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Jan. 24, 1967 J. S. PAGE, JR 3,299,955

WELL TOOL APPARATUS

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FIG. 1.

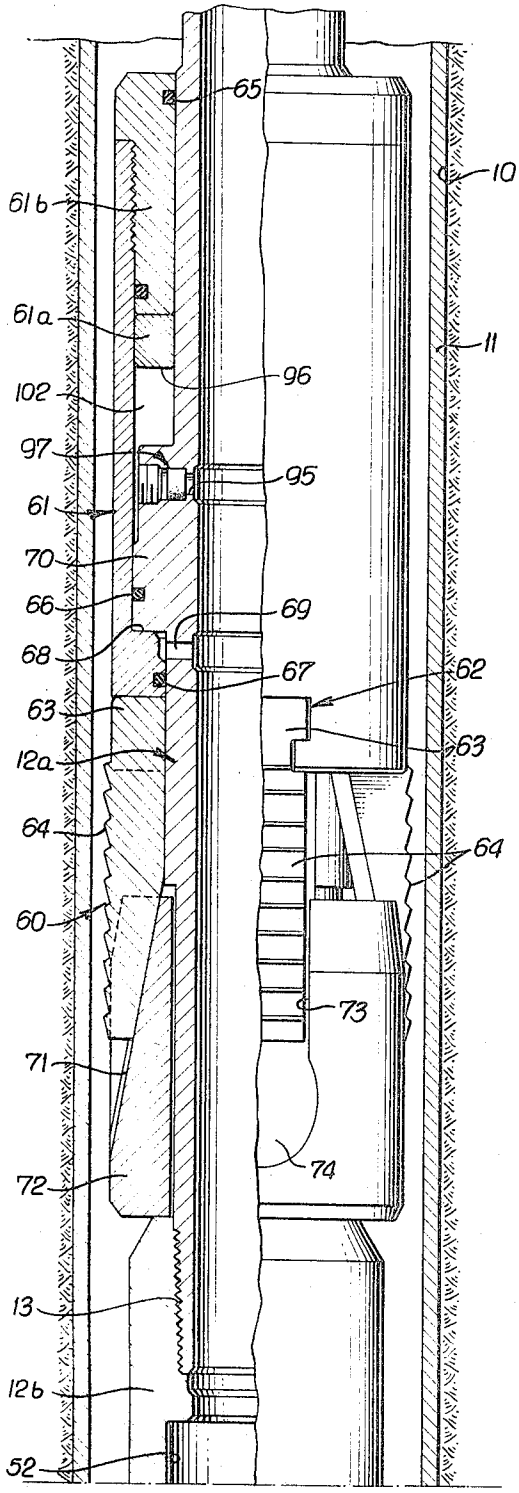
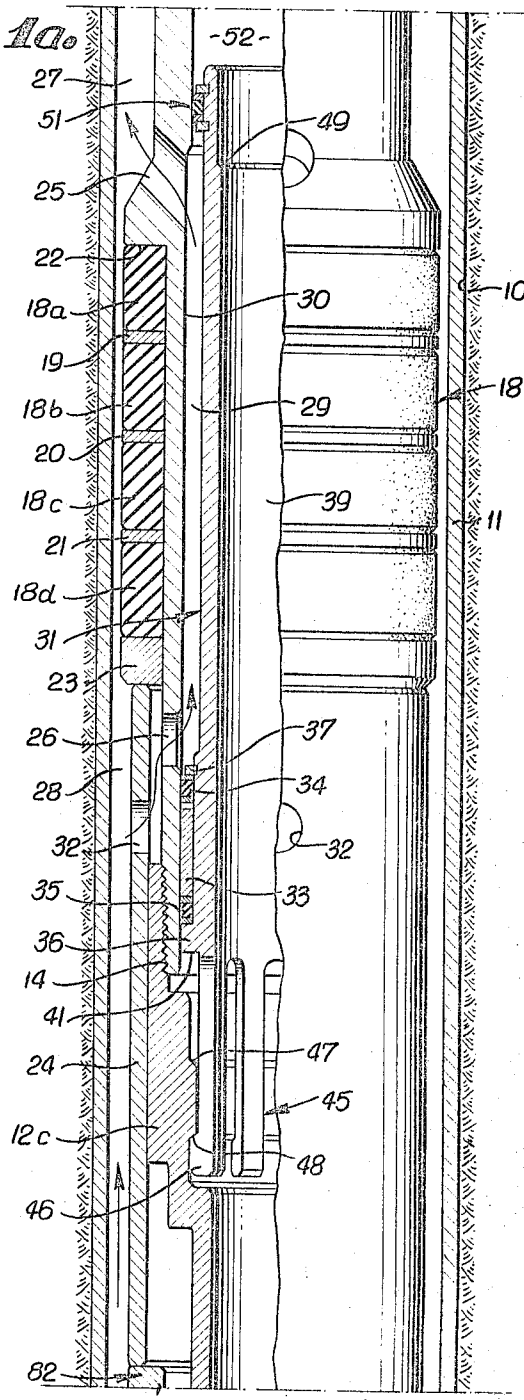


FIG. 1a.



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FIG. 1b.

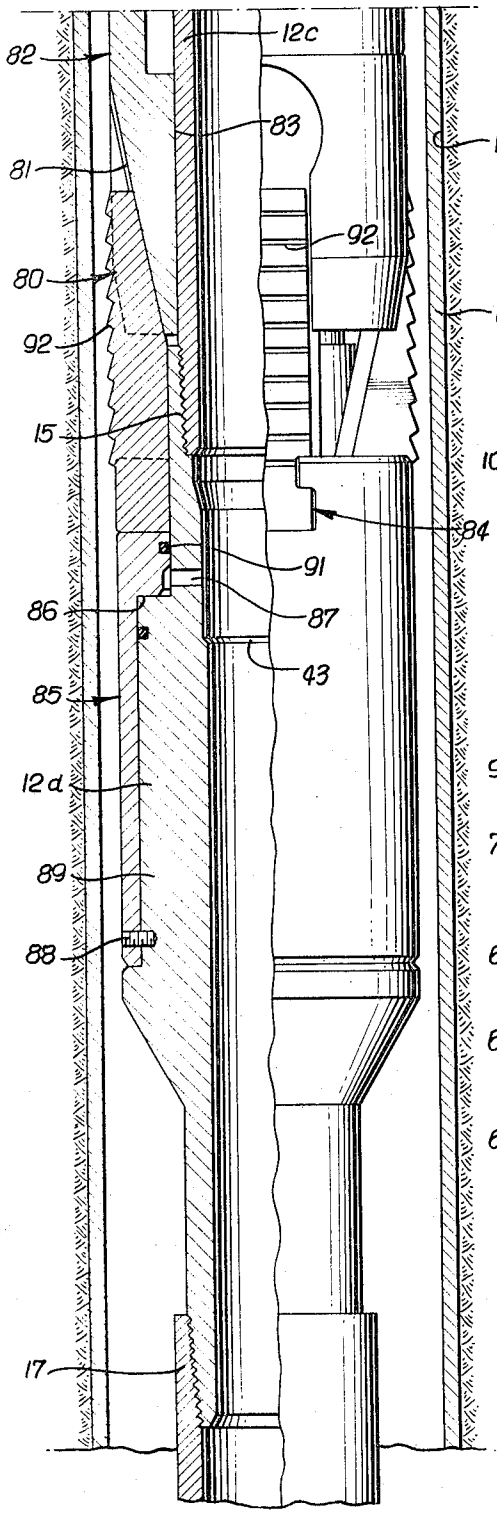


FIG. 3.

