing nipple downwardly into the interior of said housing and thence upwardly through said flow passage, pressure responsive means in said passage of said choke for regulating the rate of fluid flow through said passage, and locking means on said choke engageable with said landing nipple for removably locking said choke in position in said landing nipple.

9. A well tool comprising: an elongate tubular housing connectable in the flow string of a well and having a lateral port, an elongate tubular landing nipple disposed in said housing and having its upper and lower ends communicating with the interior of said housing, said nipple being of substantially smaller diameter than said housing whereby a flow passage is formed therebetween, said nipple having an extension projecting laterally therefrom to said housing with a bore therein communicating with said port and with the interior of said landing nipple, a valve in said bore movable between spaced seats by fluid pressures to prevent flow of fluid in either direction through said bore, a removable choke disposed in said landing nipple having sealing means for sealing between said choke and said landing nipple above and below said bore, said choke and said landing nipple forming an annular space between said sealing means, said choke having means displacing said valve from one of the seats to permit fluid flow from the exterior of said housing into said annular space, said choke having a passage communicating with said annular space and with the interior of said landing nipple whereby fluid may flow from said annular space to the interior of said landing nipple and into the interior of said housing and thence upwardly through said flow passage, a second valve movably mounted in said passage of said choke, and means biasing said second valve toward closed position, the fluid pressure from said annular space tending to open said second valve against the force exerted by the biasing means whereby the rate of flow of fluid from said annular space through said passage of said choke varies in accordance with the fluid pressure in said annular space, and locking means on said choke engageable with said landing nipple for removably locking said choke in position in said landing nipple.

10. A well tool comprising: an elongate tubular housing connectable in the flow string of a well and having a lateral port, an elongate tubular landing nipple disposed in said housing and having its upper and lower ends communicating with the interior of said housing, said nipple being of substantially smaller diameter than said housing whereby a flow passage is formed therebetween, said nipple having an extension projecting laterally therefrom to said housing with a bore therein communicating with said port and with the interior of said landing nipple, a valve in said bore movable by fluid pressures into engagement with spaced opposed seats to prevent flow of fluid in either direction through said bore, a removable choke disposed in said landing nipple having sealing means for sealing between said choke and said landing nipple above and below said bore, said choke and said landing nipple forming an annular space between said sealing means, said choke having means displacing said valve from one of said opposed seats to permit fluid flow from the exterior of said housing into said housing and into said annular space, said choke having a passage communicating with said annular space and with the interior of said landing nipple whereby fluid may flow from said annular space to the interior of said landing nipple and into the interior of said housing and thence upwardly through said flow passage, a check valve in said passage of said choke for preventing flow of fluid through said passage of said choke into said annular space, and locking means on said choke engageable with said landing nipple for removably locking said choke in position in said landing nipple.

11. A well tool comprising: an elongate tubular housing connectable in the flow string of a well, said housing having a lateral port, an elongate tubular landing nipple disposed in said housing and having its upper and lower ends communicating with the interior of said housing, said nipple being of substantially smaller diameter than said housing whereby a flow passage is formed therebetween, said nipple having an extension projecting laterally therefrom to said housing with a bore therein communicating with said port and with the interior of said landing nipple, a valve in said bore movable by fluid pressures to engage spaced seats to prevent flow of fluid in either direction through said bore, and a removable choke disposed in said landing nipple having sealing means for sealing between said choke and said landing nipple above and below said bore, said choke and said landing nipple forming an annular space between said sealing means, said choke having means displacing said valve from one of said seats to permit fluid flow from the exterior of said housing into said annular space, said choke having a passage communicating with said annular space and with the interior of said landing nipple below said bore whereby fluid may flow from said annular space to the interior of said landing nipple and downwardly in the interior of said housing and thence upwardly through said flow passage exteriorly of the nipple, said landing nipple having an annular internal groove adjacent the upper end thereof, and locking means on said choke selectively movable into said annular groove of said landing nipple for retaining said choke in place in said landing nipple.

12. A well tool comprising: an elongate tubular hous-

ing connectable in the flow string of a well and having a lateral port, an elongate tubular landing nipple disposed in said housing and having its upper and lower ends communicating with the interior of said housing above and below said port, said nipple being of substantially smaller diameter than said housing whereby a flow passage is formed therebetween, said nipple having an extension projecting laterally therefrom to said housing with a bore therein communicating with said port and with the interior of said landing nipple, a valve in said bore movable by fluid pressures into engagement with either of a pair of spaced valve seats to prevent flow of fluid in either direction through said bore, a removable choke disposed in said landing nipple having sealing means for sealing between said choke and said landing nipple above and below said bore, said choke and said landing nipple forming an annular space between said sealing means, said choke having means displacing said valve from one of said seats to permit fluid flow from the exterior of said housing into said annular space, said choke having a passage communicating with said annular space and with the interior of said landing nipple below said sealing means whereby fluid may flow from said annular space to the interior of said landing nipple and downwardly in the interior of said housing and thence upwardly through said flow passage, pressure responsive means in said choke passage for regulating the rate of fluid flow through said passage, said landing nipple having an annular internal groove adjacent the upper end thereof, and locking means on said choke selectively movable into said annular groove of said landing nipple for retaining said choke in place in said landing nipple.

