United States Patent

Kanady

[15] **3,675,718**

[45] **July 11, 1972**

[54] CONDUCTING OPERATIONS IN A WELL THROUGH A NORMALLY CLOSED VALVE

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[73] Assignee: **Esso Production Research Company**

[22] Filed: **Sept. 11, 1970**

[21] Appl. No.: **71,553**

[52] **U.S. Cl.**.....**166/297**, 166/224, 166/315

[51] **Int. Cl.**.....**F21b 23/04**

[58] **Field of Search**.....166/67, 72, 73, 114–116, 166/123, 125, 143, 144, 181, 182, 187, 224, 315; 175/107

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Primary Examiner—James A. Leppink

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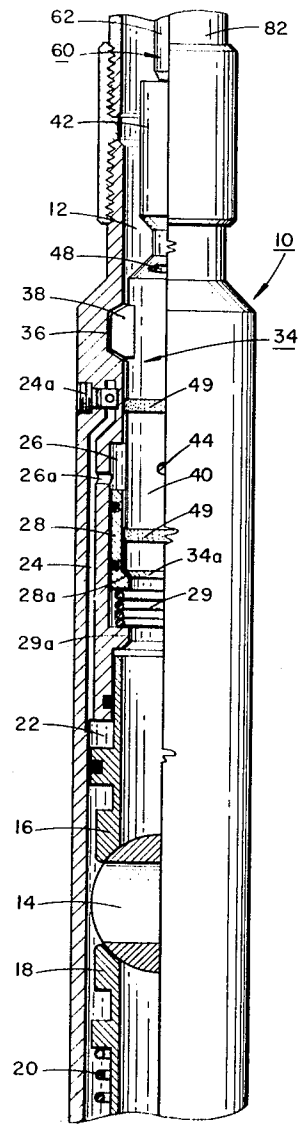
[57] **ABSTRACT**

An operation is conducted in a well below a normally closed valve therein having a full open bore therethrough which involves running a tubular member having a passageway therethrough into the well from a reel at the earth's surface and releasably connecting the tubular member to the normally closed valve. Fluid pressure introduced through the tubular member from the earth's surface or before the valve is introduced to the well is provided to open the valve and thereafter a well operation is performed through the full open bore and below the valve. The well operation may include a workover operation such as acidizing, cementing, stimulating, sand consolidation, perforating, and the like.

10 Claims, 13 Drawing Figures



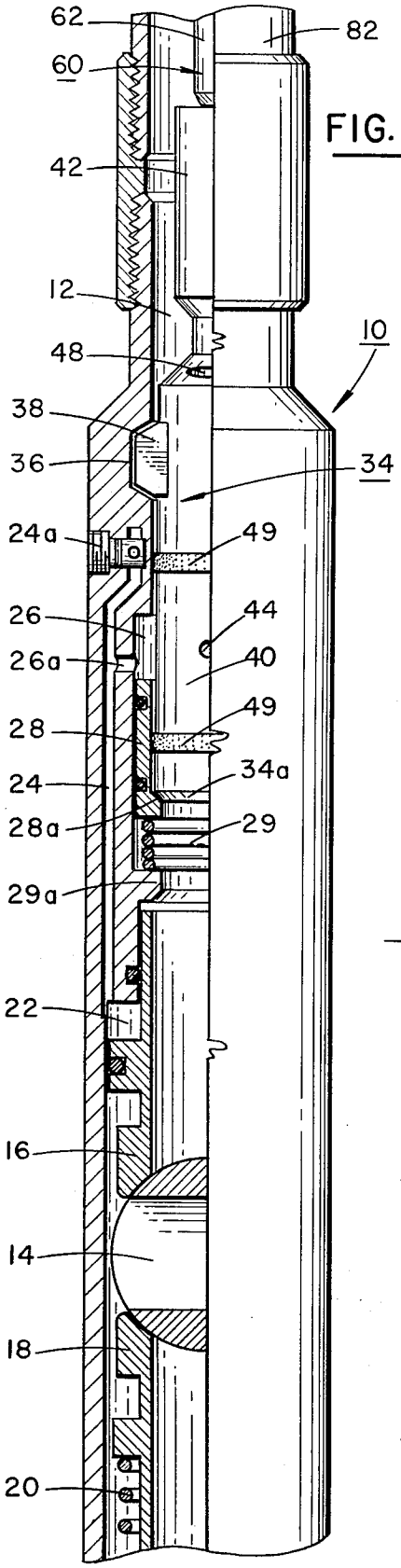


FIG. 1.