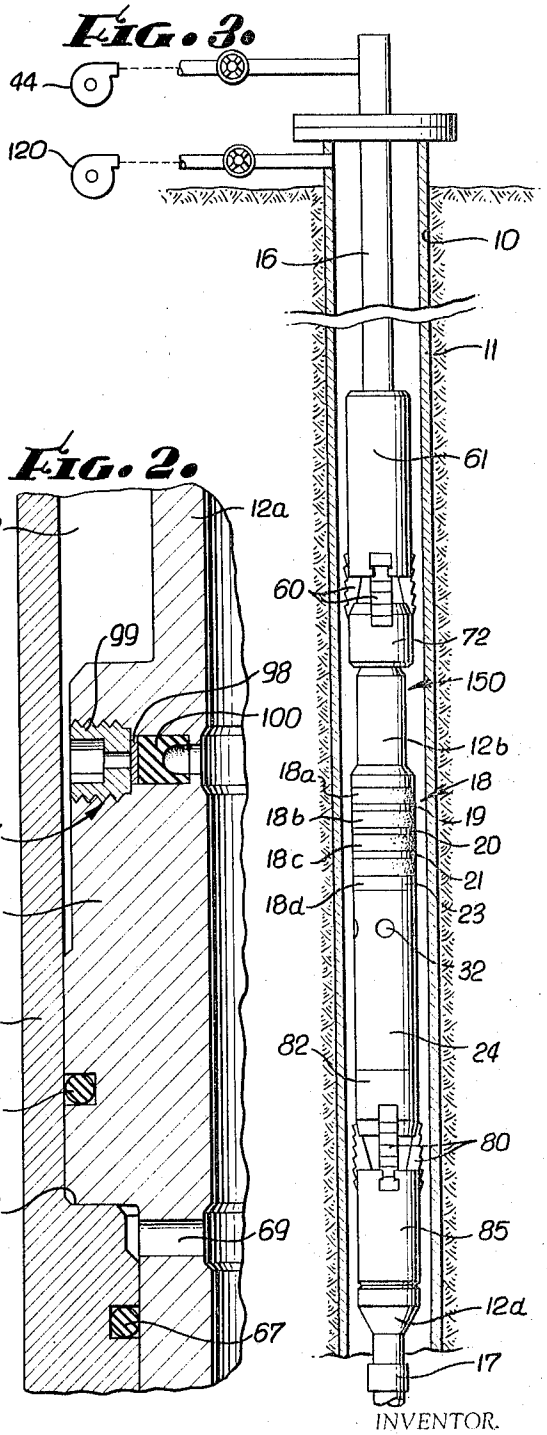


FIG. 2.

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WELL TOOL APPARATUS

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FIG. 4.

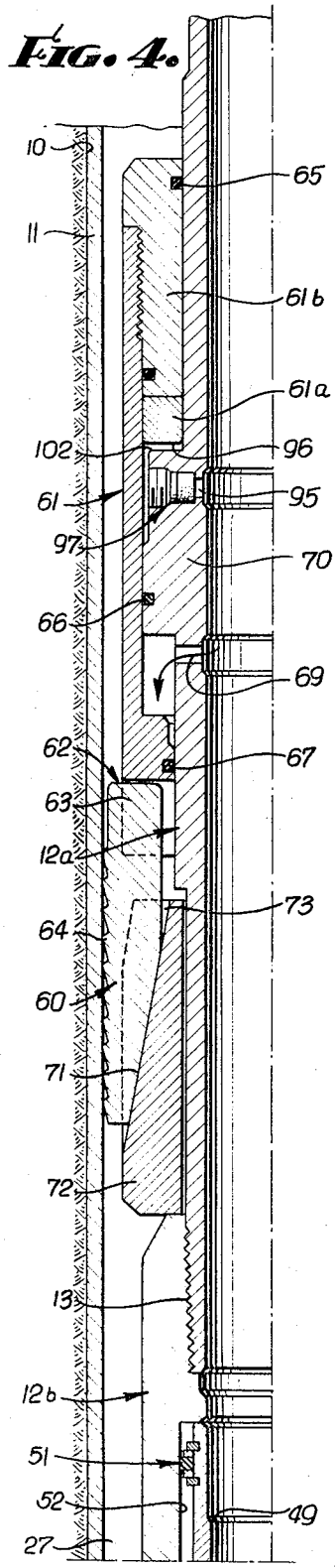


FIG. 4a.

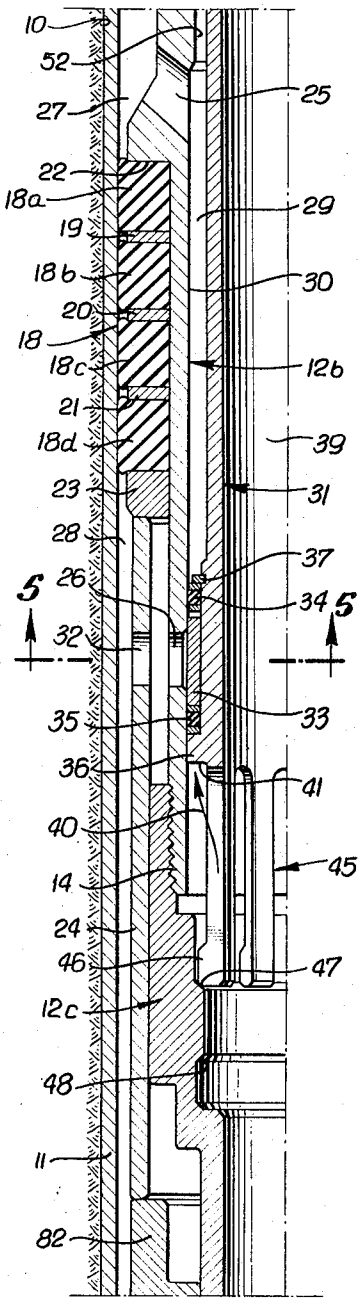
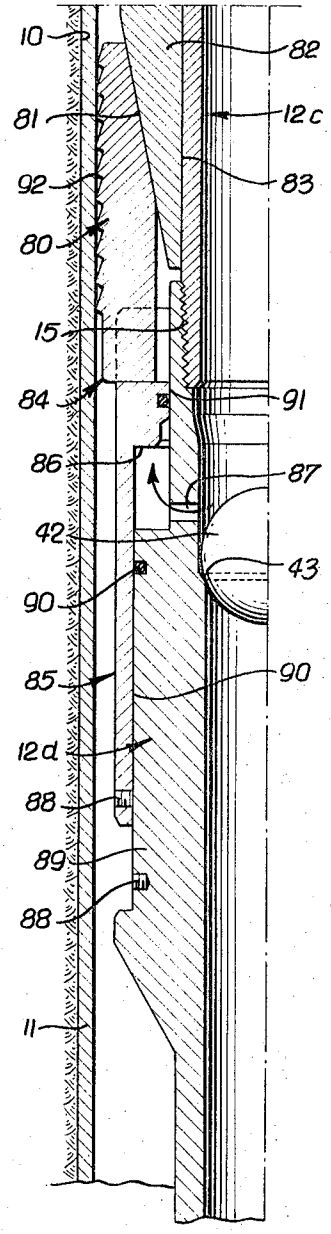


FIG. 4b.



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FIG. 6.

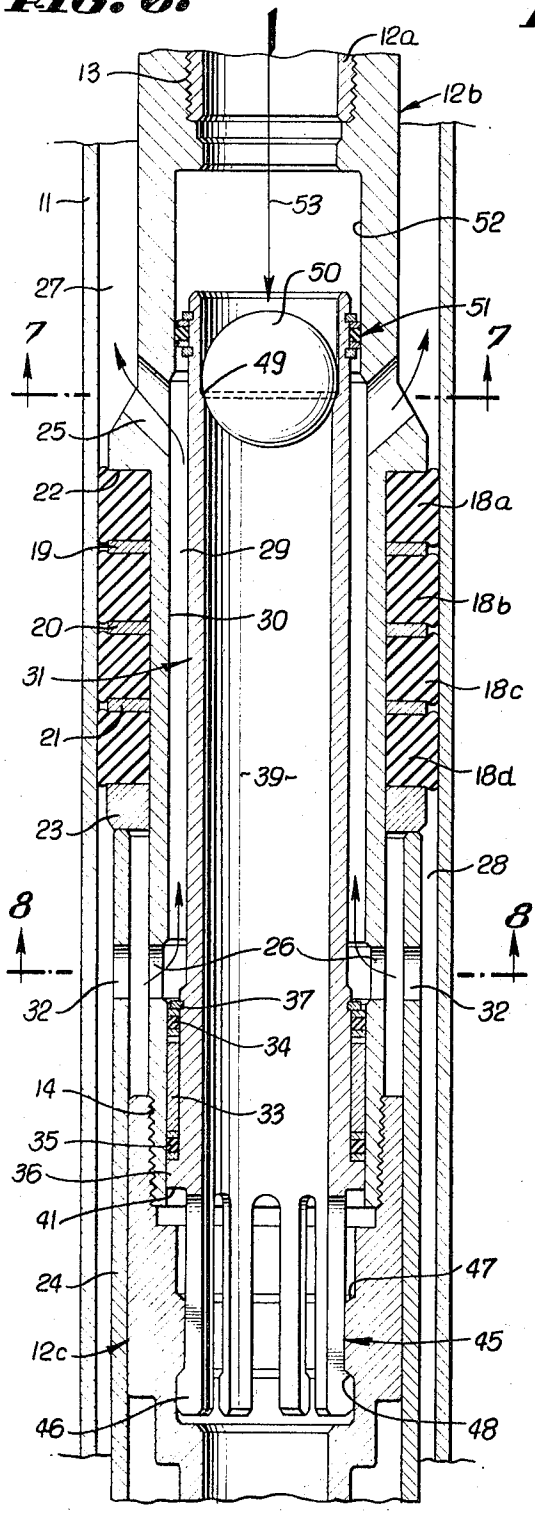


FIG. 5.

