United States Patent

[11] 3,556,220

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[54] **WELL TOOLS**
25 Claims, 18 Drawing Figs.

[52] **U.S. Cl.** **166/290,** 166/120, 166/150, 166/181
[51] **Int. Cl.** **E21b 33/13,** E21b 33/12
[50] **Field of Search** 166/290, 120, 150, 149, 181, 182

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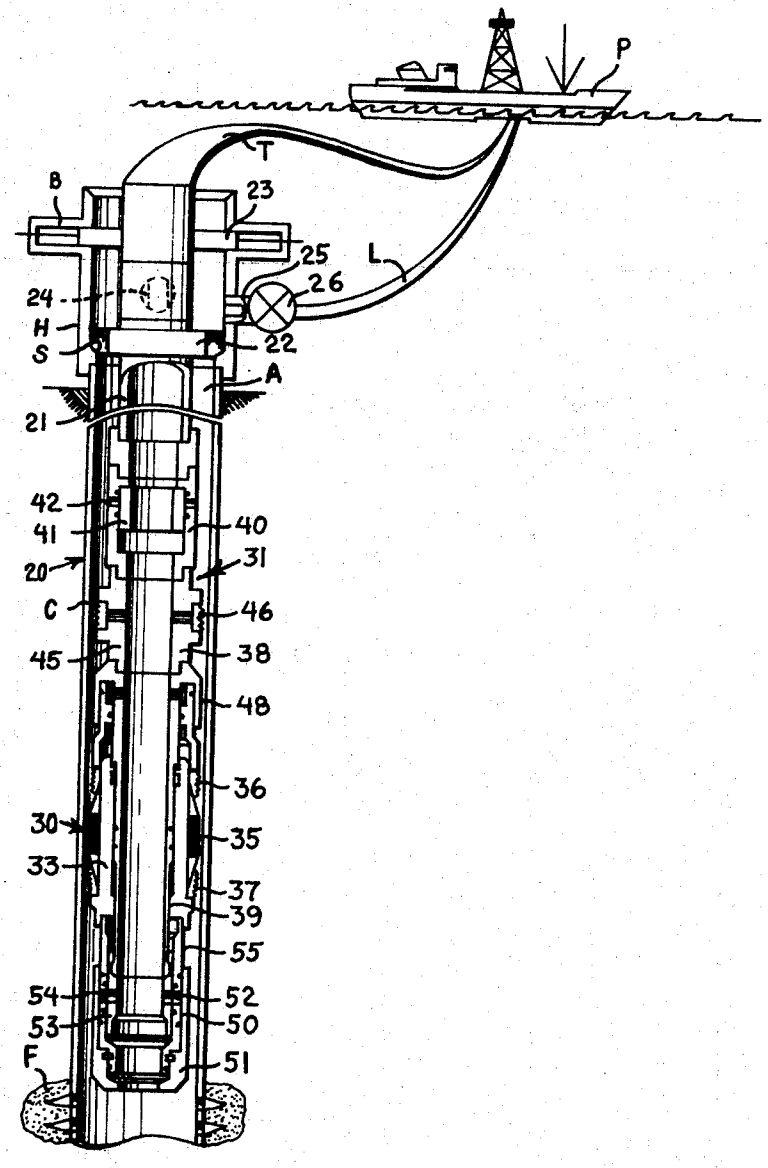
ABSTRACT: A pluggable well packer and operator means therefor runnable on a pipe string into a well and fluid pressure settable without manipulation of the pipe string to seal off and production test a well formation, and operable for cementing off said formation and plugging said well; said operator means being thereafter removable with said pipe string. The method of treating a well by means of the foregoing is also set forth.



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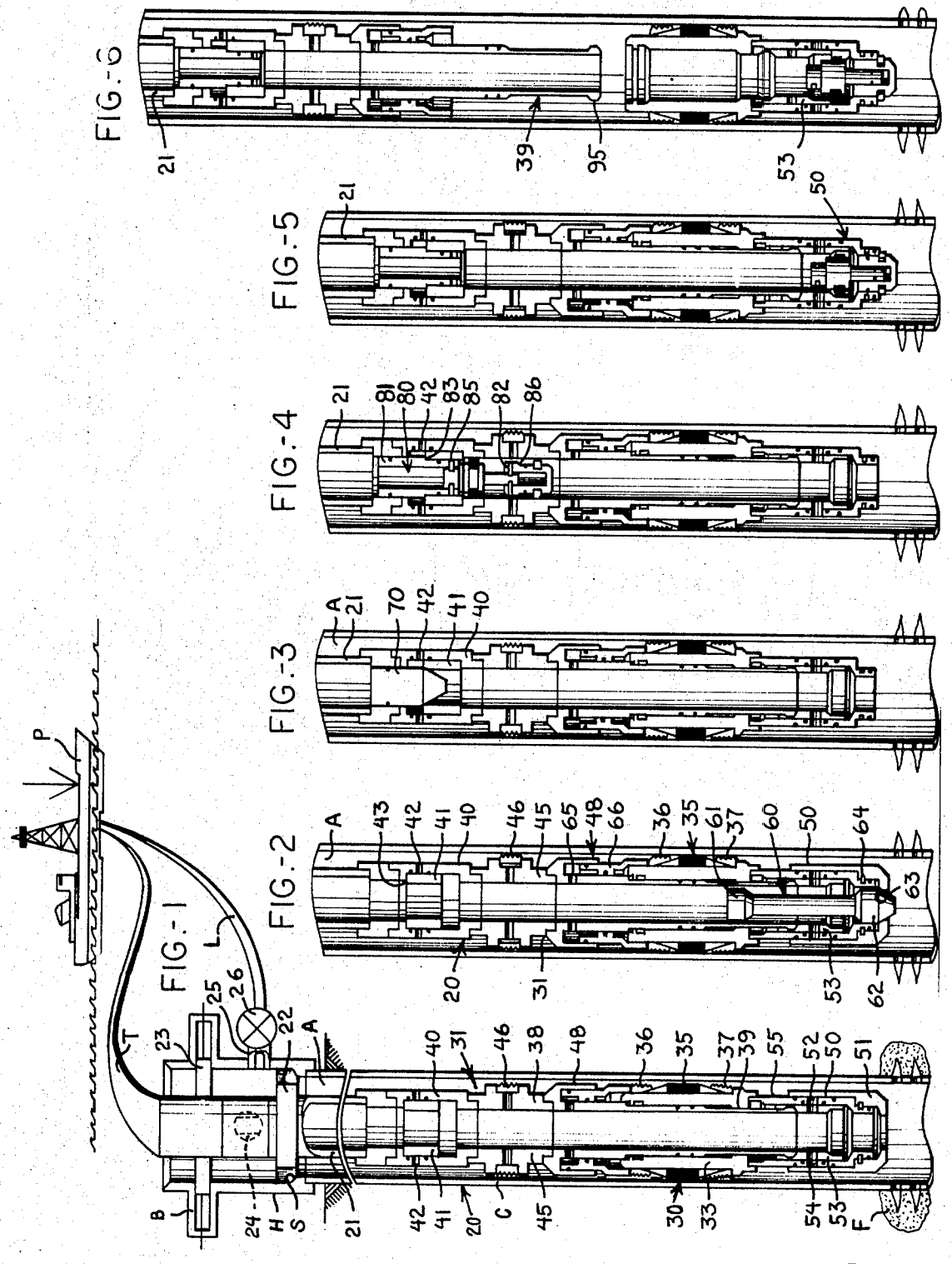