13. A well tool comprising: an elongate tubular housing connectable in the flow string of a well having a lateral port, an elongate tubular landing nipple concentrically disposed in said housing and having its upper and lower ends communicating with the interior of said housing above and below said port, said nipple being of substantially smaller diameter than said housing whereby an annular flow passage is formed therebetween, said nipple having an extension projecting laterally therefrom to said housing with a bore communicating with said port and with the interior of said landing nipple, a valve in said bore movable by fluid pressures into engagement with either of a pair of spaced valve seats to prevent flow of fluid in either direction through said bore, a removable choke disposed in said landing nipple having sealing means for sealing between said choke and said landing nipple above and below said bore, said choke and said landing nipple forming an annular space between said sealing means, said choke having means displacing said valve from engagement with one of said valve seats to permit fluid flow from the exterior of said housing into said annular space, said choke having a passage communicating with said annular space and with the interior of said landing nipple below said sealing means whereby fluid may flow from said annular space downwardly through said choke passage into the interior of said housing and thence upwardly through said annular flow passage, a second valve movably mounted in said choke passage, means biasing said second valve toward closed position, the fluid pressure from said annular space tending to open said second valve against the force exerted by the biasing means whereby the rate of flow of fluid from said annular space through said choke passage varies in accordance with the fluid pressure in said annular space, said landing nipple having an annular internal groove adjacent the upper end thereof, and locking means on said choke selectively movable into said annular groove of said landing nipple for retaining said choke in place in said landing nipple.

14. A well tool comprising, an elongate tubular housing connectable in the flow string of a well and having a lateral port, an elongate tubular landing nipple concentrically disposed in said housing and having its upper and lower ends communicating with the interior of said housing above and below said port, said nipple being of substantially smaller diameter than said housing whereby an annular flow passage is formed therebetween, said nipple having an extension projecting laterally therefrom to said housing with a bore communicating with said port and with the interior of said landing nipple, a valve in said bore movable by fluid pressures into engagement with either of spaced valve seats to prevent flow of fluid in either direction through said bore, a removable choke disposed in said landing nipple having sealing means for sealing between said choke and said landing nipple above and below said bore, said choke and said landing nipple forming an internal annular space between said sealing means, and a sleeve disposed about the lower portion of said housing forming an outer annular space therebetween, said sleeve having lateral openings in the lower portion thereof, said port communicating with said outer annular space, said choke having means displacing said valve to permit fluid flow from said outer annular space into said internal annular space, said choke having a passage communicating with said internal annular space and with the interior of said landing nipple whereby fluid may flow from said internal annular space through said choke passage downwardly into the interior of said housing and thence upwardly through said annular flow passage.

15. A well tool including, an outer tubular member, an inner tubular member within said outer tubular member and spaced therefrom to form a flow passage therebetween, conductor means extending laterally between said tubular members, said conductor means and aid members having apertures communicating with each other whereby fiuid may pass between the exterior of said outer member and the interior of said inner member, said inner member having its upper and lower ends communicating with the interior of said outer member, said outer member being connectable in the flow string of a well, a valve in one of said apertures responsive to fluid pressure to engage either of a pair of spaced valve seats therein to prevent flow of fluid in either direction through said apertures, and a removable choke disposed in said inner member having sealing means for sealing between said choke and said inner member above and below said apertures, said choke having means displacing said valve from engagement with one of said valve seats to permit fluid flow from the exterior of said outer member into said inner member, said choke having a passage communicating with the interior of said inner member between said sealing means and with the interior of said inner member below said sealing means whereby fluid may flow from said conductor means into said inner member and downwardly through said choke passage into the interior of said outer member and then upwardly through said flow passage.

16. A device of the character set forth in claim 15 which includes: a tubular sub connected to the lower end of the outer tubular member below the landing nipple and having a bore wall providing a sealing surface in said sub corresponding substantially in diameter to the bore of the inner tubular member.

17. A well tool including, an elongate tubular housing connectable in a well flow conductor and having an axial bore and a lateral port intermediate its ends, an elongate tubular landing nipple mounted concentrically in the housing and having its exterior wall spaced from the wall of the bore of the housing to provide an annular flow passage therebetween, an annular outwardly inclined enlargement at the lower end of said tubular landing nipple engaging and secured to the lower end of the inner wall of the tubular housing to hold such lower end of such said landing nipple spaced from the wall of the bore of the housing, said outwardly inclined enlargement having a flow passage therethrough providing communication between the bore of the enlarged lower portion of the landing nipple and the annular space between said landing nipple and the said tubular housing, and a radially disposed wing on

the exterior of said landing nipple connected at its outer end with the housing around the lateral port in said housing, said wing having a flow passage therethrough communicating at its outer end with the port in the housing and at its inner end with the bore of said landing nipple, the inner end of said flow passage being positioned intermediate the ends of the landing nipple, said landing nipple having a cylindrical sealing surface in its bore above and below said lateral opening and an annular locking recess in its bore above said sealing surfaces.