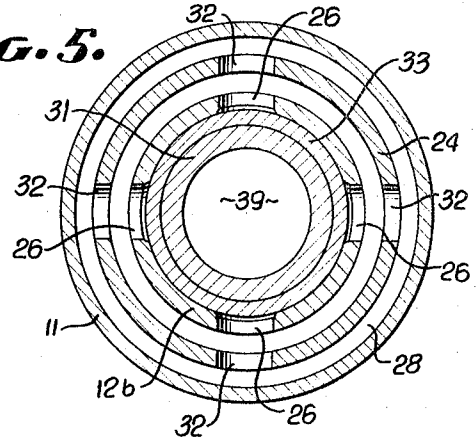


FIG. 7.

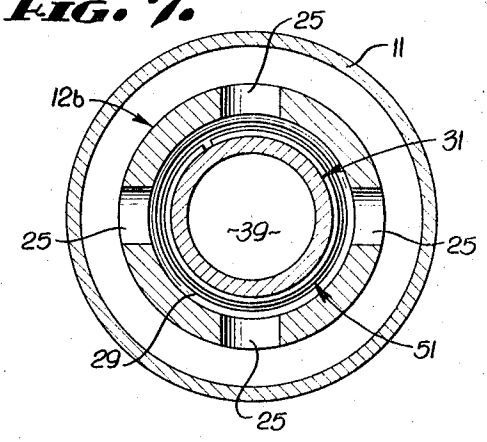
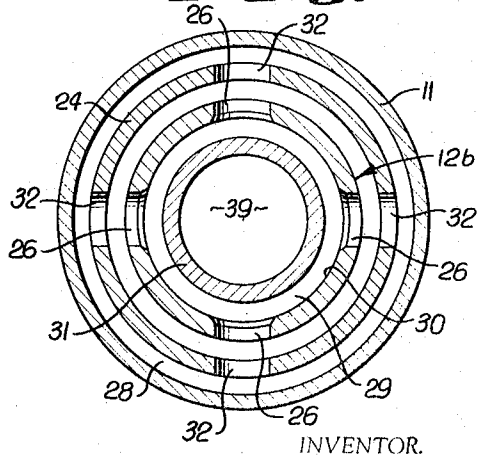


FIG. 8.



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FIG. 9.

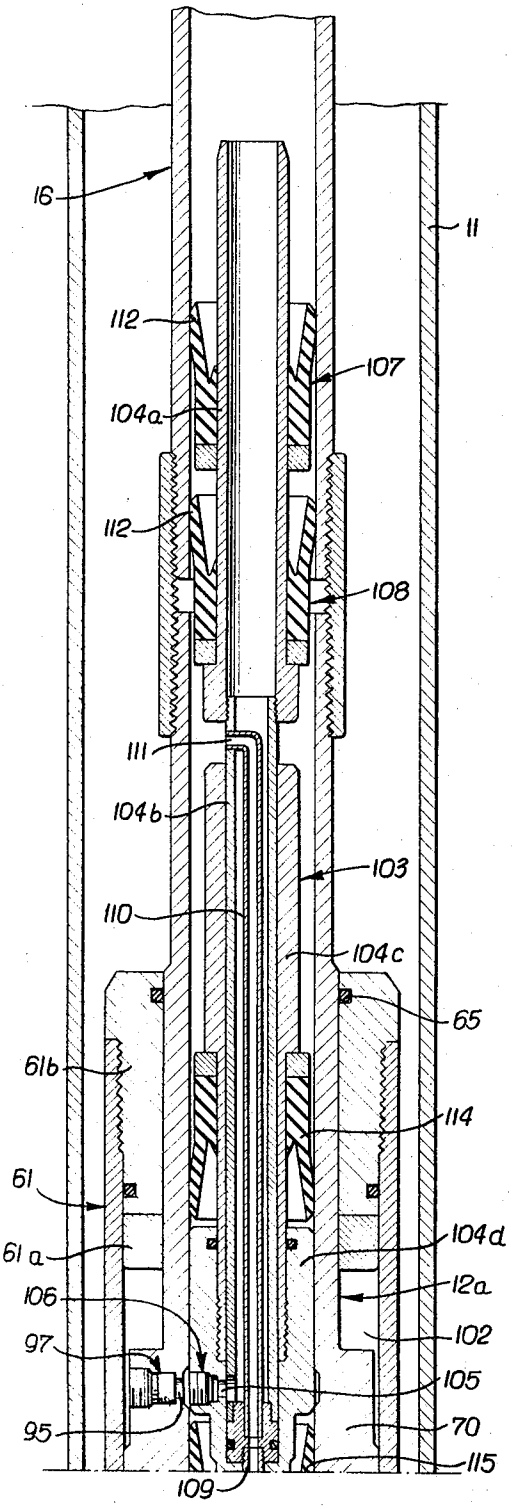
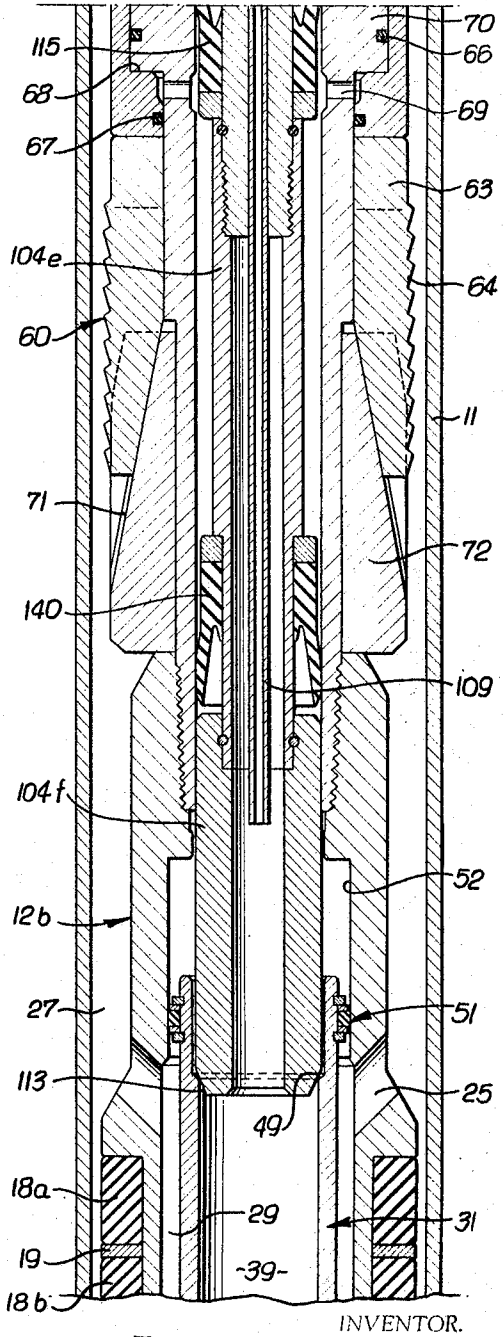


FIG. 9a.



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FIG. 10.