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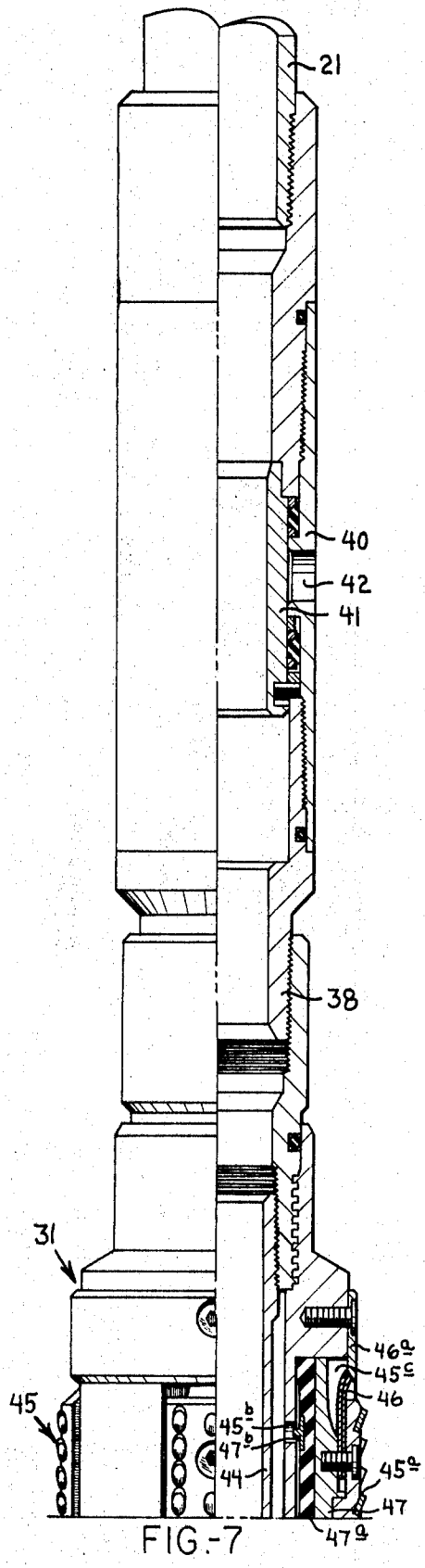

FIG.-7

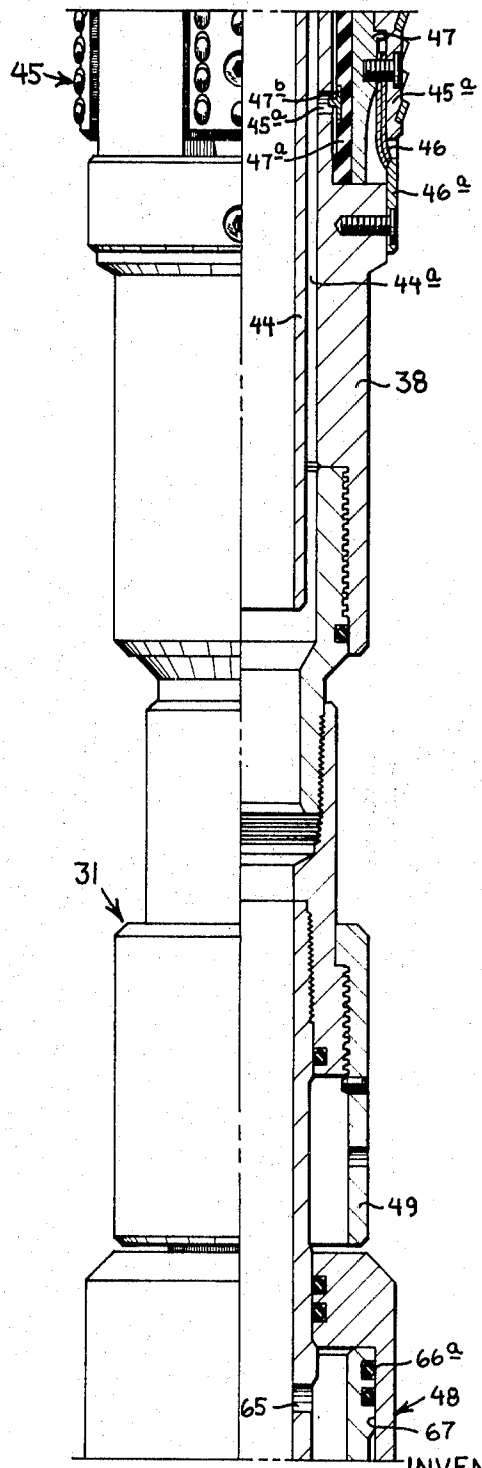

FIG.-8

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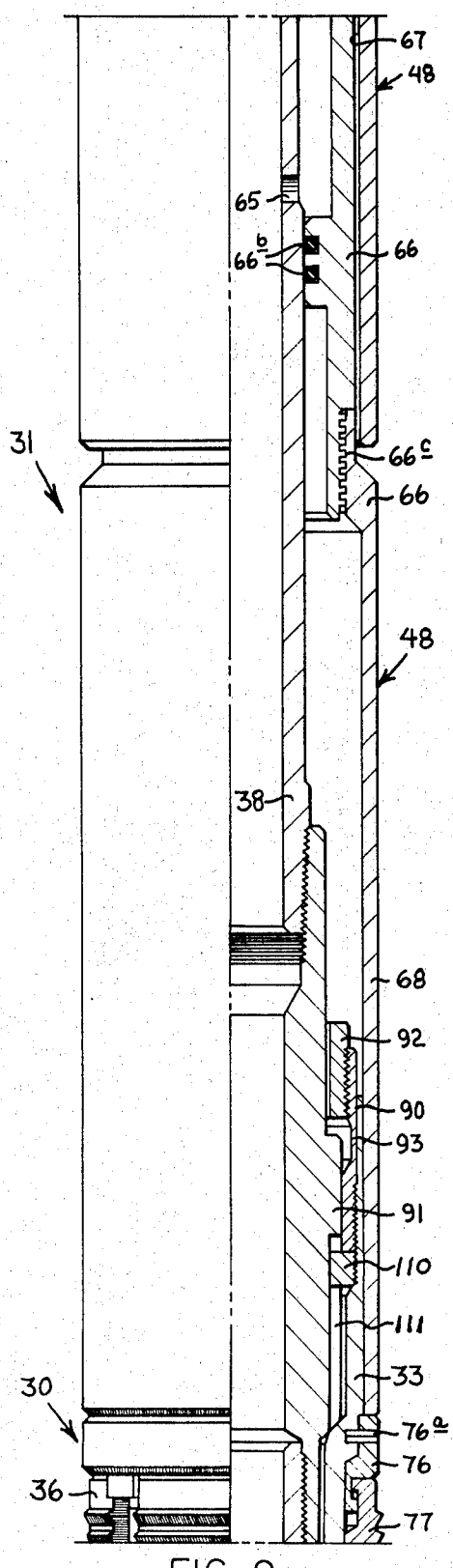