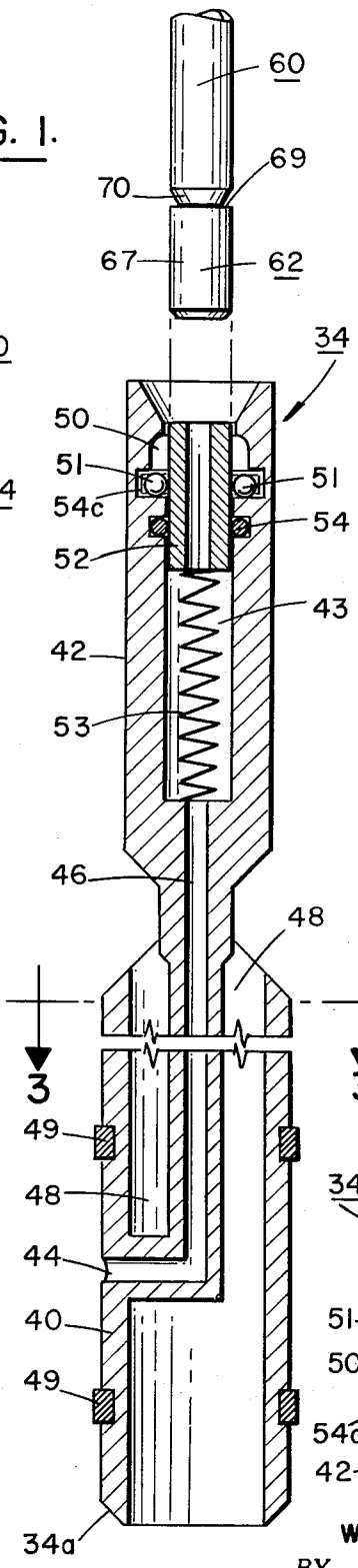
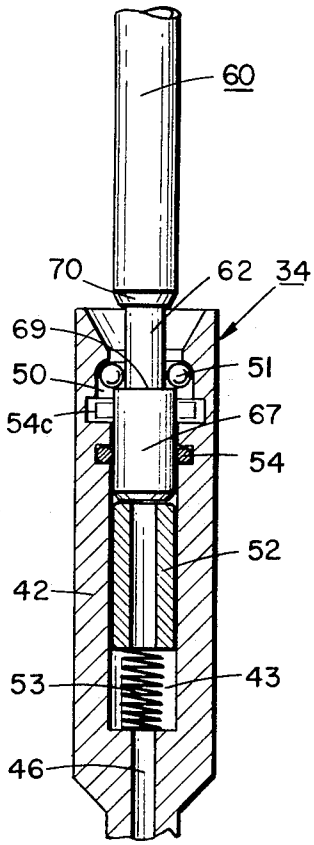


FIG. 2.

FIG. 5.



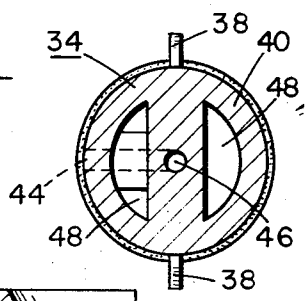


FIG. 3.

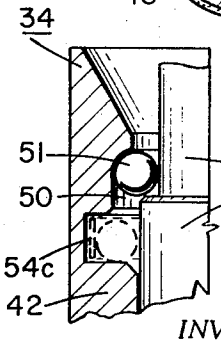


FIG. 4.

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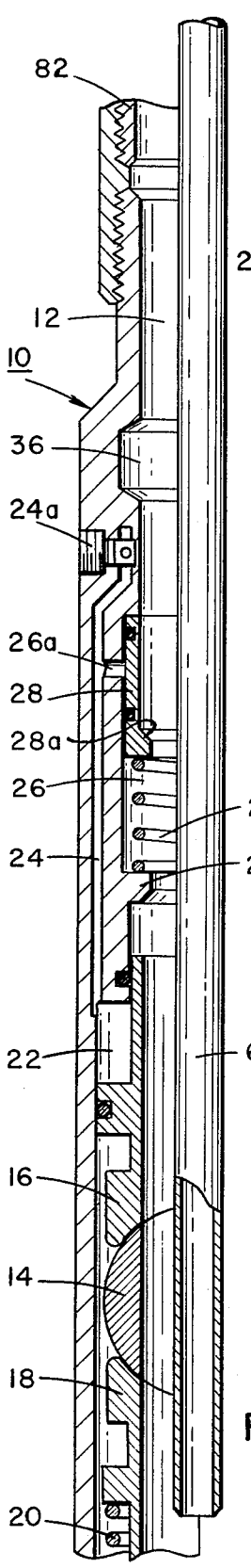

FIG. 8.

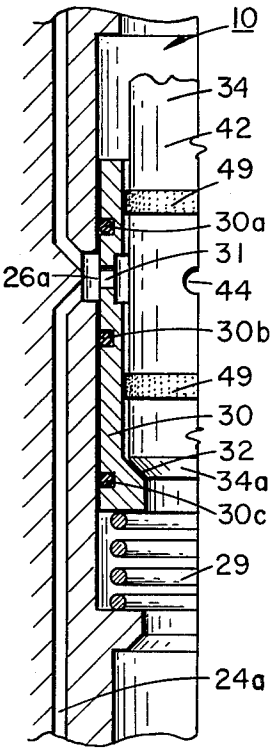

FIG. 8A.