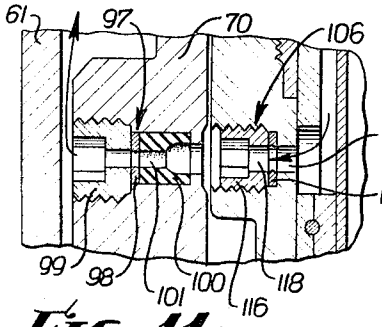


FIG. 12.

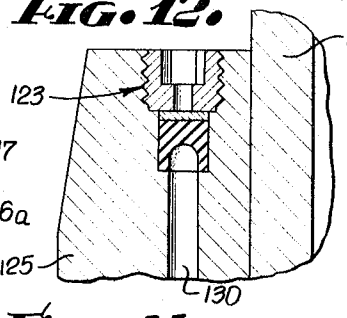


FIG. 11b.

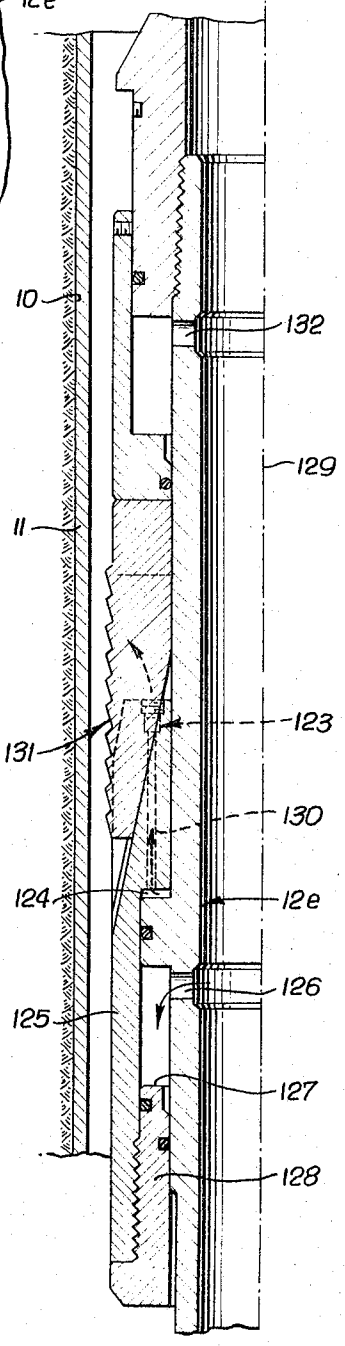


FIG. 11.

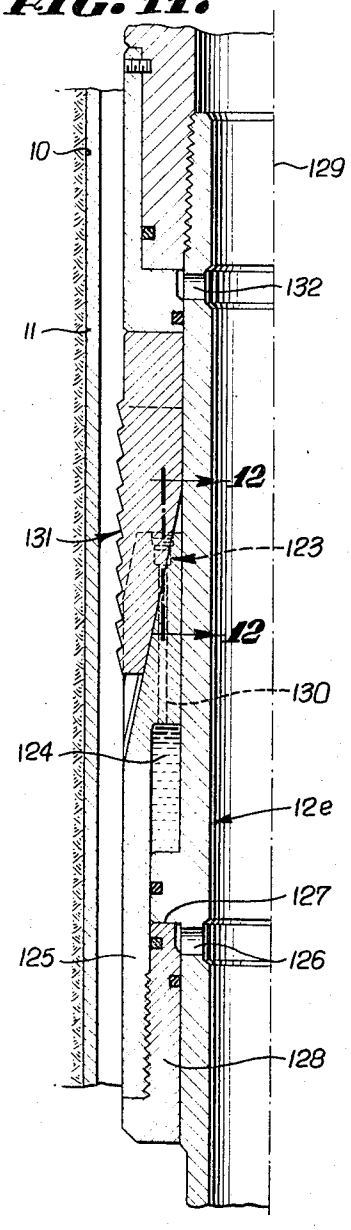
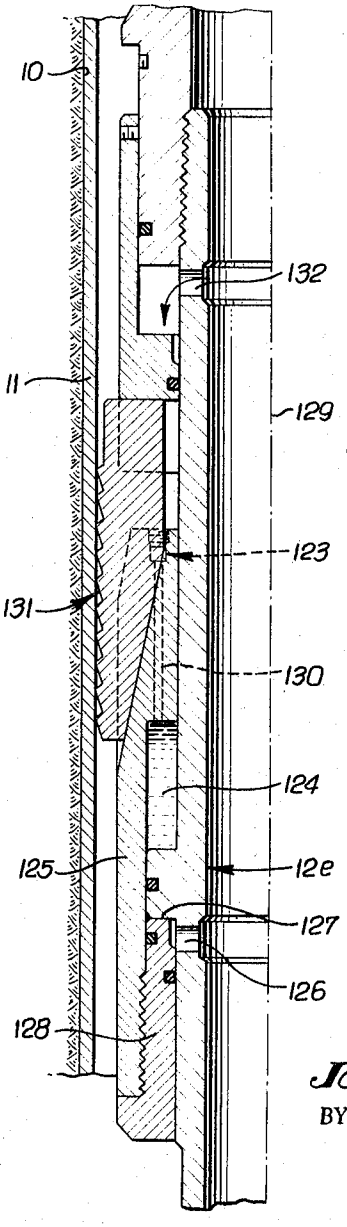


FIG. 11a.



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WELL TOOL APPARATUS

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Filed Jan. 17, 1964, Ser. No. 338,331
33 Claims. (Cl. 166—48)

This invention relates generally to the control of fluid flow in a well, and more specifically has to do with well tool apparatus and methods used to control by-passing of fluid with respect to a well packer and into or out of the annulus outside a string of tubing.

In the completion, production and treating of oil and gas wells it becomes desirable at certain times to establish intercommunication between upper and lower zones in the well outside the tubing and separated by a packer; however, when the packer has been set in position to seal off between the tubing and the well base, the establishment of such intercommunication becomes a problem. One way of meeting this difficulty is to unset the packer by manipulation of the tubing supporting the packer, but this in turn presents the additional problem of removal of the well head with consequent expenditures of considerable time and effort. Another method of establishing such intercommunication is to lower a wire line tool into proximity to a valve operable in the well to control the desired fluid flow; however, wire line manipulation imposes additional difficulties including the considerable time and expense of running the line into and out of the well.

One object of the invention is to overcome the above difficulties to the end that intercommunication between packer separated upper and lower zones in a well and outside the tubing may be quickly established without well tubing or wire line manipulation and without unsetting of the packer.

Another purpose of the invention is to provide an assembly including a packer that can be set hydraulically, which will allow for tension application to the tubing string without disruption of the packer function, and which will allow ready removal of the packer without drilling it out. Certain prior installations suffer from the disadvantage of requiring application of tubing weight for effecting packer compression and expansion to set condition. This earlier method of setting causes the tubing to buckle between the packer and the well head, resulting in increased difficulty of running service tools through the buckled tubing. Also, in shallow wells, there is oftentimes insufficient tubing in the well to provide sufficient weight for setting the packer. The latter condition has been met by using permanent packers, but these typically must be drilled out for removal from the well.

In its broader aspects, the novel apparatus contemplated by the invention and its mode of operation may be characterized as comprising a sub body connectible in a pipe string, a packer carried to seal off the annulus or annular zone between the well bore and said sub body, the body being ported to pass fluid between the body interior and the annulus at one end at least of the packer, and valving carried by the body for movement between body port opening and closing positions. The valving also has an opening through which well fluid flows endwise with respect to the sub body, and in addition the valving is exposed to transmit fluid created pressure acting to move the valving between port opening and closing positions.

Typically, the sub body is tubular and has upper and lower side porting to by-pass fluid around the packer via the body interior, the valving also being tubular and carried for axial movement in the body between a lower position in which the lower side porting is open and an upper position in which the lower side porting is closed. As a result, the interior valving may be externally exposed to

the upper porting to receive lesser or greater control fluid pressure acting downwardly in the annular zone between the tubing string and well bore, such pressure tending to move the valving downwardly to accommodate by-passing of the flow around the set packer, while the valving also remains exposed to upward flow within the well tubing. When the valve is in lower or open position, fluid can be pumped down the annulus to by-pass the set packer, to flow downward to the bottom of the tubing string and then back up the tubing, thus filling the well with fluid to the lowest desired depth. Accordingly, if mud is enabled to flow in this manner the well may be killed, or if water, oil or nitrogen are used the well may be brought into flowing condition. Also, acid or treating fluid may be introduced into the well in this manner.