FIG.-9

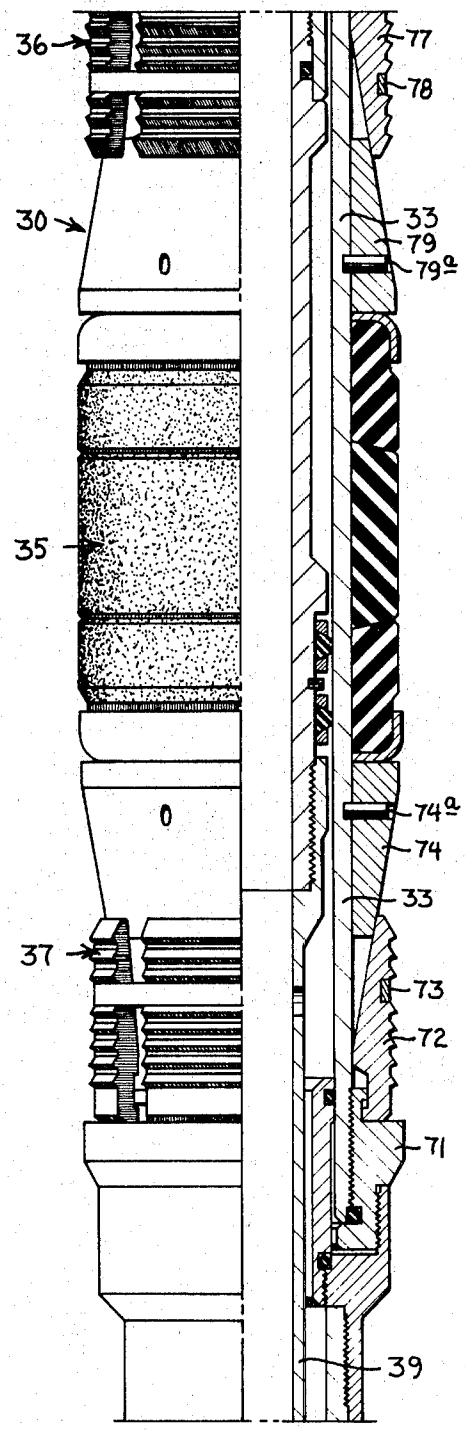

FIG.-10

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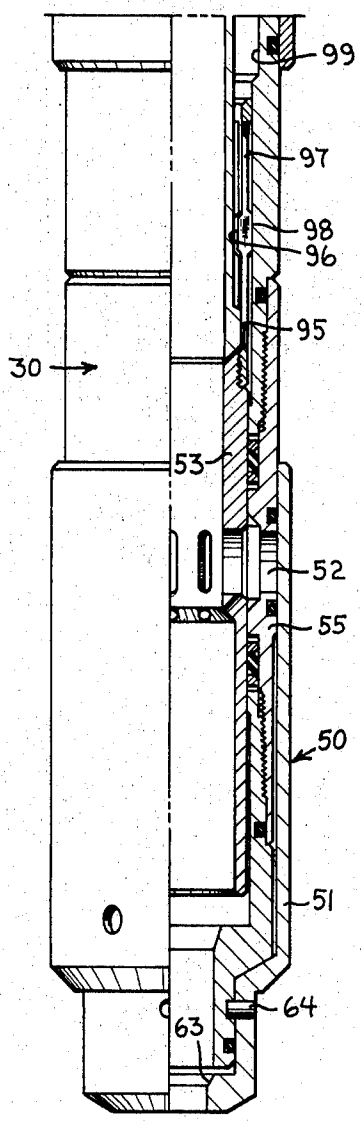

FIG.-11

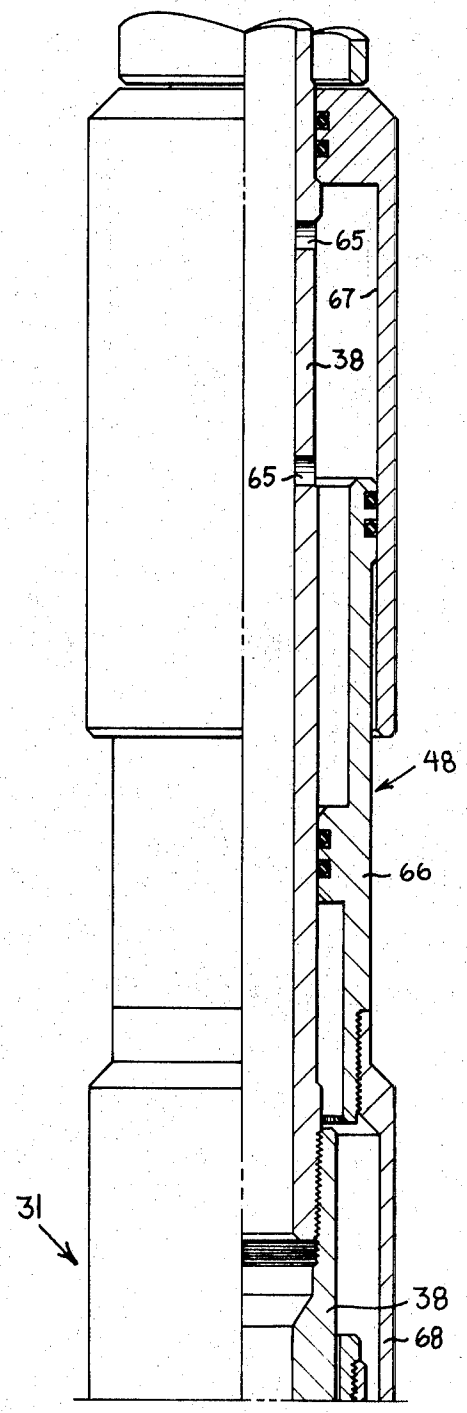

FIG.-12

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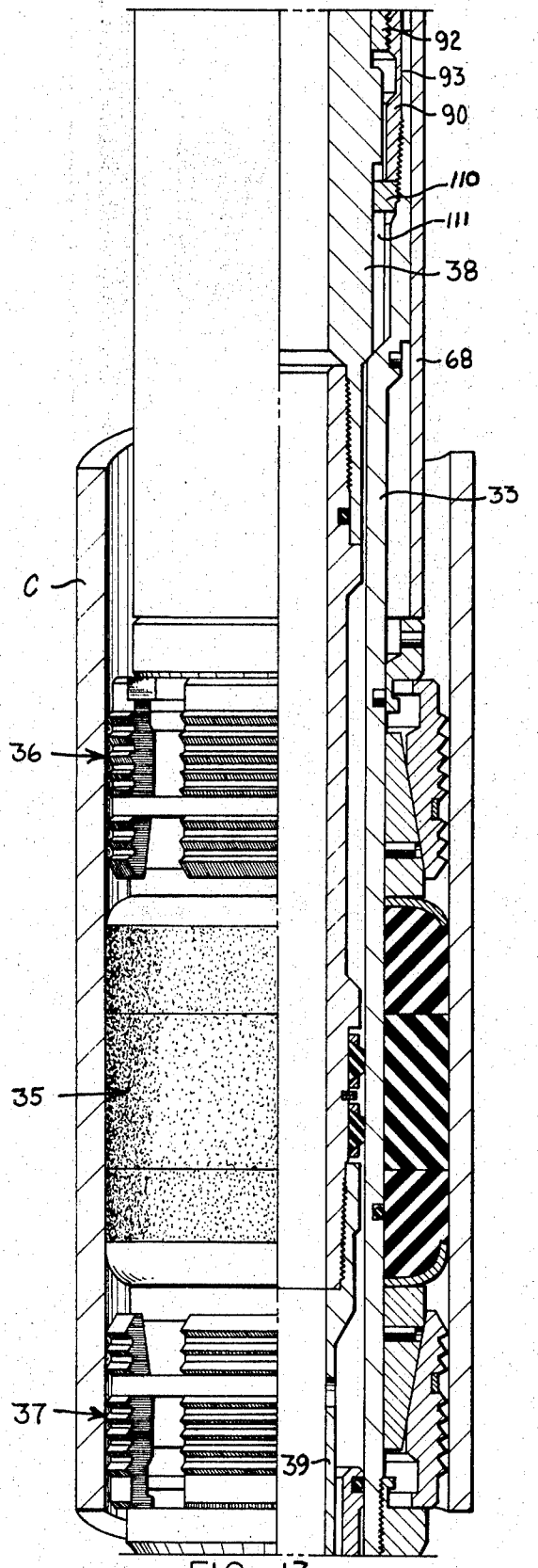