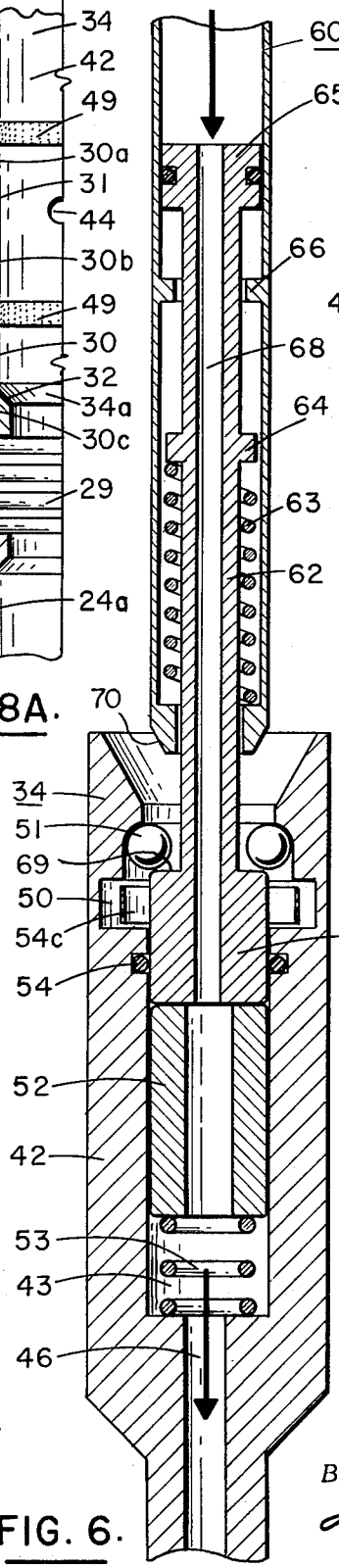

FIG. 6.

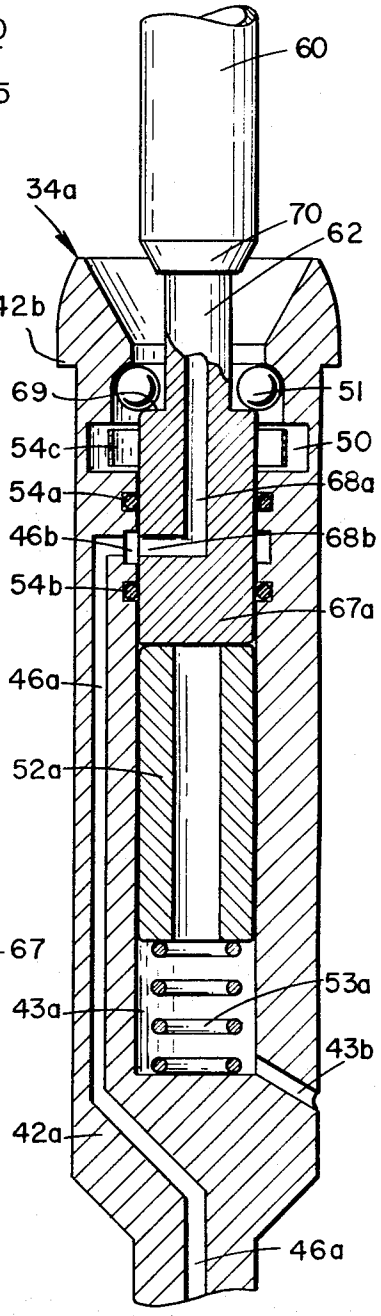

FIG. 7.

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FIG. 10.