18. A well tool comprising: an elongate tubular housing connectable in the flow string of a well and having a lateral port, an elongate tubular landing nipple disposed in said housing and having its upper and lower ends communicating with the interior of said housing, said nipple being of substantially smaller diameter than said housing whereby a flow passage is formed therebetween, said nipple having means connecting said nipple with said housing and having a lateral flow passage extending from the housing port to the interior of the landing nipple, a two-way check valve in said lateral flow passage movable by fluid pressure to positions closing off flow of fluid in either direction through said lateral passage, said housing having means at its lower end providing a bore wall having a cylindrical sealing surface corresponding substantially in diameter to the diameter of the bore of the landing nipple and spaced below the lower end of said landing nipple.

19. A well tool including: an outer tubular member; an inner tubular member within and spaced from said outer tubular member and having at its lower end an outwardly extending annular enlargement engaging and connected to the lower end of the inner wall of the outer tubular member and forming a downward continuation of said outer tubular member; flow courses in said outwardly extending enlarged portion of said inner tubular member communicating with the bore of said inner tubular member and with the annular space between the inner tubular member and said outer tubular member to form a flow passage therebetween; said inner and outer members each having a lateral port formed therein; means connecting said ports of said inner and outer members and forming a flow passage from the port of the outer member through the port of the inner member to the interior of said inner member, said inner member having its upper and lower end portions communicating with the interior of said outer member, said outer member being connectable in the flow string of a well, and a two-way check valve in the flow passage connecting the lateral ports of the inner and outer members responsive to fluid pressure to close off flow of fluid in either direction through said passage.

20. A well tool including: an elongate tubular housing connectable in a well flow conductor and having an axial bore and a lateral port intermediate its ends, an elongate tubular landing nipple mounted concentrically in the housing and having its exterior wall spaced from the wall of the bore of the housing to provide an annular flow passage therebetween, and a radially disposed wing on the exterior of said landing nipple connected at its outer end with the housing around the lateral port in said housing, said wing having a flow passage therethrough communicating at its outer end with the port in the housing and at its inner end with a lateral opening in the bore wall of said landing nipple, the inner end of said flow passage being positioned intermediate the ends of the landing nipple, said landing nipple bore providing cylindrical sealing surfaces therein above and below said lateral opening, said landing nipple having a pair of adjacent annular grooves in its bore above said sealing surfaces, and a choke insertable in said landing nipple and having sealing means engageable with the sealing surfaces in said landing nipple, said choke having positioning and locking means selectively movable into said annular grooves of said landing nipple for positioning and retaining said choke in place in said landing nipple, said positioning and locking means comprising laterally offset selector keys and locking dogs disposed in position to engage the adjacent annular grooves in the landing nipple, whereby the locking dogs lock in one of the grooves engaged by the selector key.

21. A well tool comprising: an elongate tubular housing connectable in the flow string of a well, said housing having a bore providing a cylindrical sealing surface therein at its lower end; an elongate tubular landing nipple disposed in said housing and having its lower end spaced from the cylindrical sealing surface at the lower end of said housing; said landing nipple being of substantially smaller diameter than said housing whereby a flow passage is formed between said housing and the exterior of said landing nipple; means providing a lateral passageway communicating with the exterior of the housing and with the interior of the landing nipple; and valve means in said housing between the exterior of said housing and the interior of said landing nipple controlling flow through said lateral passageway.

22. A well tool including: an elongate tubular housing connectable in a well flow conductor and having an axial bore and a lateral port intermediate its ends; an elongate tubular landing nipple mounted in the housing and having its exterior wall spaced from the wall of the bore of the housing to provide a flow passage therebetween; a lateral projection extending between said landing nipple and said housing and having a flow passage therein having communication with the interior of the landing nipple and with the exterior of the housing through the lateral port therein; valve means initially closing said flow passage to prevent flow of fluid in either direction therethrough; a choke removably positioned in said landing nipple and having sealing means sealing between said choke and said nipple above and below said flow passage and defining an annular space between said choke and landing nipple; said choke having means moving said valve means to open position to permit flow through said flow passage into said annular space; said choke having a bore therein with a lateral port communicating with said annular space whereby fluid may flow from said annular space to the port and bore of the choke; and locking means on said choke removably locking said choke in position in said landing nipple.

References Cited in the file of this patent

UNITED STATES PATENTS

2,230,107	Garrett	Jan. 28, 1941
2,245,002	Nixon	June 10, 1941
2,255,648	Bryan	Sept. 9, 1941
2,274,093	Ragland et al.	Feb. 24, 1942
2,571,478	Otis	Oct. 16, 1951