FIG.-13

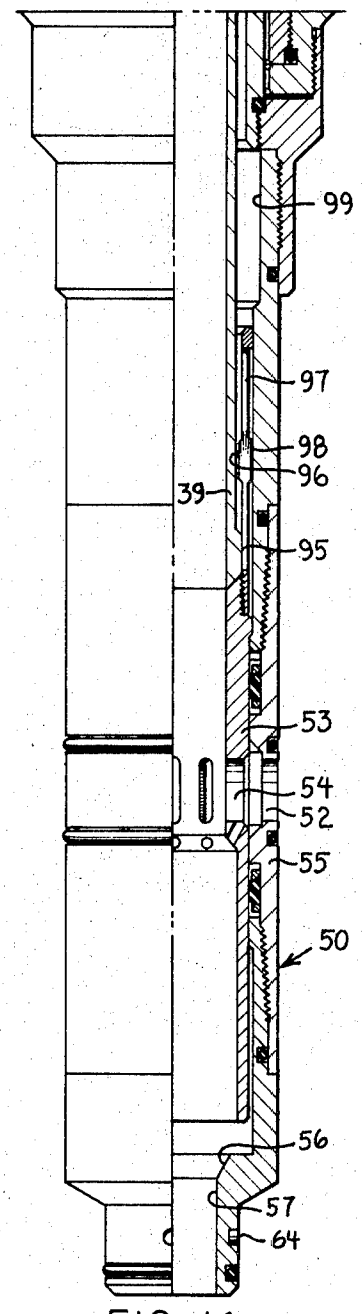

FIG.-14

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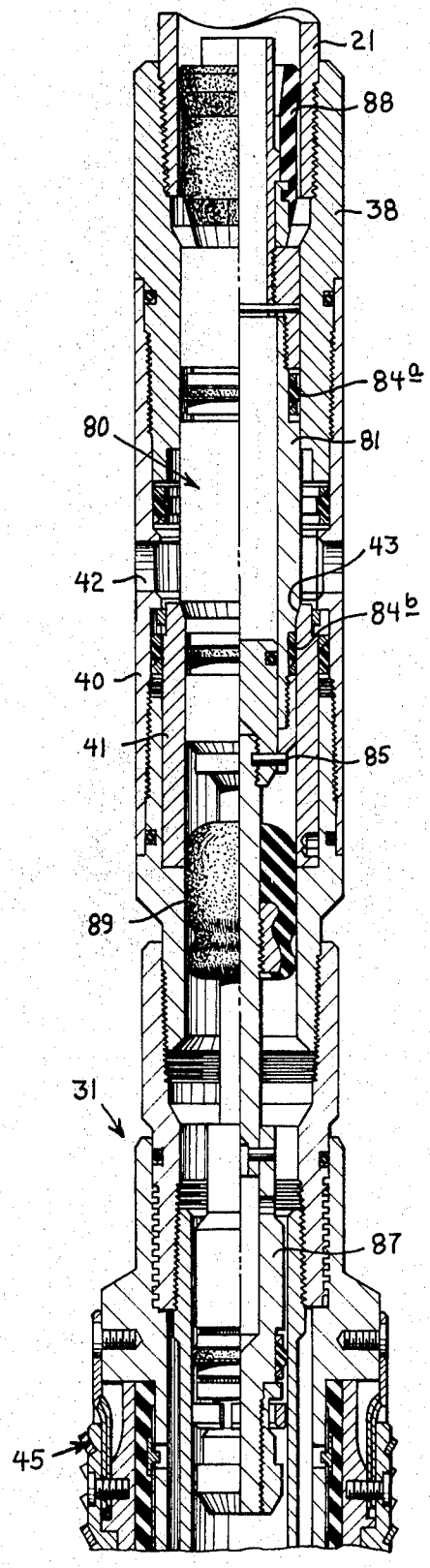

FIG.- 15.

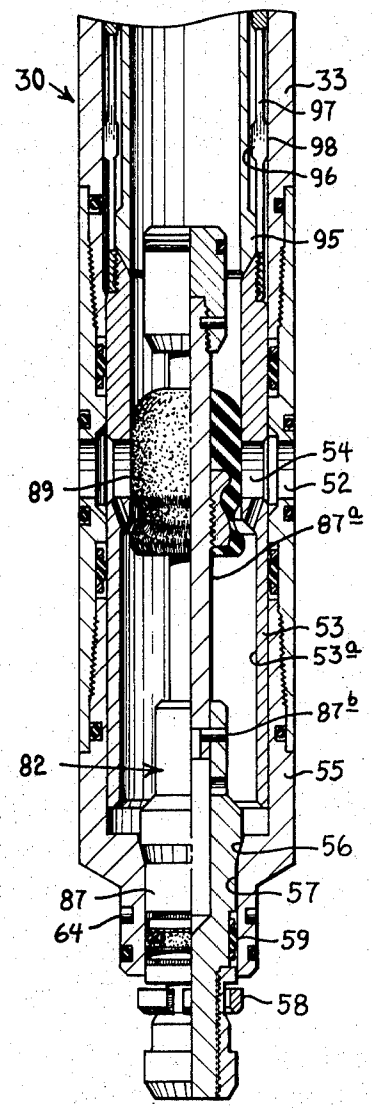

FIG.- 16

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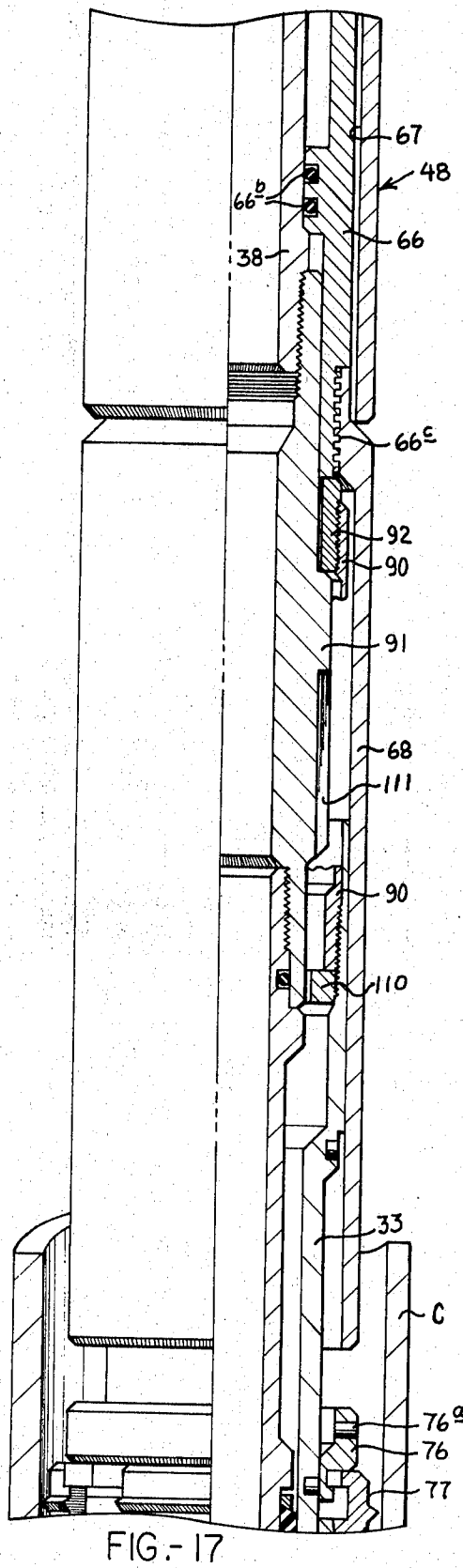

FIG.-17

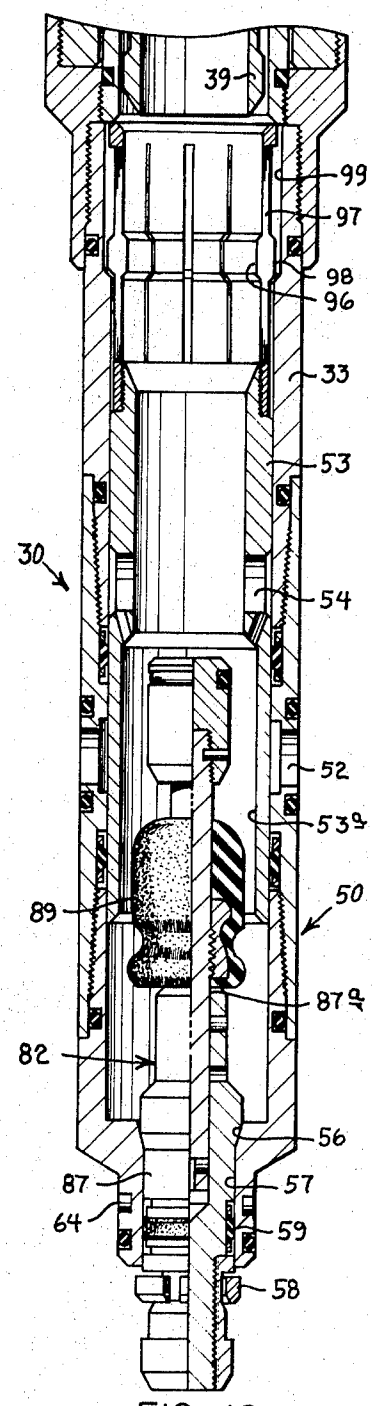

FIG.-18

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WELL TOOLS

One object of this invention is to provide an improved tool for use in the production testing of wells, particularly submarine wells.

An important object of the invention it to is to provide a production testing tool which is lowerable into a well on a pipe string, which may be set, without manipulating said pipe string, by fluid pressure applied through said pipe string.

A further object is to provide a tool of the type described which can be converted to a bridge plug subsequent to the production testing phase of the operation.

A still further object is to provide a tool of the character described which includes a running tool having flow port means openable for killing the well after the production test, and reclosable to permit the pumping of cement through the tool and into the formation below the tool for the plugging operation.