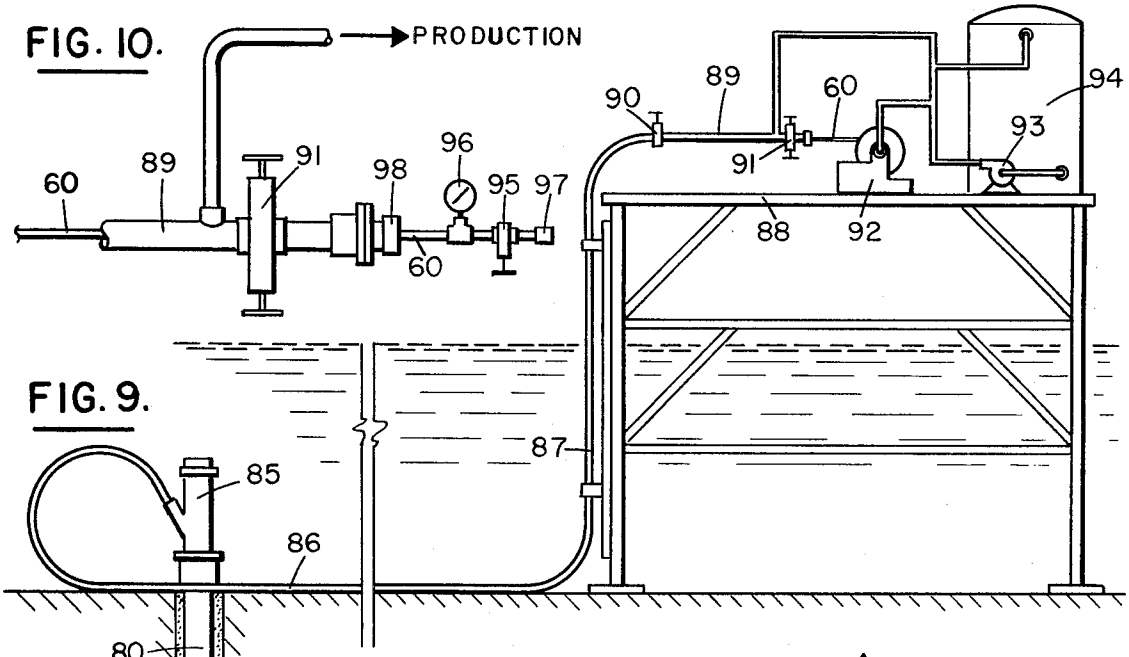

FIG. 9.

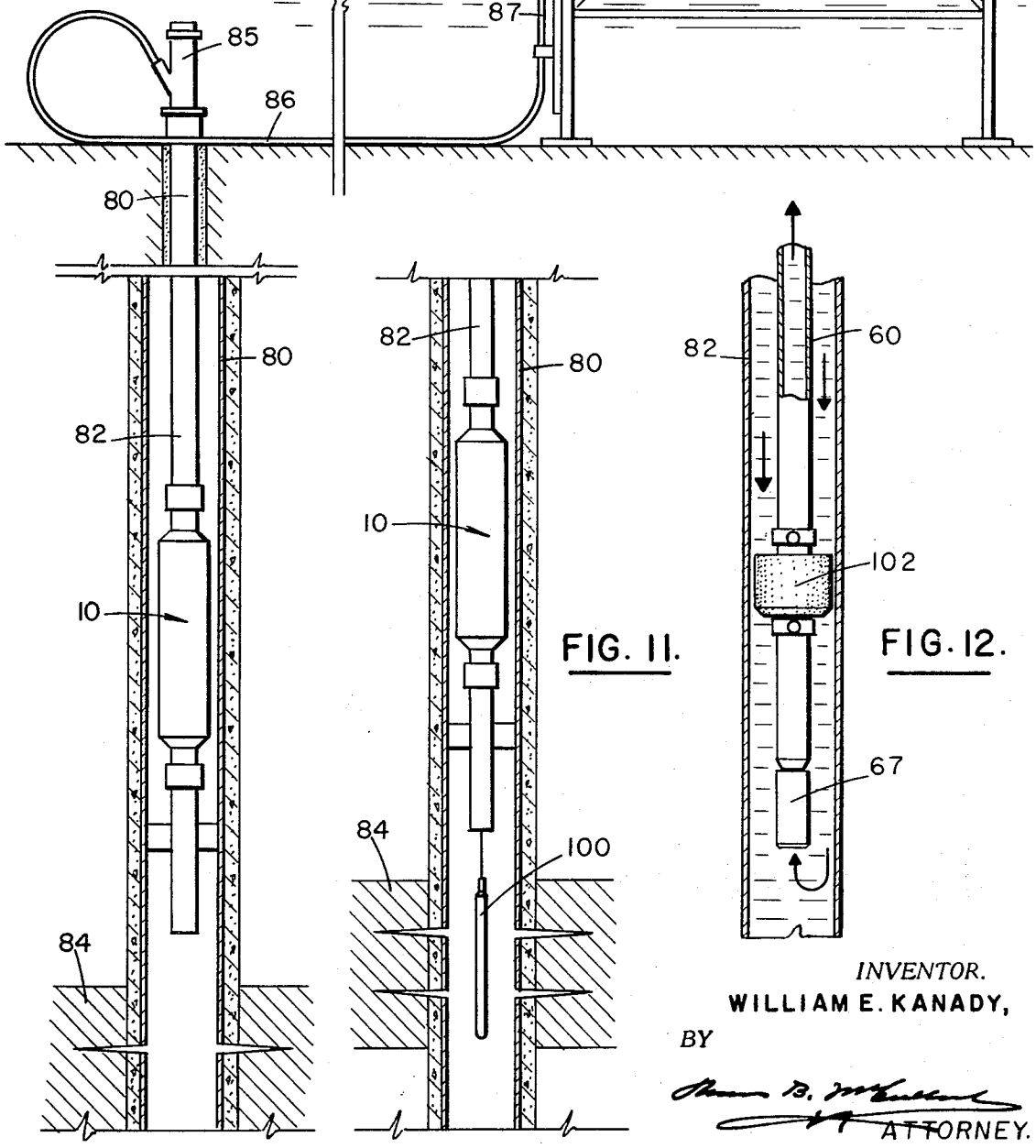

FIG. 11.

FIG. 12.

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CONDUCTING OPERATIONS IN A WELL THROUGH A NORMALLY CLOSED VALVE

CROSS-REFERENCE TO RELATED APPLICATION

This application is related to Ser. No. 850,144, now U.S. Pat. No. 3,606,927, field Aug. 14, 1969, in the names of Martin E. True and William E. Kanady and entitled, "Running in and Operation of Valves and the Like."