As will appear, the apparatus is so constructed with an interior seat for receiving a primary plug as to block downward flow of well fluid in the string for building up pressure acting to unbalance the valve for displacing it upwardly to close the lower side porting, all without unsetting the packer. In this valve closed position, the elements of the combination are in condition for normally producing the well. An additional interior seat accommodates reception of another plug operable to block downward flow of well fluid in the string for building up pressure acting to displace the valve downwardly to open the lower side porting.

Another object of the invention is to utilize the pressure acting in the string to displace the valve upwardly in such a way as to effect expansion of the packer into engagement with the well bore, as well as sub body supporting connection to the well bore. As will appear, string fluid pressure responsive actuator structure is typically provided to move upwardly for expanding the packer and upwardly spreading lower slips to grip the casing. Additionally actuator structure may be exposed to string fluid pressure to effect downward spreading of upper slips above the packer, thereby to anchor the string tubing and sub body against upward displacement while the packer remains set and the valving is operable and closable. Accordingly, the packer may remain set independently of tubing tension and weight application.

A further object of the invention is to provide for release of the upper or anchor slips to allow upward withdrawal of the string and release of the packer and lower slips, when the body side port valving is open. As will be seen, a tubular insert capable of lowering in the string is provided with an outlet for flowing high pressure fluid through a rupturable element and against the additional or upper actuator structure to release the slips, the insert having a locating shoulder to position it axially with respect to the valving, for performance of the upper slip releasing function. Thus, the invention provides for ready removal of a packer which is settable independently of tubing tension and weight application.

The invention also embraces novel and unusual methods for controlling a well into which a string of production tubing is run, the string supporting slip, packer and valve assemblies characterized as operable in the broad manner described above. Typical steps included in the unusual method of well control include running the string into the well with the by-passing valve assembly in open condition, and then introducing sufficient fluid pressure into the string to operate the slips for anchoring the string to the casing, to operate the packer for packing off between the string and casing, and to operate the valve to shut off by-passing communication around the packer. Valving operation to shut-off the by-pass typically involves the steps including closing off the string at a location proximate the said assemblies by dropping a plug in the string for descent to said location, and then building

up fluid pressure in the string above the plug to displace the valve to shut-off position, at which time the well may be produced.

Further steps in the novel and unusual method sequence comprise introducing sufficient fluid pressure into the well to operate the valve to open up by-passing communication around the packer, and introducing fluid into the well space outside the tubing to by-pass the packer in flowing downwardly to enter the string below the packer, and then to flow upwardly in the string, as in killing or treating the well.

These and other objects and advantages of the invention, as well as the details of an illustrative embodiment, will be more fully understood from the following detailed description of the drawings.

FIGS. 1, 1*a* and 1*b* are elevation views of upper, intermediate and lower sections of a sub incorporating the invention and connected in a tubing string being run into a well;

FIG. 2 is an enlarged fragmentary elevation showing a rupturable means to release upper slips seen in FIG. 1;

FIG. 3 is a vertical section taken through a well into which the tubing string and sub have been run, with the sub in position to be set in order to pack off between the sub body and well casing;

FIGS. 4, 4*a* and 4*b* are elevation views of upper, intermediate and lower sections of the novel sub after it has been set in position and with the fluid pressure responsive sleeve valve in closed position;

FIG. 5 is a cross-section taken on line 5—5 of FIG. 4*a*;

FIG. 6 is an elevation view of the intermediate section of the set sub, showing the sleeve valve downwardly displaced to open position;

FIG. 7 is a cross-section taken on line 7—7 of FIG. 6;

FIG. 8 is a cross-section taken on line 8—8 of FIG. 6;

FIGS. 9 and 9*a* are elevation views of upper and intermediate sections of the sub into which an insert has been run to release the upper or anchor slips resisting upward withdrawal of the string;

FIG. 10 is a fragmentary enlargement showing the manner in which high pressure fluid is introduced from the run-in insert to the sub in order to effect release of the upper slips;

FIGS. 11, 11*a* and 11*b* are elevation views of a modified upper section of the sub; and

FIG. 12 is an enlarged fragmentary showing of the modified manner in which high pressure fluid may be released to release the upper slips as seen in the sub of FIGS. 11, 11*a* and 11*b*.

Referring first to FIGS. 1, 1*a* and 1*b*, the representative well tool apparatus is shown being run downwardly into a well **10** which is cased at **11**. The apparatus comprises a generally endwise extending tubular body **12** including sections **12***a*, **12***b*, **12***c* and **12***d* which are interconnected in sequence at threaded joints **13**, **14** and **15**. It will be understood in this connection that the tool apparatus is in the form of a sub **150** connected in a string of tubing lowered in a well and better seen at **16** in FIG. 3. Suitable connections are made between the sub and the tubing, one such threaded connection being indicated at **17** in FIG. 1*b*.

The tubular body carries what may be referred to as packer means generally indicated at **18** in FIG. 1*a*, the packer including endwise compressible ring sections **18***a*, **18***b*, **18***c*, **18***d* separated by metal rings **19**, **20** and **21**. These elements are in turn mounted on the body section **12***b* between an upper shoulder **22** and a lower compression ring **23** which is also mounted on the body section **12***b*. It will be understood that the packer elastomer sections **18***a* through **18***d* may be subjected to expansion into sealing engagement with the casing bore in response to upward displacement of the ring **23** relative to the shoulder **22**. In this regard, the actuator ring **23** may be urged upwardly by an actuator sleeve **24** slidably mounted upon the body section **12***c*. Reference to FIG. 4*a* will show the packer **18** expanded as described, and sealing off the annular zone between the casing bore and the tubular body **12**.

The body section **12***b* is seen in FIG. 1*a* to have porting to pass fluid generally between the said zone or annulus at one end at least of the packer and the body interior. More specifically, the body has upper and lower side porting indicated at **25** and **26** to by-pass fluid between upper and lower annular zones **27** and **28**, around the packer, and via the body interior as for example the annular passage **29**. The latter is formed between the bore **30** of the body section **12***b* and the periphery of a sleeve valve **31** received within the body.

The sleeve valve may be characterized as carried by the body for movement between a first posiiton in which side porting is closed, and a second position in which the side porting is open. Thus, as seen in FIG. 1*a* the side porting is open, a suitable port **32** in the actuator sleeve **24** communicating between the zone **28** and the lower port **26** in the body section **12***b*. On the other hand, in FIG. 4*a* the lower side port **26** is closed, the valving being in its so-called first position. As there appears, the valving includes a cylindrical closure **33** and endwise spaced annular seals **34** and **35**, all retained between the valve flange **36** and a retainer ring **37** so as to be movable endwise with the valve. The seals **34** and **35** engage the bore of the body section **12***b* as the valve moves endwise, whereby the cylindrical closure **33** blocks or closes the lower port **26** which is sealed off from the interior passage **29** as seen in FIG. 4*a*.

It will also be noted that the valving means **31** contains an opening generally indicated at **39** to pass well fluid endwise therethrough, and typically during production of the well under the conditions shown in FIG. 4*a*. In this regard, the bore **39** of the valve may be generally of the same dimension as the bore of the tubing string **16**, whereby suitable tools may be run downwardly through the sub including the body **12** and the valve **31**. It is also to be noted that the valving means is exposed for transmitting fluid created pressure acting to move it between its lower and upper positions, such fluid pressure exertion being generally indicated by the arrow **40** in FIG. 4*a*. As illustrated, the valve has a downwardly facing annular shoulder **41** for receiving upward pressure exertion acting to unbalance the valve from the position shown in FIG. 1*a*, driving it upwardly to the position shown in FIG. 4*a* at such time that closure of the valving means is desired. For this purpose a primary plug, as for example a ball **42** seen in FIG. 4*b*, may be dropped downwardly in the tubing string to engage the interior port forming seat **43** to block downward flow of well fluid. When sufficient pressure is then pumped downwardly through the string, as by operation of the pump **44** in FIG. 3, the valving means **31** will be displaced from its lower to its upper position.