A yet further object is to provide a tool of the character described which is operable to permit the removal of all excess cement above the tool by reverse circulation subsequent to the cementing operation.

Another object of this invention is to provide a well tool for use in production testing and cementing of a well, particularly a submarine well, including a running tool having holddown means expandable by the fluid pressure in the flow passage of said tool, said holddown means being engageable with the interior wall of the casing so that the pressure in the well bore which tends to displace the production tool upwardly will expand the holddown means into engagement with the well casing to prevent such upward displacement, during all phases of operation of the tool.

Another object is to provide such a tool which includes a well packer portion having lateral ports in the wall thereof below the packer seal elements and a plug which is installable in the packer bore below said lateral ports, said lateral ports being closable after said plug is installed so that back flow of fluids through the tool will be prevented.

An important object of the invention is to provide a well tool and operating means therefor which can be used for the production testing and subsequent plugging of a well, by means of which both operations may be performed during a single trip of the pipe by means of which the tool is run and operated.

Another important object is to provide a system of for and method of treating a well having a casing and a wellhead, wherein a well tool and operator means are connected to a well flow conductor and lowered thereby to a desired location in said casing and said flow conductor is then suspended at the wellhead, said well tool and operator means being actuated thereafter by fluid pressure applied through said flow conductor for sealing off and production testing a well formation, and operable thereafter for cementing off said flow conductor are disconnectable from said well tool for removal from said well casing, leaving said well tool in place.

A particular object of the invention is to provide a system for and a method of treating a well having a casing and a wellhead, wherein a well tool and operator means are connected to a well flow conductor and lowered thereby to a desired location in said casing and said flow conductor is then suspended at the wellhead, said well tool and operator means being actuated thereafter by fluid pressure applied through said flow conductor for sealing off and production testing a well formation, and operable thereafter for cementing off said well formation, said well tool and operator means being provided with means for establishing flow paths for the circulation of fluids thru through flow conductor and said casing subsequent to said production testing and after said cementing operations, and wherein said operator means and said flow conductor are disconnectable from said well tool for removal from said well casing, leaving said well tool in place.

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

FIG. 1 is a fragmentary schematical view showing the well tool and operator means disposed in a submarine well ready for operation;

FIG. 2 is a fragmentary schematical view similar to FIG. 1 showing the well tool being actuated to position sealing off the well formation;

FIG. 3 is a view similar to FIG. 2 showing upper lateral flow ports being opened preparatory to killing the well;

FIG. 4 is a vie similar to FIG. 3 shown showing the upper lateral port reclosed by a straddle member and plug assembly;

FIG. 5 is a view similar to FIG. 4 showing the plug in position closing the lower end of the packer bore with lower lateral flow ports open;

FIG. 6 is a view similar to FIG. 5 showing the operator means disconnected from the well tool and the lower lateral flow ports and packer bore closed to plug the well;

FIGS. 7, 8, 9, 10 and 11, taken together, form an enlarged view, partly in elevation and partly in section, showing the details of construction of the well tool and operator means in running-in condition;

FIGS. 12, 13 and 14, taken together, form an enlarged view, partly in elevation and partly in section, of the lower portion of the operator means and the well tool showing the well tool actuated to sealing position;

FIG. 15 is an enlarged view, partly in elevation and partly in section, showing the straddle member and plug assembly closing the upper lateral flow ports of the operator means;

FIG. 16 is an enlarged view, partly in elevation and partly in section, of the lower portion of the well tool showing the plug closing the bore of said well tool before the lower lateral flow ports are closed;

FIG. 17 is a fragmentary view, partly in elevation and partly in section, of the upper portion of the well tool showing the connection between the operator means and the well tool released; and

FIG. 18 is a fragmentary view similar to FIGS. 14 and 16 showing the lower lateral flow ports closed and the lower end portion of the operator means being withdrawn from the well tool.

In the drawings, FIG. 1, a submarine well installation 20 is shown schematically, in which the well is drilled into the earth at the bottom of the body of water. The well installation includes a casing C penetrating the earth producing formation F and having a wellhead or hanger assembly H at the upper end of the casing. The hanger assembly includes a seat S and a blowout preventer B, and may be similar to the submarine wellhead installation illustrated and described in the U.S. Pat. No. 3,411,576, to Donald F. Taylor, Jr. A drilling platform or vessel P is shown as floating on the surface of the water and flexible flow conduits T and L are illustrated as extending downwardly from the drilling vessel to he wellhead H, the line T being connected to the upper end of the tubing string or production tubing 21 extending downwardly in the well casing and supported by a hanger 22 on the seat S in the wellhead. The rams 23 of the blowout preventer are shown as closed around the flow conductor T, and a valve 24, which may be an automatic or surface controlled safety valve of the type generally shown in the aforesaid U.S. Pat. No. 3,411,576, may be provided in the flow conductor T to permit disconnection of the flow conductor above the wellhead in the event of storm or other threat of damage. Similarly, the flow conduit L is connected to the side port, flow wing or outlet 25 of the wellhead H, and a valve 26 is connected in the flow conductor for controlling flow through said lateral flow port.

Obviously, to both the safety valve 24 in the tubing string 21 and the lateral flow wing valve 26 communicating with the casing annulus may be remotely controlled or may be automatically operable.

The well system and method of this comprehends the use of a well apparatus including a well packer and plug tool 30 and an operator and running tool 31 releasably connected together in longitudinal alignment and carried by the lower end of the well production tubing string 21 as shown in FIG. 1. The packer and plug tool includes a mandrel or body 33 hav-

ing a seal element 35 and upper and lower gripping means or slip assembles 36 and 37, respectively, on said body. The operator and running tool 31 includes an elongate body or mandrel 38 which is connected at its upper end to the lower end of the tubing string 21, and has a reduced lower stinger portion 39 which extends downwardly in the bore of the packer and plug tool 30. The operator and running tool also includes a lateral flow pot port sleeve valve 40 having a valve closure member 41 slidable therein for closing the lateral ports 42 in said sleeve valve, and holddown means 45*a* movable laterally thereof by fluid pressure from within the bore of the mandrel of or body of said operator and running tool. Below the holddown means, the operator means is provided with a fluid pressure responsive actuator assembly 48 which is operable in response to fluid pressure from within the bore of the mandrel to engage and move the sealing means and gripping members or slips of the packer and bridge plug to expanded gripping position engaging the bore wall of the casing, whereby the sealing means and gripping means of the packer an and bridge plug are expanded hydraulically and without mechanical operation or manipulation of the tubing string 21.

The lower portion of the mandrel or body of the packer and plug is also provided with a sliding sleeve valve assembly 50 having lateral ports initially closed by a thimble closure member or sleeve 51 telescoped over the lower end of the mandrel and closing the lateral ports 52 in the ported mandrel or body 55 of the sleeve valve assembly. Within the bore of the mandrel is a longitudinally slidable valve closure member 53 having lateral ports 54 which are initially in registry with the ports 52 in the mandrel or body. This inner sliding sleeve closure member 53 is movable longitudinally with respect to the lateral ports to reclose the ports after the same have been opened by removal the the thimble closure member 51 from the lower end of the mandrel, and will be hereinafter more fully explained. A releasable connection is provided between the lower reduced end or stinger 39 of the mandrel 38 of the operator and running tool and the inner sleeve closure member 53 for actuating the same from opened to closed positions, as will be hereinafter more fully explained.

In use in treating or operating a well, the well tubing string 21 having the operator and running tool 31 connected to the lower end thereof and carrying the packer and plug tool 30 therebelow is lowered into the well bore from the floating or other type platform P to position the packer and plug tool 30 at the desired location in the well bore with respect to the well formation F. The tubing string is then hung by means of the hanger 22 in the wellhead H and the rams 23 of the blowout preventer B are closed about the upper end of the tubing string. The flow conduit or conductor T and the lateral flow conductor L are connected to the upper end of the tubing string 21 and to the lateral flow wing 25 of the wellhead, respectively, as shown in FIG. 1, and extend from the wellhead to the platform P. Should any storm or other dangerous condition arise, the flow conduit T and the lateral flow conduit L may be disconnected in the manner set out and disclosed in the Taylor U.S. Pat Pat. No. 3,411,576, whereby it is not necessary that the tubing string and the operator and running tool and the packer and plug tool be removed from the well in the event of the occurrence of such conditions.