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention is directed to performing operations in a well having a valve located therein below the earth's surface wherein the well operation is performed through the valve which is normally closed. More particularly, the invention is concerned with method and apparatus for performing an operation through a normally closed valve in a well below the valve. In its more specific aspects, the invention is concerned with operations in a submarine well having a valve located well below water surface and adjacent the lower end of the well in which the valve is normally closed and is opened by fluid pressure introduced to it from the earth's surface and thereafter performing an operation through the open valve below the open valve either using a well tool or a workover fluid which may be a liquid fluid or a gaseous or vaporous or gasiform fluid.

2. Description of the Prior Art

It is known to run tools into a submarine well using the so-called through flow line technique. It is also known to run a tubular member into a well from a reel at the earth's surface. The use of hydraulically operated valves in wells is also known, but customarily a separate line (run outside the production tubing) to provide operating fluid has been used which is expensive and subject to operating difficulties and also has to be run simultaneously with the well pipe. In submarine wells, it has been conventional to employ valves at or near the surface to contain pressure in the well; but these valves and that portion of the well containing same if above water bottom must be protected against wave and wind action. In the present invention, the valves are located deep in the well below water bottom or earth surface to contain pressure far below the surface and operated by supplying fluid through a continuous tubular member which is run into the well conduit or tubing string eliminating the necessity of a separate line for operating fluid and avoiding operating difficulties. Also, the present invention allows operations to be conducted in the well below the valve while maintaining the valve in the open position which is advantageous over the art as shown more fully hereinafter. Prior art considered with respect to this invention include: U.S. Pat. Nos. 3,116,793, 3,394,760, 3,346,045, and 3,373,818

Composite Catalog (1968–69) of *Oil Field Equipment and Services*, Published by World Oil, a Gulf Publishing Company Publication, pages 3,820 and 3,821.

SUMMARY OF THE INVENTION

The present invention may be briefly described as involving method and apparatus for conducting operations in a well having a valve located below the earth's surface, which valve is normally closed and in which the valve is opened by fluid pressure either at or from the earth's surface, preferably through a tubular member extending from a reel at the earth's surface and connected to the valve housing by a releasable connecting means.

The invention may be further summarized as involving apparatus comprising a valve housing having an open bore and a normally closed valve means in the housing providing in its open position a full open bore through the housing. Means are provided in the valve housing for opening the valve on application of fluid pressure, the means including a passageway having an opening into the bore of the housing in the wall of the valve housing and communicating with the valve means; the passageway opening into the open bore is closed by closure means in the open bore which is normally urged to a position to close the opening and maintain fluid pressure on the valve means.

BRIEF DESCRIPTION OF THE DRAWING

The present invention may be briefly described and illustrated by reference to the drawing in which:

FIG. 1 is a view partly in section of a valve housing with a sleeve valve and having positioned therein a locking mandrel;

FIG. 2 is an enlarged sectional view of the locking mandrel;

FIG. 3 is a cross-sectional view taken along line 3—3 of FIG. 2;

FIG. 4 is an enlarged fragmentary view of the locking assembly of the mandrel;

FIG. 5 is a view showing the lower end of the continuous tubing locked in the upper end of the mandrel;

FIG. 6 is an enlarged sectional view showing the connection of the continuous pressure tubing to the mandrel;

FIG. 7 is a view illustrating a modification of the present invention;

FIG. 8 is a view of the valve housing with the mandrel removed and the valve held open by trapped pressure and a well tool being lowered therethrough;

FIG. 8A illustrates a modification of the sleeve valve of FIGS. 1 and 8;

FIG. 9 illustrates the apparatus of the present invention positioned in a submarine well;

FIG. 10 shows a production hook-up incorporating the device of the present invention;

FIG. 11 illustrates a well tool, such as a perforator, lowered through the valve housing; and

FIG. 12 illustrates a means for pumping the continuous pressure tubing through the well pipe or production string.

DESCRIPTION OF THE PREFERRED MODE AND EMBODIMENT WITH REFERENCE TO THE DRAWING

Referring now to FIGS. 1–5, numeral **10** designates a ball valve housing adapted to be connected into a production tubing string which extends to the earth's surface. Such valve assemblies are well known to the art and are fully illustrated on pages 3,820 and 3,821 of the Composite Catalog (1968–69) of Oil Field Equipment & Services.

The housing **10** has a central bore **12** extending through the longitudinal axis thereof. A rotatable ball type valve **14** is positioned in the bore **12** for operably closing and opening the passage through said bore. Operation of the valve **14** is accomplished by movement of a pair of sleeve assemblies **16** and **18**, positioned above and below the ball **14** respectively and make sealing contact therewith. The ball valve **14** of FIG. **1** is shown in the closed position and is held in such position by the bias of spring **20** against sleeve **18** in an upward direction. Opening of the valve **14** is accomplished by downward movement of sleeve **16** by means of fluid pressure introduced in chamber **22** formed between sleeve **16** and the bore **12** of housing **10**.