FIGS. 1*a* and 4*a* also illustrate one form of latching mechanism for releasably holding the valving means in each of said upper and lower positions. Typically, the latching mechanism means includes inwardly flexible vertically elongated fingers **45** depending from the valve means and having outwardly facing terminal latch shoulders **46**. The fingers are circularly spaced in such manner that the latch shoulders **46** are engageable with upper and lower annular shoulders **47** and **48** on the body section **12***c*. Accordingly, when sufficient upward fluid pressure is exerted on the valving means, the latch shoulders **46** on the fingers cam inwardly to disengage the lower shoulder **48**, allowing the valve to move upwardly to the FIG. 4*a* position, at which time the latch shoulders **46** spring outwardly to engage the upwardly facing shoulders **47** on the body. The latter prevent downward movement of the closed valve until such time as sufficient downward force is exerted on the valve.

Such downward force application as referred to may be effected in the manner shown in FIG. 6, as by introducing a secondary plug into the string **16**, and allowing the plug to drop and engage the interior port forming seat **49** for blocking downward flow of well fluid through the valving means. Typically, the plug may comprise a ball **50** as shown, and of larger diameter than the bore **39** of the valving means. Since the valve periphery is sealed off at **51** from the stepped or reduced bore **52** of the body section **12***b*, sufficient fluid pressure pumped into the string and exerted downwardly in the direction of the arrow **53** in FIG. 6 will be transmitted by the plug to the valve and overcomes the resistance to downward displacement of the valve imposed by the latching means described above, with the result that the valve will move to its lower position in the sub body, as seen in FIG. 6. The ball plugs **42** and **50** referred to above may be pumped into and out of the tubing string at times when opening and closing of the valve is desired, and after the packer **18** has been set in the casing.

As mentioned in the introduction, the invention contemplates the connection of the sub body to the well bore and expansion of the packer into sealing engagement therewith in order that the valve means may be operated in response to fluid pressure exertion, all without unsetting of the packer. Referring to FIGS. 1 and 4, the means operable to effect body supporting connection with the well bore includes outwardly spreadable upper slips above the packer, and as for example are shown generally at **60**, the slips in FIG. 1 being retracted from engagement with the bore, whereas they have been spread into engagement with the bore in FIG. 4. The slips are carried by a cylindrical actuator **61**, by virtue of a conventional so-called T-slot connection **62** retaining the upper portions **63** of the slips while accommodating outward spreading of the lower portions carrying wickers or serrations **64** operable to grip the casing bore. Actuator **61** is carried by the upper body section **12***a*, having sealable sliding engagement therewith at the locations **65**, **66** and **67**. Furthermore, the actuator is exposable to fluid pressure within the body interior and communicated to the actuator piston face **68** via a duct **69** through the body wall. Accordingly, when the primary plug **42** is seated at **43**, and sufficient fluid pressure is pumped into the tubing above the plug, the piston face **68** is displaced downwardly relative to the reaction flange **70** on the body **12***a*, thereby to displace the slips **60** downwardly. Outward spreading of the downward traveling slips occurs by wedging action effected by the tapered surfaces **71** of the cone member **72** carried on the sub body. As is clear, slots **73** are cut at intervals around the cone member to receive the circularly spaced slips, and slot clearance is provided at **74** to be taken up by the downward terminals of the slips as they travel downwardly and spread outwardly to the position shown in FIG. 4. When the slips firmly engage the casing, upward thrust transmitted by the sub body section **12***b* to the cone member **72** is then transmitted to the slips and to the casing, firmly anchoring the sub body against upward removal as might otherwise occur during setting of the packer and anchoring of the lower slips.

Turning now to FIGS. 1*b* and 4*b*, means is provided to effect the above described outward spreading of the lower slips and expansion of the packer, as for example when downward flow of well fluid in the string is blocked by the primary plug **42**. Here again, slips **80** are formed to have wedge surface engagement at **81** with a cone member **82**; however, the latter member is vertically slidable at the interface **83** and on the sub body section **12***c* in order to transmit upward thrust to the actuator sleeve **24** operable to compress the packer as described above. The slips have T-slot interconnection at **84** with the lower actuator **85**, the latter having a piston face **86** to which pressure fluid is transmitted via the duct **87** in the sub body section wall. When sufficient pressure is thus communicated from the sub bore to the

piston face **86**, the actuator **85** travels upwardly after shearing the pin **88** interconnecting the actuator and the reaction flange **89** on the sub section **12***d*. The actuator has sealing and sliding engagement with the periphery of the section **12***d* at the locations **90** and **91**. Upward travel of the slips **80** effects their outward spreading on the cone member and also compression of the packer by force transmission to the cone member and actuator sleeve **24**. As a result, the slip wickers or serrations **92** firmly grip and anchor against the casing bore as seen in FIG. 4*b*.

Release of the lower slips when upward withdrawal of the tool is desired occurs by virtue of such upward withdrawal carrying the cone member **82** out from under the slips **80**. On the other hand, upward withdrawal of the tubing string is prevented by the upper slips unless their release is otherwise effected. It is another feature of the invention to provide for such release of the upper slips at times when upward withdrawal of the string and unsetting of the packer is desired. In this regard, FIGS. 1 and 4 show the provision of an additional duct **95** in the body upper section **12***a* through which fluid pressure may be communicated to the downwardly presented piston face **96** of the actuator **61**, the latter typically including ring **61***a* and nut **61***b*. In addition, rupturable means is provided as indicated at **97** to block flow of predetermined high pressure fluid through the side port **95** in less than sufficient quantity to effect the upper slips release. Such rupturable means is better seen in FIGS. 2 and 10 to include a rupturable diaphragm **98** retained between a nut **99** threaded into the reaction flange **70** and a retainer **100** which is ducted at **101**. Accordingly when fluid pressure of sufficient magnitude is exerted upon the diaphragm **98**, it ruptures to admit the high fluid pressure into the space **102** for upward exertion of fluid pressure against the piston face **96**, driving the actuator **61** upwardly to retract the slips **60** from the cone member **72**. As a result, the upper slips are released to allow upward withdrawal of the tubing string and the tool.

Reference to FIGS. 9 and 9*a* will show the method whereby high pressure fluid is locally transmitted to the rupturable means **97** previously referred to. As illustrated, an insert means **103** is lowered downwardly through the tubing string **16** for applying the high pressure fluid. The insert includes a tubular member **104** made up of endwise interconnected tubular sections **104***a*–**104***f*, section **104***d* being ported at **105** to deliver pressure through the side thereof. Another rupturable means **106** is provided at the port **105** to block escape of high pressure fluid below a predetermined level. Accordingly, pressure fluid may be pumped into the string to drive the insert member **104** downwardly therein and into the position shown in FIGS. 9 and 9*a*, without rupturing the means **106**. Pressure cups, typically formed of rubber, are shown at **107** and **108** on the insert section **104***a*, and opening upwardly to receive pressure application for driving the insert downwardly within the tubing.

During such downward travel of the insert, fluid encountered below the insert passes upwardly therein through the by-pass pipes **109** and **110**, the latter exhausting at **111** into the tubing just below the cups **107** and **108**. The flexible wipers **112** on the cups allow relative upward passage of such liquid discharge as the insert moves downwardly. Cup **140** on section **104***e* seals against the tubing bore to assure entrance of fluid into pipe **109**.

As seen in FIGS. 9 and 9*a*, the insert has a shoulder **113** proximate the lower terminal of the section **104***f*, and located in such manner as to insure straddling of the duct **95** and rupturable means **97** by pressure cups **114** and **115** as seen in FIGS. 9 and 10 when the insert downward travel is arrested. As a result, high pressure fluid discharging through the rupturable means **106** has access to the rupturable means **97**. In accordance with another feature and unusual advantage of the invention, the shoulder **113** engages the seat **49** formed in the valve means

31, thereby to drive valve means downwardly to its lower position in the sub body, at which time the rupturable means 106 and 97 are in communication. Sufficient fluid pressure may then be pumped into and built up in the tubing to pass downwardly through the insert and rupture the means 106, filling the space between the cups 114 and 115 above and below the level of the rupturable means 97. The cups seal off against the bore of the sub body section 12*a* to allow sufficient pressure build up to rupture the means 97 in order to release the upper slips as described. Thereafter, the tool and insert may both be upwardly withdrawn with the tubing string.