In carrying out the process and method of treating the well after the well installation has been made in the casing, a packer setting bar and plug 60 is pumped or otherwise moved through the tubing string into the bore of the packer and plug tool 30.

The elongate packer setting bar and plug 60 is circulated through the tubing string 21 into the bore of the packer and plug tool until the large plug member 62 at the lower end of the setting bar and plug engaged the seat 63 formed by the reduced lower internal flange portion of the thimble 50 to close the lower end of the bore and prevent fluid flow therethrough, as shown in FIG. 2. The thimble is held against displacement c shear pins or other suitable yieldable means 64 until a predetermined fluid pressure, preferably obtained by pumping such as water, into the well tubing, is directed through the lateral openings 65 in the actuator assembly 48 of the operator tool into the cylinder 66 to act on the longitudinally movable actuator piston 66, which has seals 66*a* engaging the wall of the cylinder 67 and seals 66*b* engaging the mandrel 33, to move the same longitudinally on the mandrel 38 of the operator and running tool until the enlarge skirt 68 threaded at 66*c* on the lower end of the piston engaged and compresses the gripping means 36 and 37 toward each other and expands the sealing member 35 into sealing engagement with the bore wall of the well casing. The pin 76*a* releasably holding the upper slip carrying sleeve 76 in an upper retracted position on the mandrel is sheared to permit the upper slips 77 to move downwardly on the upper expander cone 79 and shear the pin 79*a* holding the cone 79 in its upper position. The seal means 35 is compressed downwardly to shear the pin 74*a* holding the lower expander cone 74 in its upper retracted position, and such lower cone moves downwardly within the lower slips 72 to spread the retaining band 73 and expand the lower slips to gripping position on the supporting flange 71 on the mandrel 33. The seal means is then fully expandable and the upper slips 77 are expanded to gripping position spreading the band 78 to permit such expansion. The packer is thus set in gripping sealing position by fluid pressure applied through the actuator assembly 48 of the operator and running tool without mechanical movement or actuation of the tubing string.

A suitably elevated pressure is then applied by means of the liquid, such as water, in the tubing string and acts on the plug 62 of the packer setting bar and plug 60 to shear the pins 64 and force the thimble 50 downwardly off the ported valve body 55 at the lower end of the mandrel 33 of the packer to open the lateral ports 52 and 54 and to move the setting bar and plug out of the lower open end of the bore of the packer and plug. The enlarged head 61 at the upper end of the setting bar provides a restriction to fluid flow through the bore of the mandrel of the packer and plug and assures that the elongate setting bar moves the thimble off the valve body at the lower end of the mandrel of the packer and plug tool.

The packer and plug tool are now in the set gripping and sealing position shown in FIG. 3; and, with the packer to set, and the tubing full of fluid, such as water, and the lower open end of the packer and plug open to flow therethrough, the well is in condition to be tested for production. Fluids may be flowed from the well formation F upwardly through the bore of the packer and plug and the operator and running tool through the tubing string 21 to the surface of the water at the platform P.

With the packer and plug tool so set in sealing position, the formation is tested for productivity and determination of whether to complete the well in that formation, or to cement the tested formation and then test another producing zone. After the completion of the production test, the well is making no liquids, or if the well formation will take the fluids present in the tubing string 21 without damage, it is possible to cement the well bore below the packer without killing the well by admitting mud or loading fluid from the annulus into the tubing string. In such case, the cement would be pumped downwardly through the packer and plug tool and out the open end thereof to close the well bore therebelow.

If, however, as is the usual case, it is desired to kill the well and then to introduce cement for plugging, a weighted plug tool 70 is dropped into the well bore through the conductor and moved downwardly therein by gravity until the plug tool engages the seat 43 at the upper end of the closure sleeve 41 of the lateral flow sleeve valve 40 in the operator and running tool. Fluid pressure introduced into the well flow conductor T and tubing 21 above the plug 70 will force the sleeve 41 downwardly to open the lateral ports 42 for flow therethrough. When it has been determined that the sleeve is opened, the loading fluid, or mud or the like, in the annulus A between the casing and flow tubing string is permitted to enter through the ports 42 and circulates the plug 70 out of the well

tubing back upwardly through the production tubing **21** and conduit T. A column of loading fluid or mud will now be present in the tubing string, and the cement may be introduced in the usual manner into the well.

A straddle and sealing plug assembly **80** comprising a tubular straddle port closure member **81** and a closure plug assembly **82** releasably secured thereto is inserted into the flow conduit T and pumped downwardly ahead of the cement through the tubing string **21** into the upper end of the bore of the operator and running tool **31**, as shown in FIGS. **4** and **15**. An external annular shoulder **83** on the tubular port closure member **81** engaged the seat **43** at the upper end of the sleeve **41** and limits further downward movement of the tubular straddle port closure. Sealing members **84***a* and **84***b* on the port closure sleeve **81** seal between the closure sleeve and the bore wall of the mandrel or body **38** of the operator tool above and below the ports **42** to close off fluid flow through such lateral ports. An annular upwardly facing sealing cup **88** on the upper end of the straddle closure members assures that fluid pressure will move the assembly into the well and bore of the operator and running tool. Further fluid pressure applied to the closure plug assembly **82** will shear the pins **85** connecting the plug assembly to the tubular port closure **81** and cause the closure plug assembly to move downwardly through the bore of the operator and running tool and the packer and plug until a stop shoulder **86** on the lower mandrel section **87** of the plug assembly engages the shoulder **56** at the upper end of the flange forming the lower reduced bore **57** of the ported valve body **55** at the lower end of the mandrel of the packer and plug tool. A split locking ring **58** on the mandrel section **87** is disposed to engage the lower end of the mandrel to lock the plug assembly in place in the bore of the body **55**, and sealing means **59** on the exterior of the mandrel of the plug seals with and closes the bore **57** of the body against flow therethrough.

With the parts in the position shown in FIGS. **5** and **16**, cement pumped down through the tubing string **21** will flow downwardly through the operator and running toll **31** and the packer plug assembly **30** and act on the large resilient bulbar a seal member **89** to force the stem section **87**of the plug mandrel downwardly after shearing the pin **87***b* connecting the stem and mandrel, to move the bulbar seal member into the enlarged bore **53***a* of the sliding closure sleeve **53** below the lateral ports **54** and **52**. The cement may then flow outwardly through the lateral ports **54** and **52** of the sliding sleeve valve assembly **50** at the lower end of the mandrel of the packer and plug tool **30**, and will enter the formation through the perforations in the casing C or other openings thereto below the packer. Since high pressures are used in cementing, the hold-down assembly prevents upward displacement of the packer and plug tool during cementing or application of high pressures during other operations. The elongate toothed gripping members or buttons **45***a* are normally biased inwardly to retracted positions in the lateral recesses **45***c* in the mandrel **38** by leaf springs **46** retained in the recesses by retaining rings **46***a* secured by bolts to the mandrel. Seal supports **47** are secured by bolts to the gripping member members **45***a* with the walls of the recess whereby fluid pressure from within the bore of the mandrel acting through the lateral apertures **45***b* forces the gripping members **45***a* outwardly to grip the casing wall and prevent upward movement of the operator and running tool. Metal protective inserts **47***b* in the seal member disposed to cover the lateral apertures **45***b* prevent extensive damage to the seal member by external fluid pressure. An elongate tubular protector sleeve **44** secured to the mandrel above the lateral apertures and extending substantially below the lowermost aperture provides an annular chamber or receptacle **44***a* into which water-pump grease or similar material may be disposed to exclude cement, sand or other foreign matter form entry into the recesses **45***c* behind the gripping members **45***a*, so that such members are assured of being retractable.

After a suitable quantity of cement has been introduced and a suitable cementing squeeze pressure has been obtained, the operator and running tool **31** is lifted by means of the tubing string **21**, as shown in FIG. **6**, and the lower reduced or stinger portion **39** of the mandrel **38** of the operator and running toll lifts the sliding closure sleeve **53** to move the ports **54** therein above the upper seal **56** in the bore of the valve body and to move the imperforate portion of the sleeve opposite the ports **52** in the body and between the seals **56** on opposite sides of the ports **52** to close the lateral ports against flow therethrough. With the parts in this position, all flow past the packer and plug tool is cut off, and the well bore is plugged at and below the packer and plug.

The releasable connection between the operator and running tool **31** and the packer and plug tool **30** is released, as the yieldable cylindrical shear sleeve **90** is sheared by the lifting force of the flange **91***a* on the connector body **91** of the mandrel **38** acting against the bushing **92** threaded into the shear sleeve above the weakened shear section **93** in the shear sleeve, as shown in FIG. **17**, to permit to the operator and running tool to move upwardly longitudinally of the packer an and plug tool and away from the same. Such upward movement of the operator and running tool moves the reduced lower or stinger portion **39** of the operator and running tool mandrel **38** upwardly, and the flange **95** at the lower end of the stinger engages the inwardly projecting bosses **96** on the resilient leaf spring sections **97** formed in the upper portion of the sliding closure sleeve **53** to move the sliding closure sleeve upwardly until the outer bosses **98** on said leaf spring sections enter the annular recess **99** in the upper portion of the bore of the valve body member **55**, and are moved outwardly by the flange into the recess top to permit the flange to pass the inner bosses **96** and the operator and running tool to be completely disengaged from the sliding closure sleeve sleeve.

The closure sleeve is then in the upper position shown in FIG. **18**, closing off the lateral flow ports **54** and **52** of the sliding sleeve valve assembly **50**. The plug assembly **82** also closes the bore of the packer and plug tool at the lower end of the body **55**, and the straddle closure sleeve **81** closes the lateral ports **42** in the lateral flow ported sleeve valve **40**. Any excess cement in the well bore above the packer and plug tool may be then circulated out of the well by pumping downwardly through the casing and upwardly through the tubing to remove the same in the usual manner.

In the event it is desired to establish circulation between the tubing-casing annulus and the bore of the tubing string before the operator and running tool **31** is disconnected from the packer and plug tool **30**, circulation fluid introduced into the annulus will enter the ports **42** in the sleeve valve **40** and act on the downwardly facing differential area of the straddle closure sleeve **81** defined by the large upper seals **84***a* and the smaller lower seals **84***b* to move the closure sleeve **81** upwardly ad and permit the circulation fluids to enter the bore of the operator and running tool **31** and flow upwardly through the tubing **21**.

After the operator and running tool has been disconnected from the packer and plug tool, the tubing string **21** with the operator and running tool connected thereto may be pulled out of the well casing and refitted, leaving the packer and bridge plug tool in place in the well; and, a new packer and plug tool may be connected to the operator and running tool for running into the well. The operations of testing and treating the well hereinbefore described may then be repeated, locating the packer and plug tool at a different position in the well and carrying out the operations and method previously described herein.

The operator of a will usually avoid cementing a formation which in tests shows good potential, and understandably so, because to do so would likely have a seriously detrimental effect upon the formation. If such is the case, instead of cementing, the operator would merely lift the flow tubing **21** to withdraw the stinger **39** from the packer and plug tool. Such withdrawal moves the valve closure sleeve **53** upwardly into position closing the lateral flow ports **52** and leaving the plug tool **81** in place closing the lower end of the bore of the man-

drel **33**, so that flow through the bore of the packer and plug tool in either direction is closed off and the formation just tested is isolated from the well bore above the packer and plug tool. If desired, production testing of shallower formations above the packer and plug tool can then be carried out.

If it is later desired to produce the formation sealed off below the packer and plug tool, a tubing string having a body and stinger member, similar to the flanged connector body **91** and the reduced lower extension or stinger **39** of the operator and running tool **31** with the flange **95** at its lower end, can be lowered into the well to engage and move the closure sleeve **53** downwardly in the body **55** to open the lateral ports **52** to permit the lower formation F to be produced through such ports and up the tubing string. This stinger would be provided with seals such as the seals **115** on the stinger **39** and the flanged connector body would be provided with a J-slot instead of the straight slot **111** for engagement with the J-lug **110** in the upper end of the bore of the packer and plug tool to latch the stinger in stationary sealing position in the bore of the packer and plug tool to direct fluids flowing from the formation F to the tubing string and the well surface.

Alternatively, the packer and plug tool could be drilled up or destroyed and removed from the well bore by well known techniques, and the well completed in the lower formation in the usual manner for po production through the tubing string. The foregoing description of the invention is explanatory only, and changes in the details of the constructions 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. **17**

I claim:

1. Well apparatus adapted to be operated in a well bore, including: first and second tubular body means releasably connected in axially aligned relationship; normally retracted expansible gripping means and sealing means on said first body means; normally retracted expansible holddown means on said second body means; means on said second body means for connecting it to a well flow conductor for moving said first and second body means into said well bore; and fluid pressure responsive actuator means on said second body means operable to expand said gripping means and said sealing means on said first body means to gripping and sealing engagement with the wall of said well bore; said second body means being disconnectable from said first body means upon longitudinal movement of said second body means relative to said first body means.

2. Well apparatus of the character set forth in claim **1**, wherein said second body means has initially closed, openable, and reclosable lateral flow port means provided thereon for communicating the interior of said second body means with the well bore exteriorly of said second body means above said sealing means of said first body means when said lateral port means is open for establishing circulation of fluids through said flow conductor and said well bore above said sealing means.

3. Well apparatus of the character set forth in claim **1**, wherein said first body means has initially closed, openable, and reclosable lateral flow port means providing a fluid passage between the interior of said first body means and the well bore below said sealing means when said later said lateral flow means is open.

4. Well apparatus of the character set forth in claim **3**, wherein plug means is provided in the bore of the said first body means to close the bore of said first body means below said lateral flow port means of said first body means.

5. Well apparatus of the character set forth in claim **2**, wherein closing means is provided to reclose the lateral flow port means of said second body means after the same has been opened.

6. Well apparatus of the character set forth in claim **1**, wherein connecting means are provided on said first body means and said second body means releasably connecting the same, said connecting means including yieldable means constructed to fail when stressed to a predetermined value to effect disconnection of said second body means from said first body means when said second body means is moved longitudinally relative to said first body means.

7. Well apparatus of the character set forth in claim **4**, wherein sleeve port closure means is provided on said first body means movable to close said lateral flow port means of said first body means when said second body means is disconnected from said first body means.

8. Well apparatus of the character set forth forth in claim **7**, means on said sleeve port closure means and means on said second body means coengageable to move said sleeve port closure means to position closing said lateral flow port means of said first body means upon withdrawal of said second body means from said first body means.

9. Well apparatus of the character set forth in claim **7**, including: laterally movable connector means carried by said sleeve port closure means, said connector means having inner and outer bosses formed thereon; flange means on the lower portion of said second body means engageable with said inner bosses of said connector means of said sleeve port closure means to move said closure means from open to closed position; recess means provided in said first body means for receiving said outer bosses of said connector means of said sleeve port closure means when said closure means is disposed in a position closing said lateral flow port means of said first body means, whereby said connector means may be moved laterally to a position releasing the inner bosses of said connector means from engagement with said flange means of said second body means to permit withdrawal of said second body means from said first body means, leaving said sleeve closure means closing said lateral flow port means and said plug means closing the bore of said first body means below said sleeve closure means.

10. Well apparatus of the character set forth in claim **1**, wherein said hold down means on said second body means comprises normally retracted gripping means exposed to and expandable by fluid pressure in said second body means into engagement with the inner wall of said well bore to hold said second body means against longitudinal displacement in said well bore.

11. Well apparatus of the character set forth in claim **10**, including: sleeve closure means in said second body means initially closing the lateral flow port means thereof and shiftable to a position opening said port means; and means for said shifting said sleeve closure means from to port-closing port-opening position, said shifting means being insertable into said second body means through said flow conductor to engage said sleeve closure means for moving the same in response to fluid pressure.

12. Well apparatus of the character set forth in claim **11**, including closure sleeve means for reclosing said lateral flow port means of said second body means after the same has been opened, said closure sleeve means being insertable into said second body means through said flow conductor.

13. Well apparatus of the character set forth in claim **10**, including yieldable barrier means disposed in said second tubular body means between said hold down means and the bore of said second body means for excluding actuating fluids, cement, or other foreign matter from direct contact with said hold down means.

14. Well apparatus adapted to be operated in a well bore, including: well packer and plug tool means; operator and running tool means; means releasably connecting said well packer and plug tool means and said operator and running tool means in axially aligned relationship; normally retracted expansible sealing means on said packer and plug tool; normally retractor expansible gripping means on said packer and plug tool above and below said sealing means; actuator means on said operator and running tool engageable with said upper gripping means of said pacer packer and plug tool and operable by fluid pressure to move said gripping means and said sealing means of said packer and plug tool to gripping and

sealing position; normally retracted fluid pressure expansible hold down means on said operator and running tool; lateral flow port sleeve valve means on said operator and running tool above said packer and plug tool; flow conductor means connected to the upper end of said operator and running tool; hanger means on said flow conductor for suspending the same from a wellhead at the upper end of the well bore; and means insertable into said packer and plug tool for plugging the same; said means releasably connecting said operator and running tool to said packer and plug tool being releasable upon longitudinal movement of said operator and running tool relative to said packer and plug tool after said packer and plug tool is anchored in sealing position in said well and plugged.

15. The method of treating a well penetrating an earth formation, comprising the steps of: lowering a pressure actuatable tubular holddown and setting tool and tubular setting tool and tubular packer and plug well tool releasably connected to said holddown and setting tool into the well on a flow conductor to a location above the earth formation to be treated; suspending the flow conductor at the upper end of the well; pressurizing said flow conductor to actuate said holddown and setting tool to hold the lower end of the flow conductor against movement in said well and to move said packer and plug well tool to anchored sealing position between said flow conductor and the bore of said well; testing said earth formation by flowing fluids from said formation through said well tool and said flow conductor to the surface.

16. The method of claim **15**, including the additional steps of: establishing a fluid passageway between the bore of said flow conductor and the well bore above said well tool; and circulating fluid through said well bore above said well tool, through said fluid passageway and through said flow conductor to kill said well.

17. The method of claim **16**, including the additional steps of: closing said fluid passageway between said flow conductor and said well bore; and forcing cement through said flow conductor and said well tool to plug said well bore below said well tool.

18. The method of claim **17**, including the additional steps of: plugging the bore of said well tool; disconnecting said holddown and setting tool from said well tool; and removing said flow conductor and holddown and setting tool from said well.

19. The method of claim **17**, including the additional steps of: plugging the bore of said well tool; disconnecting said holddown and setting tool from said weld tool, circulating control fluid through said well bore and SAID flow conductor above said well tool to remove unused cement from said well; and removing said flow conductor and said holddown and setting tool from said well.

20. The method of claim **15**, including the additional steps of: establishing a fluid passageway between the bore of said holddown and setting tool and the well bore above said packer and plug well tool; injecting cement into the upper end of said flow conductor to displace the contents of the flow conductor through said fluid passageway into the well bore above said well tool; closing said fluid passageway; forcing a portion of said cement through said well tool into the well bore below said well tool to plug the well bore below said well tool; reopening said fluid passageway; injecting fluid into the upper end of the well bore exteriorly of the flow conductor and through said fluid passageway to displace the unused cement in the flow conductor to the surface.

21. The method of claim **20**, including the additional steps of: plugging the bore of said well tool; disconnecting said holddown and setting tool from said well tool; and removing said flow conductor and and setting tool from said well.

22. Them The method of claim **15**, including the additional steps of: establishing a fluid a passageway between the bore of said holddown and setting tool and the well bore above said well tool; injecting a predetermined amount of cement into the upper end of said flow conductor to displace the contents of said flow conductor through said fluid passageway into the well bore above said well tool; closing said fluid passageway; forcing fluid into the upper end of the flow conductor for forcing said cement through said well tool into said earth formation until a desired predetermined squeeze pressure is reached; maintaining said squeeze pressure plugging the well bore at said well tool; and disconnecting said holddown and setting tool from said well tool and removing said flow conductor and holddown and to setting tool from said well, leaving said well tool in said well bore.

23. The method of claim **15**, including the additional steps of: establishing a fluid passageway between the bore of said holddown and setting tool and the well bore above said well tool; forcing fluid into the upper end of said well bore exteriorly of said flow conductor and through said fluid passageway to displace the contents of said well bore above said well tool into said flow conductor to the upper end of said flow conductor; injecting cement into the upper end of the flow conductor to displace the contents of said flow conductor through said passageway and into the well bore above said well tool; closing said fluid passageway; forcing fluid into the upper end of said flow conductor and forcing cement through said well tool into said earth formation until a desired predetermined squeeze pressure is reached; maintaining said squeeze pressure; plugging said well bore at said well tool; disconnecting said holddown and setting tool from said well tool; and removing said flow conductor and holddown and setting tool from said well, leaving said well tool in place in said well bore to plug the same.

24. In the method of claim **22**, the step of: circulating fluid down said well bore exteriorly of said flow conductor into the lower end of said holddown and setting tool and up through said flow conductor to remove unused cement from the well after disconnecting said holddown and setting tool from said well tool and before removing said flow conductor and holddown and setting tool from said well.

25. In the method of claim **23**, the step of of: circulating fluid down said well bore exteriorly of said flow conductor into the lower end of said holddown and setting tool and up through said flow conductor to remove unused cement from the well, after disconnecting said holddown and setting tool from said well tool and before removing said flow conductor and holddown and setting tool from said well.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,556,220 Dated January 19, 1971

Inventor(s) Harry E. Schwegman

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 5, omit "it to"
Column 1, line 44, omit "of"
Column 1, line 52, after "off" insert --said well formation; a wherein said operator means and--
Column 1, line 66, omit "thru"; same line, after "through" insert --said--
Column 2, line 9, for "vie" read --view--; same line, omit "sh
Column 2, line 24, omit "showing the well tool"
Column 2, line 52, for "he" read --the--
Column 2, line 66, omit "to"
Column 2, line 70, after "this" insert --invention--
Column 3, line 8, omit "pot"
Column 3, line 10, after "means" insert --45 having fluid pres expansible gripping means or buttons--
Column 3, line 12, omit "of" (first occurrence)
Column 3, line 20, omit "an"
Column 3, line 34, for "the" (first occurrence) read --of--
Column 3, line 58, omit "Pat" (first occurrence)
Column 3, line 70, for "engaged" read --engages--
Column 3, line 74, for "c" read --by--
Column 4, line 1, after "pumping" insert --fluid,--
Column 4, line 7, for "enlarge" read --enlarged--
Column 4, line 8, for "engaged" read --engages--
Column 4, line 42, for "to" read --so--
Column 4, line 55, after the comma (,), insert --if--
Column 5, line 12, for "engaged" read --engages--
Column 5, line 38, for "toll" read --tool--
Column 5, line 39, omit "a"
Column 5, line 58, omit "member"; same line, after "45a" inser --and have fluid pressure seals 47a on their inner side sealing--
Column 5, line 71, for "form" read --from--
Column 6, line 3, for "toll" read --tool--
Column 6, line 18, omit "to" (second occurrence)

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(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,556,220 Dated January 19, 1971

Inventor(s) Harry E. Schwegman

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

(continued from Page 1)

Column 6, line 19, omit "an"
Column 6, line 33, omit "sleeve" (first occurrence)
Column 6, line 52, omit "ad"
Column 6, line 67, before "will" insert --well--
Column 7, line 26, omit "po"
Column 7, line 27, begin new paragraph
Column 7, line 31, omit "17"
Column 7, line 62, omit "said later"
Column 7, line 63, after "flow" insert --port--
Column 7, line 65, omit "the" (second occurrence)
Column 8, line 10, after "claim 7," insert --including--
Column 8, line 47, omit "said" (second occurrence)
Column 8, line 48, omit "to"; same line, after "port-closing" insert --to--
Column 8, line 70, for "retractor" read --retracted--
Column 8, line 73, omit "pacer"
Column 9, line 16, omit "tubular setting tool"
Column 9, line 17, omit "and" (first occurrence) and insert
Column 9, line 46, for "weld" read --well--
Column 9, line 47, for "SAID" read --said--
Column 10, line 10, omit "Them"
Column 10, line 11, omit "a" (second occurrence)
Column 10, line 20, after "pressure" insert a semicolon (;)
Column 10, line 23, omit "to"
Column 10, line 34, before "passageway" insert --fluid--
Column 10, line 51, omit "of" (second occurrence)

Signed and sealed this 18th day of May 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

WILLIAM E. SCHUYLER,
Commissioner of Pate