A fluid passage **24** is formed in housing **10** and extends from the upper end of chamber **22** to an annular recess **26** formed in the wall of bore **12**, above the chamber **22**. Fluid passageway **24** also extends from the chamber **22** to a pressure connection means such as check valve **24***a* positioned in the outer wall of housing **10**. The function of connection **24***a* and passageway **24** will be hereinafter described.

A sleeve valve **28** is slidably arranged within the recess **26** of central bore **12** of the housing **10** and is biased upwardly by spring means **29** which is supported on its lower end by shoulder **29***a* and bears upwardly against the lower end of sleeve valve **28**. Sleeve valve **28** in its upwardly biased position closes port **26***a* which communicates recess **26** with passageway **24**.

Formed on the inner wall of sleeve valve **28** is an annular shoulder **28***a* for landing or seating the tubular locking mandrel **34** shown more clearly in FIG. **2**. A locking in recess **36** is provided in the bore wall and adapted to receive outwardly

biased latching dogs 38 of mandrel 34. As shown, the locking mandrel 34 in FIG. 1 is landed in the bore 12 of housing 10 on shoulder or seat 28a with the spring biased dogs 38 releasably engaged in recess 36. The lower end 34a of the mandrel 34 bears against the shoulder 28a of sleeve valve 28 holding it down and exposing the port 26a. In FIG. 1, the housing 10 and sleeve assembly 16 are provided with unnumbered sealing means, the function of which is apparent.

Referring now to FIG. 2, mandrel 34 is formed of a lower section 40 and an upper throat section 42. The throat section 42 having a bore 43 in fluid communication with an external port 44 of the section 40 by way of passageway 46. Vertical flow passages 48 extend through the entire length of section 40 whereby when the assembly is seated in the bore 12 of housing 10 production fluids may flow therethrough. Seal rings 49 above and below port 44 seal the annulus between mandrel 34 and the wall of bore 12 and sleeve valve 28 whereby fluid tight communication may be had between passages 46 and 24.

The throat section 42 of mandrel 34 is provided with a locking ball recess 50 containing locking balls 51 which are normally held in unlocking position by a spring biased retainer sleeve 52 which is urged to a retaining position by means of spring 53. Sealing means 54 seal between the cylindrical sleeve 52 and the wall of bore 43. It will be noted that the ball recess 50 is formed of a larger diameter section connected to a smaller diameter section just above.

As shown more clearly in FIG. 6, the throat section 42 of mandrel 34 is adapted to receive the lower end of a pressure tube 60 which is lowered through the pipe string from the earth's surface. The pressure tube 60 is provided with a telescoping member 62 which is designed to be extended out the lower end of tubing 60 by means of fluid pressure within tube 60. The telescoping member 62 is urged to a collapsed position by means of a spring 63 which biases between the lower end of tube 60 and a shoulder 64 on member 62. A piston head 65 is formed on the upper end of telescoping member 62 in sealing engagement with the inner wall of tube 60. A stop means 66 is provided on the inner wall of tube 60 below the piston head 65. It will be noted that the stinger end 67 is of the same O. D. as the pressure tube and is adapted, when extended, to sealingly engage within the bore 43 with sealing ring 54. The telescoping member 62 is provided with a central passageway 68 extending throughout the longitudinal axis thereof. The larger diameter of the stinger 67 provides a shoulder 69 which is adapted to engage the locking balls 51 when the stinger is projected into the bore 12 of throat section 42. The lower end of tubing 60 is also provided with a tapered surface 70 for the purpose of engaging the locking balls 51 when it is desired to disconnect from the mandrel 34.

The modification shown in FIG. 7 provides a locking mandrel whereby the ball valve 14 of FIG. 1 may be run in the well bore or casing in the open position, the difference being in the stinger assembly, the function of the retainer sleeve 52a and the placement of the pressure passageway in the mandrel.

The stinger head 67a of telescoping member 62 extending out of pressure tube 60 is somewhat longer than the head 67 and is provided with a side port 68b which is in fluid communication with passageway 68a. When in the locked-in position as shown in FIG. 8, the port 68b is in contact with an annular recess 46b which by way of passage 46a is in fluid communication with port 34 shown in FIG. 1 and 2. The bore 43a has a bleed port 43b which allows downward movement of the stinger head 67a and the sleeve 52a. The bore 43a is also grooved above and below the recess 46b to provide seal rings 54a and 54b. It will be obvious that when the stinger head 67a is removed from the bore 43a the retainer sleeve 52a moves up under bias of spring 53a and retains locking balls 51 in the larger portion of recess 50 and also seals off the recess 46b and passage 46a by means of seals 54a and 54b.

The primary purpose however of the placement of recess 46b and passage 46a is to allow pressurizing of chamber 22 of FIG. 1 before running the ball valve assembly 10 in the well bore. It may be desirable at times to run the assembly in the wall bore with the ball valve in the open position. For such an operation, the mandrel 34a is placed and locked in the housing 10 with the sleeve 52a acting not only as a ball retainer but also as a sleeve valve to close off the upper end of passageway 46a. With the mandrel so placed, a pressure source (not shown) is screwed into or otherwise connected to the pressure connection 24 (shown in FIG. 1) and the chamber 22 pressurized to move the sleeve piston 16 downwardly and open the ball valve 14. The source is disconnected and the pressure in chamber 22 maintained by means of the check valve type connection 24 and sleeve 52a.

The modification in FIG. 7 also provides an external shoulder 42b on section 42a of the mandrel 34a for the purpose of running or retrieving the mandrel 34a by wire line methods; however, it will be understood as heretofore stated that the mandrel 34 or 34a may be installed in the valve housing 10 prior to running the assembly.

FIG. 9 illustrates a possible offshore production installation in which the present invention may be incorporated. A ball valve or safety valve housing 10 is placed in a well casing 80 in a production string or pipe 82 adjacent a production formation 84. The production string 82 is connected to a platform 88 and a lubricator manifold 89 by way of well head 85, flowline 86, and riser 87. Suitable piping and valving connects the manifold 89 to a storage tank 84 and pump means 93. The manifold 89 is also provided with valve means 90 and a ram type closure means 91. A tubing reel 92 is provided for running and removing the continuous pressure tubing 60, and the connecting means attached therein.

Referring now to FIG. 8 the mandrel 34 or 34a has been removed and the sleeve valve 28 is closing off port 26a thereby trapping pressure in chamber 22 and holding valve 14 open. As shown a continuous tubing 60a which may be run in from reel 92 of FIG. 9 is lowered through the valve housing 10 and valve 14 which now provides a full open bore. The tubing 60a, being open on its lower end, may be used for sand washing below the housing 10 in the well bore adjacent the formation 84.

The tubing 60a may be used for other operations below the housing 10 such as acidizing, sand consolidation, cementing off perforations or introducing oil surfactants or other fluids into the sand formation 84. Also as shown in FIG. 11, a gun perforator such as 100 may be run into the well bore by way of production pipe 82. Although not shown the gun 100 would be provided with a cup or piston means whereby 17 may be pumped through the pipe section 87, 86 and well head 85 and through well pipe 82 by way of pump 92 on platform 88.

The sleeve valve 30 of FIG. 8A provides a more positive action in closing off port 26a. The sleeve 28 is provided with seals 30a and 30b which seal above and below port 30 when the port 30 is in line with port 26a and allows fluid tight communication between port 44 of mandrel 34 and passageway 24a. When sleeve 30 is in its uppermost position port 26a is sealed off by sleeve valve 30 and seals 30b and 30c. As can be seen in FIG. 8A the seals 30a, 30b and 30c provide equalization of pressure whereby the sleeve 30 will move up to the closing position under bias of spring 29 as the mandrel 34 or 34a is removed from the housing 10 by tubing 60. To prevent leakage of fluid pressure from chamber 22 is desirable for the sleeve 30 to move upwardly with the mandrel 34 or 34a.

OPERATION

The mandrel 34 or 34a may be placed in the housing 10 prior to running the pipe string 82 or it may be run in after by way of continuous tubing 60. Once the mandrel is placed the pressure tubing 60 incorporating the telescoping section thereof is inserted in the lubricator manifold 89 and by mechanical means not shown is fed into the flowline and hence into the production string 82 until the stinger head end 67 is in the approximate position shown in FIG. 2. Pressure is applied by way of pump 93 to the piston head 65 (FIG. 6). As

the head 67 moves down it contacts and pushes down the retainer sleeve 52 until the shoulder 69 is below or adjacent the larger portion of ball recess 50. This allows the ball spring 54c to bias the balls inwardly against the smaller diameter portion of member 62 and above the shoulder 69. As pressure is relieved in tubing 60 the spring 63 and also spring 53 force the head 62 upwardly pushing the locking balls 51 into the smaller portion of recess 50 where they are retained by the shoulder 69. An upward strain may then be applied to the pressure tubing 60 to compress spring 63 and provide a force against the locking means whereby it may not be forced downwardly when future pressure is applied through the pressure tubing 60. With the device connected as in FIG. 6 pressure can now be applied to the tubing 60 and therefore to chamber 22 of the housing 10, through port 44 to recess 26, the mandrel 34 having forced sleeve valve 28 downwardly by its lower end 34a bearing against the shoulder 28a thus overcoming the force of spring 29 to open port 26a allowing fluid pressure to open ball valve 14.

FIG. 9 illustrates a hookup for maintaining pressure in chamber 22 and also allowing production flow to storage tank 94. Ram type valve means 91 closes off around tubing 60 therefore affording a seal between it and the inner wall of manifold 89. Gripping means 98 (FIG. 10) maintains a predetermined strain on tubing 60. A gauge 96 indicates the pressure in tubing 60 and chamber 22. Valve means 95 maintains the pressure while connecting means 97 affords a means for connecting to a pressure source when needed.

It may be desirable to run or retrieve the mandrel 34 with the tubing 60 connected thereto as shown in FIG. 7. If it is desirable to disconnect the tubing from the mandrel 34 while in the well bore the tubing 60 is lowered by its own weight. As the tubing 60 is lowered the tapered surface 70 pushes the balls 51 and the head 67 downwardly until the balls 51 are opposite the larger portion of recess 50. This allows the head 67 to snap upwardly under bias of springs 63 and 53, thus allowing the head 67 to be withdrawn from the top of the mandrel 34, and the retainer sleeve 52 to move up under bias of spring 53 whereby it covers the recess 50 and retains the locking balls 51. After disconnecting in the manner shown, the tubing member 60 may be used to perform well servicing operations such as placing inhibitors, removing paraffin, and injecting fluids such as oil, gas, surfactants, and the like or in performing other well servicing operations. Thereafter, the apparatus of the present invention may again be connected to the housing 10 as has been described.

With a valve housing 10 and a rotatable ball valve 14 and sleeve valve 28 and mandrel 34, numerous advantages over the prior art devices are possible. Thus, with sleeve valve 28 in a closed position the ball valve 14 may be opened by pressurizing chamber 22 by connection means 24a prior to running of the casing 80 and housing 10 in production string 82. This allows a full opening bore while running in the casing 80 and string 82 and a full opening string on bottom without use of the mandrel 34. Moreover, when the ball valve 14 is opened by action of the mandrel 34 on the sleeve valve 28 after the housing 10 has been positioned and introduction of pressure through port 44 into recess 26, port 26a and passageway 24 to chamber 22, withdrawal of the mandrel while maintaining pressure allows the sleeve valve 28 to close with the pressure in chamber 22 holding the valve 14 open. This allows workover operations to be performed in the sand 84 or below the valve 14 as has been described. Such operations may include by way of illustration but not by way of limitation, sand washing, acidizing, sand consolidation, cementing using a fluid cement slurry, running of a tool such as a gun perforator through ball valve 14, and operating, and retrieving same. Other tools may also be run in, operated below, and retrieved through the ball valve 14 in the open position. Additionally, the mandrel 34 may be removed connected to the tubing 60 and the production string 84 and housing 10 left in the well with the valve 14 open or closed as desired. Valve 14 may be closed by release of fluid pressure in tubing 60 provided the passageway such as 68a leading to passageway 46a is closed as shown in FIG. 8. Operations may be conducted with the valve 14 open as has been described in description taken with the drawing with the mandrel 34 34a either in the housing 10 or removed therefrom. Of course with the mandrel 34 or 34a in the housing 10 only fluids which may be either liquid, gaseous or gasiform may be introduced through the valve 14 whereas with the mandrel 34 or 34a removed well tools may be introduced through the valve 14 and operations conducted below as has been described.

Although the present invention is illustrated as applied to a single pipe well completion, it will be understood that the device may be also incorporated in a dual completion where two production pipe strings are run parallel to each other and may be interconnected intermediate or adjacent their lower ends with a crossover to provide a fluid circulation path.

While the tubular means 60 may be run into the well by mechanical force exerted by the reel 92 and injection means not shown), the tubular means 60 may also be run in by fluid pressure introduced into the lubricator 89 by pump 93. If such pressure means is used, the tubing 60 may be provided with piston means 102 (see FIG. 12) attached thereto between the tubing 60 and the well pipe and such piston means may be of the differential pressure type allowing excess pressure encountered to be bypassed through or around the pistons. This is especially desirable if one of the two pipe strings were to be used as a service string as may be required in underwater well completions.

While the invention has been described and illustrated with respect to an offshore well with the reel on a platform, the reel may be located at another accessible location such as on a vessel or onshore.

It will be seen from the foregoing description of the best mode and embodiment that the present invention including method and apparatus allows the obtaining of unobvious and improved results.

The nature and objects of the present invention having been completely described and illustrated and the best mode and embodiment contemplated set forth what I wish to claim as new and useful and secure by Letters Patent is:

I claim:

1. A method for conducting an operation in a well below a normally closed valve therein having a full open bore therethrough which comprises:
   running a tubular member having a passageway therethrough into said well from a reel at the earth's surface;
   releasably connecting said tubular member to a normally closed valve;
   introducing fluid pressure to open said valve;
   removing said tubular member from said well with said reel; and
   then performing a well operation in which a well tool is run through said full open bore and operated below said valve.

2. A method in accordance with claim 1 in which said well operation comprises introducing fluid through said tool and said full open bore and below said valve.

3. A method in accordance with claim 2 in which the fluid is cement.

4. A method in accordance with claim 1 in which the fluid pressure is introduced through said tubular member.

5. A method in accordance with claim 1 in which the fluid pressure is introduced at the earth's surface to open said valve before it is run into the well.

6. A method in accordance with claim 1 in which the fluid is a liquid.

7. A method in accordance with claim 1 in which said valve is closed after operating and removing said tool.

8. A method in accordance with claim 1 in which the well tool is a perforator which is operated below said valve.

9. A method in accordance with claim 1 in which the perforator is a gun perforator which is retrieved after operating same.

10. A method in accordance with claim 1 in which the well tool is a tubular member through which said well operations are performed.

* * * * *