Referring briefly back to FIG. 10, the rupturable means 106 therein shown is similar to that identified at 97 in the same figure. Thus, it includes a rupturable diaphragm 116*a* and a nut 116, retaining the diaphragm in position to be ruptured in response to the exertion thereagainst of sufficiently high fluid pressure. Fluid then exhausts through the port 117, the rupture diaphragm, and a port 118 in the nut, for application to the rupturable means 97 in the sub body.

Referring now to a typical operation involving the use of the novel apparatus, reference will be made first to FIG. 3 showing the tool after it has been run downwardly in the well along with the tubing string 16 to which it is connected as a sub. During the running-in process, the valve 31 is nromally in the position shown in FIGS. 1, 1*a* and 1*b*, so that fluid in the annulus and between the sub and the casing may by-pass the packer. After the running-in of the tool, it is set in position by spreading the slips and extending the packer as previously described, fluid pressure being pumped into the string as by pump 44, to effect this step. Such fluid pressure may also be used to operate the valve 31 into shut-off condition whereby communication around the packer through the passage 29 is blocked, as seen in FIGS. 4, 4*a* and 4*b*.

The pressure introducing step may be considered as including the closing off of the string at a location proximate the packer, slip and valve assemblies, as by dropping a plug in the string for descent to said location, and then building up fluid pressure in the string above the plug to displace the valve to shut-off position. Under these conditions, the well is normally ready for production. A further step in the overall method includes introducing sufficient fluid pressure into the well to operate the valve opening up by-passing communication around the packer. This step may be carried out by closing off the string as would occur by dropping a plug in the string for descent to said location and then building up the fluid pressure in the string above the plug to displace the valve to open position. See for example the description in connection with FIGS. 4*b* and 6.

Fluid may then be introduced into the well space outside the string, as for example by operating pump 120 in FIG. 3, the downwardly flowing fluid by-passing the packer to enter the string therebelow, all without displacement of the set packer or manipulation of a wire line in the string. Such fluid may comprise drilling mud introduced to kill the well, in which event the mud may also flow upwardly in the string from the lower extremity thereof. The fluid might also comprise water pumped into the annulus to induce well production of petroleum. Alternatively, the fluid might comprise acid introduced to treat the formation below the packer.

When such fluid is pumped into the annulus, it will be seen from FIG. 1*a* that the fluid may flow downwardly through the upper port 25 and outwardly through the lower port 26. At the same time, it exerts hydrostatic pressure downwardly against the valve at the location 37 in FIG. 1*b* to hold the valve in open condition. Accordingly, inadvertant closing of the valve is additionally resisted by the weight of the fluid being pumped downwardly in the annulus.

Referring finally to FIGS. 11, 11*a*, 11*b* and 12, a modified rupturable means is indicated at 123 in a position to release auxiliary fluid pressure from the confined space 124 when the cone member 125 is forced downwardly relative to the sub body section 12*e* shown. For this purpose, high pressure fluid is delivered through the port 126 in the section 12*e* to drive the piston face 127 of the cone member nut 128 downwardly, as better seen in FIG. 11*b*. The confined fluid 124 which normally blocks downward travel of the cone member is then exhausted through the rupturable means 123 when the pressure of said confined fluid reaches a predetermined high level. The rupturable means 123, which is better seen in FIG. 12, is similar to that shown at 97 in FIG. 10, but is located at the upper terminal of the cone member 125 in the space between successive slips arranged circularly about the axis 129. A duct 130 communicates between the space containing the fluid 124 and said rupturable means. Setting of the upper slips 131 by fluid pressure exertion through the port 132 is carried out as seen in FIG. 11*a* in a manner similar to that described in connection with FIG. 1.

I claim:

1. Well tool apparatus of the character described, comprising a generally endwise extending tubular body adapted for connection in a pipe string to be lowered in a well, packer means carried for sealing off the annular zone between the well bore and said body, the body having porting to pass fluid between said zone at one end at least of said packer and the body interior, and valving means carried by the body for vertical movement between a first position in which the porting is closed and a second position in which the porting is open, said valving means containing an opening to pass well fluid endwise therethrough, the body carrying an interior port forming seat to receive a primary plug acting to block downward flow of well fluid, the valving means being exposed to the body interior to receive application of well fluid pressure acting to move the valving means vertically upwardly between said positions when downward flow of well fluid in the string is blocked by said primary plug.

2. Well tool apparatus of the character described, comprising a generally tubular axially extending body adapted for connection in a pipe string to be lowered in a well, the body having a passage to flow well fluid therethrough, packer means carried for sealing off the annular zone between the well bore and said body, the body having side porting to pass fluid between said zone at one end at least of said packer and the body interior, and generally tubular valving means carried for axial movement in the body between a first position in which the side porting is closed and a second position in which the porting is open, said valving means containing an interior opening to pass fluid endwise therethrough, the body carrying an interior port forming seat to receive a primary plug acting to block downward flow of well fluid, the valving means being exposed to the body interior to receive application of well fluid pressure acting to move the valving means vertically upwardly between said positions when downward flow of well fluid in the string is blocked by said primary plug.

3. Well tool apparatus of the character described, comprising a generally endwise extending tubular body adapted for connection in a pipe string to be lowered in a well, packer means carried for expansion sealing off the annular zone between the well bore and said body, other means movable to effect body supporting connection with the well bore and expansion of the packer, the body having porting to pass fluid between said zone at one end at least of said packer and the body interior, and valving means carried for movement in the body between a first position in which the porting is closed and a second position in which the porting is open, said valving means containing an opening to pass well fluid endwise therethrough, said valving means and other means being exposed for transmitting fluid created pressure acting within the string to move the valving means between said positions and to so move said other means.

4. Well tool apparatus of the character described, comprising a generally tubular axially extending body adapted for connection in a pipe string to be lowered in a well, the body having a passage to flow well fluid, packer means carried for sealing off the annular zone between the well bore and said body, the body having side porting to pass fluid between said zone at one end at least of said packer and the body interior, and generally tubular valving means carried for axial movement in the body between a first position in which the side porting is closed and a second position in which the side porting is open, said valving means containing an opening to pass fluid endwise therethrough, the body having an interior port forming seat to receive a primary plug acting to block downward flow of well fluid, the valving means being exposed to the body interior to receive application of well fluid pressure acting to move the valving means in one direction between said positions when downward flow of well fluid is blocked by said primary plug, the valving means having a port forming seat to receive a secondary plug acting to block downward flow of well fluid through the valving means and transmitting pressure acting to move the valving means in the opposite direction between said positions.

5. Well tool apparatus of the character described, comprising a generally tubular and vertically axially extending body adapted for connection in a pipe string to be lowered in a well, the body having a passage to flow well fluid therethrough, packer means carried for sealing off the annular zone between the well bore and said body, the body having upper and lower side porting to by-pass fluid in said zone around said packer means via the body interior, and generally tubular valving means carried for axial movement in the body between a lower position in which the lower side porting is open and an upper position in which the lower side porting is closed, said valving means containing an opening to pass fluid endwise therethrough, said body having an interior port forming seat below said valving means to receive a primary plug acting to block downward flow of well fluid, the valving means being exposed to the body interior to receive application of well fluid pressure acting to move the valving means upwardly to said upper position when downward flow of well fluid in the string is blocked by said primary plug.

6. Apparatus as defined in claim 5 in which said valving means has downward fluid pressure receiving extent, and upward fluid pressure receiving extent greater than said downward fluid pressure receiving extent.

7. Apparatus as defined in claim 5 in which said body has stops to limit vertical travel of said valving means at said upper and lower positions.

8. Apparatus as defined in claim 5 in which said valving means has a port forming seat to receive said closure in the form of a secondary plug acting to block downward flow of well fluid through the tubular valving means and transmitting pressure acting to move the valving means downwardly into said lower position.

9. Apparatus as defined in claim 8 including balls comprising said primary and secondary plugs.

10. Apparatus as defined in claim 8 including latching mechanism for releasably holding the valving means in each of said upper and lower positions.

11. Apparatus as defined in claim 10 in which said latching mechanism includes inwardly flexible vertically elongated fingers on the valve means and having outwardly facing terminal latch shoulders, and upper and lower annular shoulders on said body to engage said latch shoulders.

12. Apparatus as defined in claim 5 including means carried by said body and operable to effect body supporting connection with the well bore and expansion of the packer into sealing engagement with the well bore, said last named means including outwardly spreadable lower slips below the packer, and fluid pressure responsive lower actuator structure exposable to fluid pressure within said body and movable upwardly to effect outward spreading of the slips and expansion of the packer when downward flow of well fluid in the string is blocked by said primary plug.

13. Apparatus as defined in claim 12 in which said last named means also includes outwardly spreadable upper slips above the packer, and fluid pressure responsive upper actuator structure exposable to fluid pressure within said body and movable to effect outward spreading of the upper slips when downward flow of well fluid in the string is blocked by said primary plug.

14. Apparatus as defined in claim 13 in which said last named means includes a tubular extension of said body having a first side port to communicate fluid pressure in the string to said upper actuator structure for moving it in one axial direction effecting spreading of the upper slips, said extension having a second side port to communicate high fluid pressure in the string to said upper actuator structure for moving it in the opposite axial direction effecting release of the upper slips, and rupturable means blocking flow of predetermined high pressure fluid through said second side port in less than sufficient quantity to effect said upper slips release.

15. The apparatus of claim 14 in which said rupturable means is at said second port.

16. The apparatus of claim 14 in which said rupturable means is at an auxiliary fluid pressure release duct to release a confined supply of said auxiliary fluid blocking movement of said upper actuator structure in said opposite axial direction.

17. Apparatus as defined in claim 14 including insert means movable downwardly into said tubular extension to locally supply high pressure fluid to said second side port.

18. Apparatus as defined in claim 17 in which said insert means includes a tubular member having an outlet for flowing high pressure fluid from within said member to the exterior thereof to enter said second side port in said extension, sealing cups carried by said member to seal off between said member and extension above and below said outlet, a flow line to by-pass fluid within said extension around said cups, and a shoulder to transmit force acting to locate the insert with respect to said valving.

19. For combination in a string of well tubing, a generally tubular and vertically axially extending body, outwardly spreadable slips carried by the body, fluid pressure responsive actuator structure exposable to fluid pressure within the body and movable generally axially to effect outward spreading of the slips into body supporting connection with the well bore, said body having a first side port to communicate fluid pressure in the string to said actuator structure for moving it in one axial direction effecting spreading of the slips, said body having a second side port to communicate relatively high fluid pressure in the string to said actuator structure for moving it in the opposite axial direction effecting release of said slips, and rupturable means at said second port blocking flow of predetermined high pressure fluid through said second side port in less than sufficient quantity to effect said slip release.

20. In the method of controlling a well into which a string of production tubing is run, the string supporting slip, packer and valve assemblies characterized as operable respectively to anchor the string to the casing, to pack-off between the string and casing and to control vertical by-passing around the packer of fluid in the annular space between the string and casing, the valve assembly also characterized as fluid pressure operable, the steps that include running the string into the well with the valve assembly in open condition, then introducing sufficient fluid pressure into the string for communication to said assemblies to operate the slips for anchoring the string to the casing, to operate the packer for

packing off between the string and casing, and to operate the valve to shunt off by-passing communication around the packer, and including the further step of introducing sufficient fluid pressure into the well to operate the valve opening up by-passing communication around the packer.

21. The method of claim 20 in which said first recited pressure introducing step includes closing off the string at a location proximate said assemblies by dropping a plug in the string for descent to said location, and then building up fluid pressure in the string above said plug to displace the valve to shut-off position.

22. The method of claim 20 in which said further step is carried out by closing off the string at a location proximate said assemblies by dropping a plug in the string for descent to said location, and then building up fluid pressude in the string above the plug to displace the valve to open position.

23. The method of claim 22 including introducing fluid into the well space outside the string to by-pass the packer, to enter the string below the packer and to flow upwardly in the string.

24. The method of claim 20 in which said further step is carried out by introducing fluid into the well space outside the string to build up fluid pressure therein for displacing the valve to open position and thereafter to bypass the packer as the fluid flows downwardly in the well.

25. The method of claim 24 in which said fluid comprises drilling mud introduced to kill the well.

26. The method of claim 24 in which said fluid comprises water introduced to enter the string below the packer and flow upwardly in the string to induce well production of petroleum.

27. The method of claim 24 in which said fluid comprises acid introduced to treat the formation below the packer.

28. In sub-combination, a generaly tubular axially extending body adapted for connection in a pipe string to be lowered in a well, the body having a side port to pass the flow of well fluid between the body exterior and interior, and generally tubular valving means carried for axial movement in the body between a first position in which said fluid flow through the side port is blocked and a second position in which said fluid flow through the side port is unblocked, the body carrying an interior port forming seat to receive a primary plug acting to block downward flow of well fluid, the valving means having surface extent exposed to the body interior to receive application of well fluid pressure acting to move the valving means in one direction between said positions when downward flow of well fluid is blocked by the primary plug, the valving means having a port forming seat to receive a secondary plug acting to block downward flow of well fluid through the valving means and transmitting pressure acting to move the valving means in the opposite direction between said positions.

29. The combination of claim 28 in which the body has stops to limit vertical travel of said valving means at said upper and lower positions.

30. The combination of claim 28 including balls comprising said primary and secondary plugs.

31. Well tool apparatus of the character described, comprising a generally tubular and vertically axially extending body adapted for connection in a pipe string to be lowered in a well, the body having a passage to flow well fluid therethrough, packer means carried for sealing off the annular zone between the well bore and said body, the body having upper and lower side porting to by-pass fluid in said zone around said packer means via the body interior, and generally tubular valving means carried for axial movement in the body between a lower position in which the lower side porting is open and an upper position in which the lower side porting is closed, said valving means containing an opening to pass fluid endwise therethrough, the valving means being exposed to the body interior to seat a closure acting to close said opening and to transmit fluid created pressure for moving said valving means between said positions, said valving means being exposed to said upper porting to receive fluid pressure acting downward in said zone and through said upper porting tending to move said valving means downwardly to said lower position.

32. For combination in a string of well tubing, a generally tubular and vertically axially extending body, outwardly spreadable slips carried by the body, fluid pressure responsive actuator structure exposable to fluid pressure within the body and movable generally axially to effect outward spreading of the slips into body supporting connection with the well bore, said body having a first side port to communicate fluid pressure in the string to said actuator structure for moving it in one axial direction effecting spreading of the slips, said body having a second side port to communicate relatively high fluid pressure in the string to said actuator structure for moving it in the opposite axial direction effecting release of said slips, and repturable means blocking flow of predetermined high fluid pressure through said second side port in less than sufficient quantity to effect said slip release, said rupturable means being at an auxiliary fluid pressure release duct to release a confined supply of said auxiliary fluid blocking movement of said actuator structure in said opposite axial direction.

33. For combination in a string of well tubing, a generally tubular and vertically axially extending body, outwardly spredable slips carried by the body, fluid pressure responsive actuator structure exposable to fluid pressure within the body and movable generally axially to effect outward spreading of the slips into body supporting connection with the well bore, said body having a first side port to communicate fluid pressure in the string to said actuator structure for moving it in one axial direction effecting spreading of the slips, said body having a second side port to communicate relatively high fluid pressure in the string to said actuator structure for moving it in the opposite axial direction effecting release of said slips, and insert means movable downwardly into said tubular extension to locally supply high pressure fluid to said second side port, said insert means including a tubular member having an outlet for flowing high pressure fluid from within said member to the exterior thereof to enter said second side port in said extension, sealing cups carried by said member to seal off between said member and extension above and below said outlet, a flow line to by-pass fluid within said extension around said cups, and a shoulder to transmit force acting to locate the insert with respect to said valving.

References Cited by the Examiner

UNITED STATES PATENTS

2,795,281	6/1957	Christian	166—129
3,118,502	1/1964	Cochran	166—129
3,122,205	2/1964	Brown et al.	166—120

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,299,955 January 24, 1967

John S. Page, Jr.,

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

In the heading to the printed specification, line 3, for "assignor to" read -- assignor of 50% to --; column 11, line 2, for "shunt" read -- shut --; column 12, line 37, for "spredable" read -- spreadable --.

Signed and sealed this 24th day of October 1967.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents