April 17, 1962 B. W. MOLLER 3,029,875

WELL TEST-COMPLETION TOOL

Filed Oct. 14, 1957 3 Sheets-Sheet 1

Fig. 10

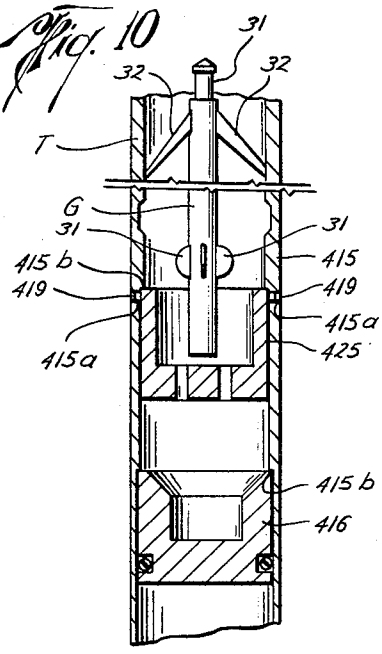


Fig. 1

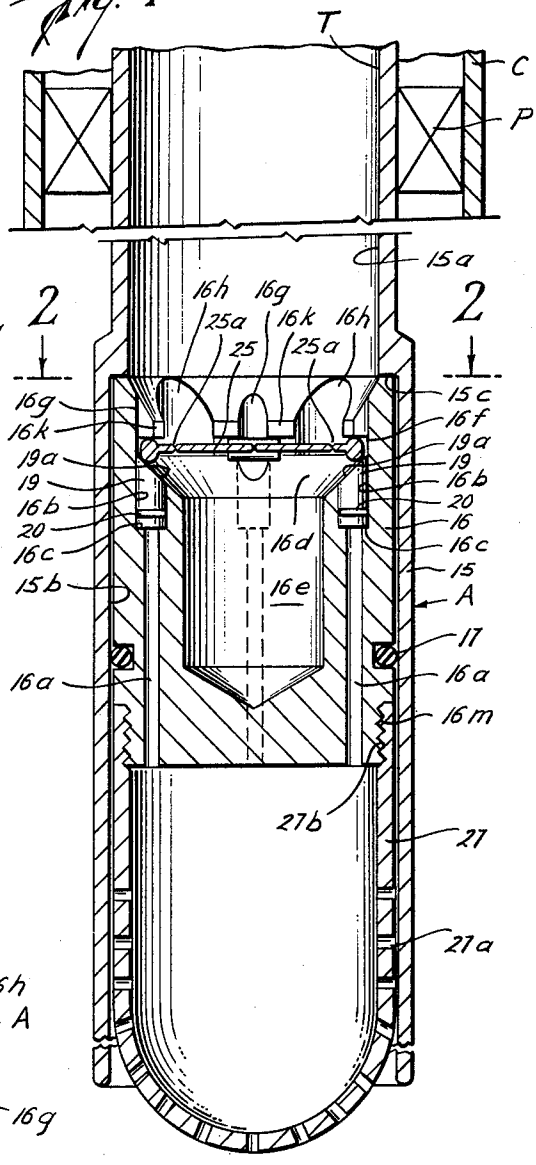
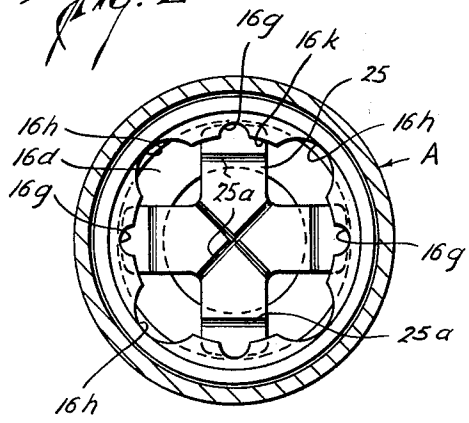


Fig. 2



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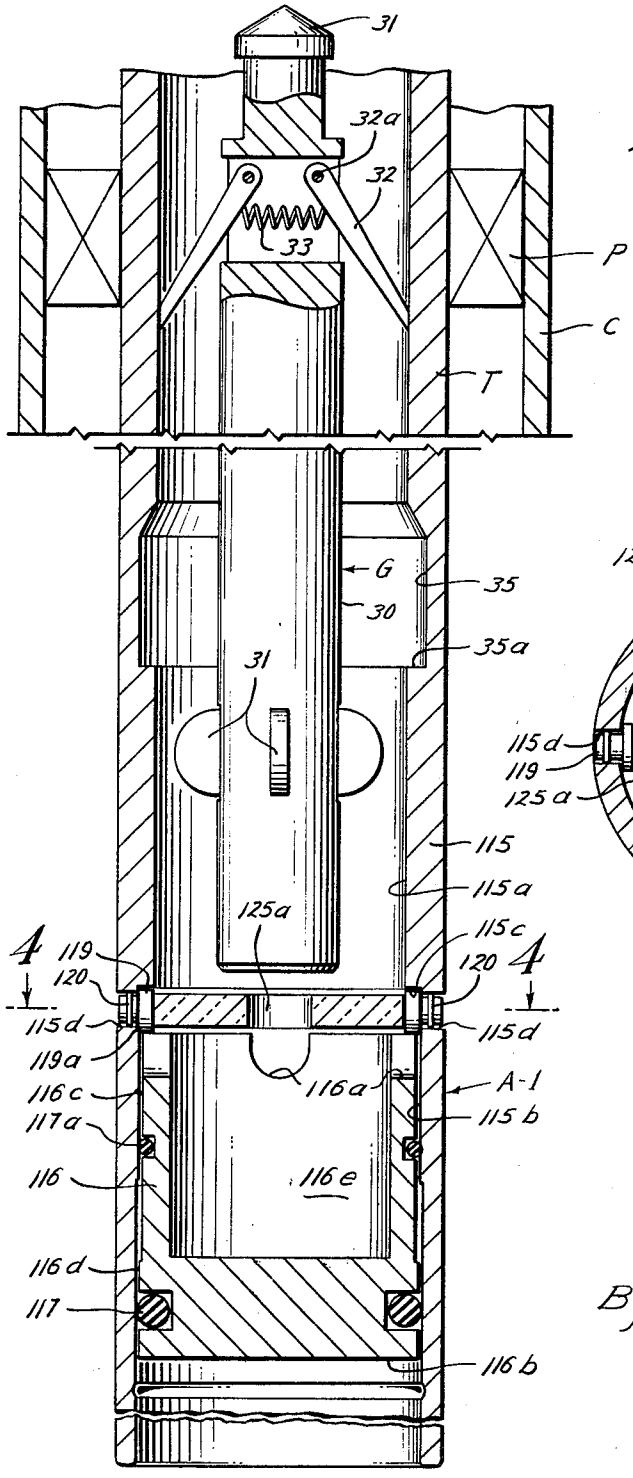


Fig. 3

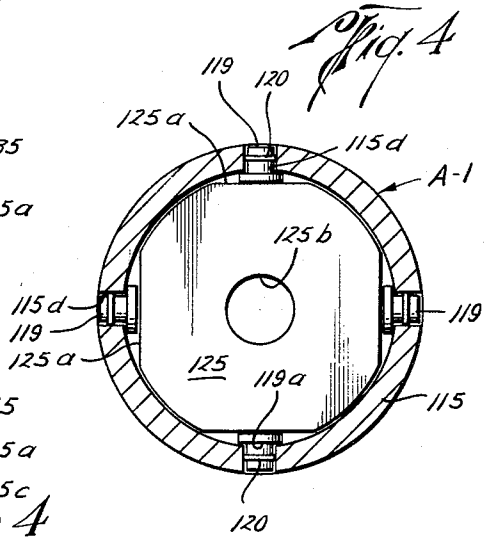


Fig. 4

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WELL TEST-COMPLETION TOOL

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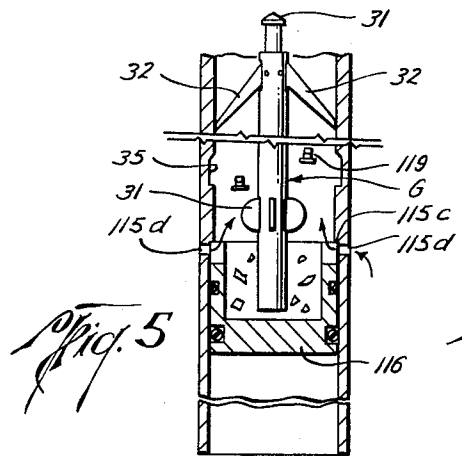


Fig. 5

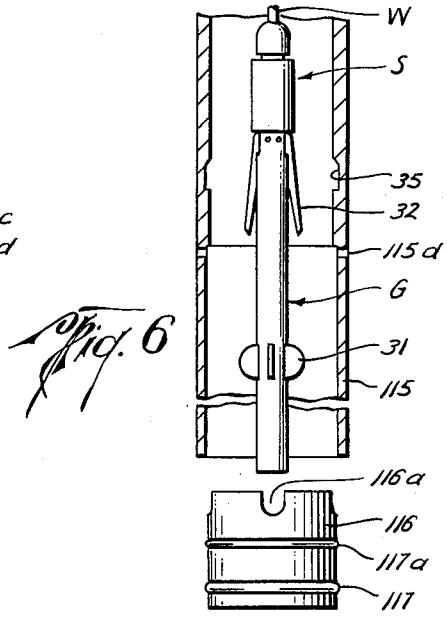


Fig. 6

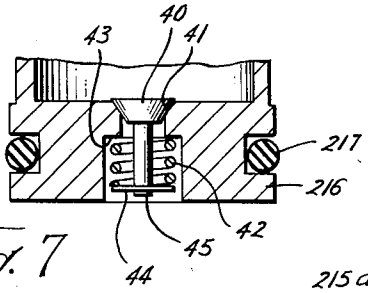


Fig. 7

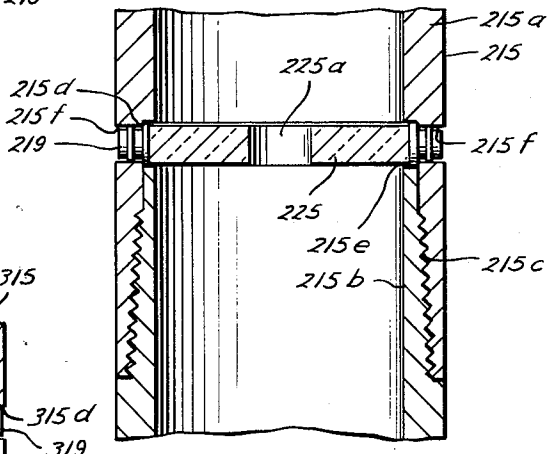


Fig. 8

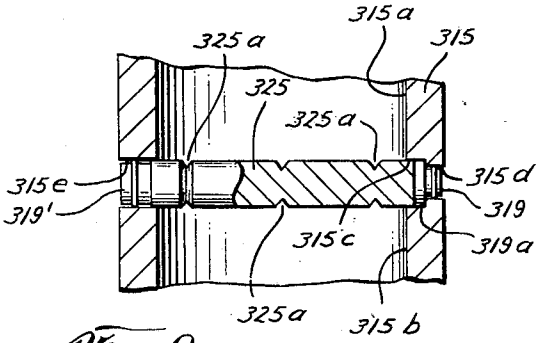


Fig. 9

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WELL TEST-COMPLETION TOOL

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Filed Oct. 14, 1957, Ser. No. 689,835
19 Claims. (Cl. 166—224)

This invention relates to well tools and in particular to well test and completion tools.

In the completion of oil wells and the like for the production of the oil or other fluid therefrom, it is generally desirable to obtain a test sample of the formation in the well which is to be produced so that it can be determined whether or not additional well operations are to be performed prior to the final setting of the tubing, packer, and surface production equipment. Under the present practice, relatively expensive formation test sampling tools are used for obtaining such test samples of the formation. After the test samples are obtained, the test tools must be removed from the well if the tests indicate that additional well operations must be performed. When the test sampling tool is to be removed, large and expensive surface equipment must be moved over the well, the well must be "killed" wtih heavy fluid or mud to prevent the oil or other well fluid from flowing, and the tubing must be pulled to remove the test tool so that well operations such as squeeze cementing, perforating, fracturing, and the like can be performed. Besides the obvious expense and time required for such procedure, the heavy fluid or mud used to kill the well is often injurious to the ultimate producing ability of the well.

In other instances, formation test tools are used for performing what is generally known as "dry tests." A dry test is made after a well formation has been sealed by squeeze cementing and prior to making additional or now perforations in the well casing. The dry test is performed by running the test tool in the tubing when a packer is set above the cemented formation and with the tubing empty or dry. Therefore, when the test tool is opened, the effectiveness of the cement seal on the formation is determined because if any fluid leaks through the cement seal, fluid will be collected in the test tool. Test tools now used for such dry tests are not full bore and are relatively expensive so that it becomes necessary to pull the test tool from the well hole before the well casing is reperforated and the setting of the well tubing is completed for production.

One object of this invention is to provide a new and improved test-completion tool for use in oil wells and the like for obtaining an initial test sample of a well formation or for making an initial dry test, and for subsequently permitting the performance of various well operations without requiring the removal of said test-completion tool from the well.

An important object of this invention is to provide a new and improved test-completion tool which is simplified in construction and operation and which is relatively inexpensive as compared to prior formation sampling tools so that it is economically and operationally practical to leave said test-completion tool in the well after a dry test or a test sampling of the well fluid is performed and during the subsequent production of oil or other fluid from the well.

Another object of this invention is to provide a new and improved well test-completion tool for use in oil wells and the like, wherein said tool is adapted to be used in conjunction with a well packer so that a test of the area in the well below the packer may be conducted and so that subsequent well operations may be conducted in the area below the packer without removing the test-completion tool from the well.

A further object of this invention is to provide a new and improved well test-completion tool for use in oil wells and the like, wherein the tool is adapted to be run on or in a well tubing, and wherein the tool has means for providing a bore therethrough which is the same size as the bore of the tubing or which is sufficiently large so that well tools may be lowered therethrough for performing well operations subsequently to the testing of the well with said test-completion tool without requiring the removal of said test-completion tool from the well.

Still another object of this invention is to provide a new and improved well test-completion tool which has one or more test holes therein for admitting a test sample of well fluid into the tool, the test holes being closed by plugs which are held by a frangible means so that fracturing of the frangible means opens the test holes, and the bore of said tool having a closure therein which is removable after the test holes are opened so that the full bore of the tool is opened for conducting various well operations therethrough.

An additional object of this invention is to provide a new and improved well test-completion tool wherein one or more test ports in the tool are adapted to be opened by dropping a go-devil or weight on the tool, and wherein the full bore of the tool is adapted to be subsequently opened with the go-devil or weight or fluid pressure.

The preferred embodiment of this invention will be described hereinafter, together with other features thereof, and additional objects will become evident from such description.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings forming a part thereof, wherein an example of the invention is shown, and wherein:

FIG. 1 is a vertical sectional view illustrating one form of the tool of this invention;

FIG. 2 is a cross-sectional view taken on line 2—2 of FIG. 1 to further illustrate the form of the invention shown in FIG. 1;

FIG. 3 is a view, partly in elevation and partly in section, illustrating another form of the tool of this invention;

FIG. 4 is a cross-sectional view taken on line 4—4 of FIG. 3;

FIG. 5 is a view similar to FIG. 3, except that FIG. 5 illustrates the tool after the test port or ports have been opened with a go-devil or other weighted member;

FIG. 6 is a view, partly in elevation and partly in section, illustrating a further step in the operation of the device of FIG. 3 wherein the go-devil or weighted member is utilized for removing the closure means or plug in the bore of the tool for opening such bore to conduct a well operation or operations therethrough;

FIG. 7 is a partial sectional view illustrating a modified

portion of the closure plug or member which is utilized in the tool of this invention;

FIG. 8 is a vertical sectional view illustrating a portion of the tool of this invention to show a modified part thereof as compared with FIGS. 1 and 3;

FIG. 9 is a view, partly in section and partly in elevation, showing a modified portion of the tool of this invention; and

FIG. 10 is a vertical sectional view illustrating a further modification of the tool of this invention.

In the drawings, the letter A designates generally the tool of this invention which is adapted to be run with or in a well tubing or pipe T, a portion of which is illustrated in FIG. 1. As will be explained more in detail, the tool A may be connected with the lower end of the tubing T by means of the usual threaded connection (not shown) so as to form a continuation of the tubing T as illustrated in FIG. 1, or the tool A may be positioned within the tubing T. The tool A is positioned for initially receiving a test sample or for conducting a dry test of the well and for subsequently conducting a well operation or operations through the tool A. A well packer P of conventional construction is positioned between the tubing T and well casing C. By way of example, the packer P could be of the hookwall type, the permanent type, the wire line type or any other type of packer which is adapted to be set in a well casing between the casing and the tubing.

Considering the invention now in detail, reference is first made to FIGS. 1 and 2 of the drawings wherein one form of the tool A is illustrated. As shown therein, the tool A has a tubular body or mandrel **15** which has an internal bore portion **15***a* with a diameter which is at least as large as the internal diameter or bore of the well tubing or pipe string T thereabove. Although the tool A is ordinarily located at the lower end of the tubing T and below the packer P, such tool A can be located in the tubing T at a point above the packer P, as will be evident hereinafter. The lower bore portion **15***b* of the tubular body or mandrel **15** is enlarged as compared to the bore **15***a* thereof and the bore of the tubing T so as to provide an annular lateral shoulder **15***c* within the body or mandrel **15**.

A closure member or plug **16** having an external diameter substantially equal to the internal diameter of the bore portion **15***b* is adapted to be positioned within the mandrel or tubular body **15** for closing fluid flow through the bore of the mandrel or tubular body **15**. The plug **16** has a central recess **16***e* which opens upwardly of the plug and has a lower cylindrical wall and an upper downwardly and inwardly inclined wall **16***d* above and merging with the cylindrical wall of the recess **16***e*. At the upper end of the wall **16***d*, there is an internal annular groove **16***f* with an annular vertically extending bottom wall. Above this groove **16***f* is an internal annular flangelike member with notches **16***g* and recesses **16***h* therein. Inwardly extending projections **16***k* are formed between the notches **16***g* and the recesses **16***h*. The closure plug **16** preferably includes a seal ring **17** formed of rubber or other resilient sealing material for contact with the bore portion **15***b* of the mandrel or tubular body **15** so as to prevent fluid flow between the plug **16** and the mandrel or body **15**. The seal **17** may of course be positioned on the mandrel or body **15** in sealing contact with the external surface of the plug **16** if desired. The closure plug or member **16** is formed with one or more test ports or openings **16***a* which establish fluid communications from the area below the plug **16** to the area thereabove within the tubular mandrel or body **15**. In the form of the invention illustrated in FIG. 1, there would be four of such test ports or openings **16***a*, but the invention is not limited to any particular number of such ports or openings **16***a*. Preferably, the ports **16***a* have enlarged bores **16***b* at their upper ends which form a shoulder **16***c* in each of the ports or openings **16***a*. A test opening plug **19** is adapted to be positioned within the enlarged portion **16***b* of each of the ports or openings **16***a*. The shoulder **16***c* in each of the ports or openings **16***a* limits the downward movement of each of the test port plugs **19**. It is desirable to have a seal ring **20** with each of the test plugs **19** to provide a resilient seal between the plugs **19** and the enlarged bore portions **16***b*. The rings **20** are formed of rubber or other resilient sealing material and are preferably of the type known as O-rings. Such test port plugs **19** therefore function to close the flow of fluid through the test ports or openings **16***a* from the area below the plug **16** to the area thereabove.

The upper ends **19***a* of the test plugs **19** are formed at an angle or inclination as shown in FIG. 1, but as will be more evident hereinafter, the inclination of the ends **19***a* is not necessary. As seen in FIG. 1, the angle or inclination of the ends **19***a* is substantially the same as the angle or inclination of the inclined annular surface **16***d* formed in the closure plug or member **16** so that the ends **19***a* of the plugs **19** lie in substantially the same annular plane as the annular inclined surface **16***d*. As previously explained, the internal inclined annular wall **16***d* is inclined at an angle downwardly and inwardly so that the wall **16***d* merges with the internal vertical walls of the central recess **16***e* formed in the closure plug or member **16**. Also, the annular vertically extending bottom wall of the annular groove **16***f* is formed of such a diameter that it forms a continuation of the vertical wall of each enlarged bore **16***b* of each test port **16***a* or is slightly larger than such vertical wall. Also, the notch **16***g* above each of the enlarged bores **16***b* has a slightly larger radius than the radius of each of the test port plugs **19**. Therefore, each of the plugs **19** is positioned in its respective enlarged bores **16***b* by dropping same downwardly through one of the notches **16***g*, along the wall of the groove **16***f* and then into the enlarged bore **16***b* until contact is made with the shoulder **16***c*.

The test port plugs **19** are held in the position shown in FIG. 1 with their lower portions in engagement with the shoulder **16***c* by means of a retainer member or block **25**. The retainer member **25** is formed of a frangible material in the preferred form of the invention, examples of which are cast iron and pot metal, but plastic and other similar frangible materials will also be suitable. To facilitate the fracturing of the retainer member **25** in a desirable pattern when it is desired to release or move same from its position retaining the plugs **19** in the test ports **16***a*, the member **25** may be scored or grooved as indicated at **25***a* and as best seen in FIG. 2.

The particular shape of the retainer member **25** illustrated in FIGS. 1 and 2 would generally be used. Such member **25** in FIGS. 1 and 2 has four arms in the shape of a cross so that one arm is provided for each of the plugs **19**. Accordingly, four recesses **16***h* are also provided for the insertion of the arms of the retainer member **25** into a position in contact with the plugs **19**. Thus, the retainer member **25** is initially turned so that its arms are aligned with the recesses **16***h* and then it is dropped or moved downwardly so that the arms pass downwardly in the recesses **16***h* to a point below the lower surface of the inwardly extending projections **16***k* as best seen in FIGS. 1 and 2. Therefore, after the retainer member **25** has dropped downwardly below the inwardly extending projections **16***k*, it is turned or partially rotated so that it is locked or positioned below the lower surfaces of such projections **16***k* and over the plugs **19**. Such position is illustrated in FIGS. 1 and 2 of the drawings. It should be pointed out that the ends of the arms of the member **25** are preferably enlarged and rounded as best seen in FIG. 1 so that such heavier section supports plugs **19** which are forced upwardly by well hydrostatic pressure, and so that the central portion of the retainer member **25** is relatively thin for fracturing when desired and also

to provide the rounded surfaces at the ends of the arms of the member 25 so that when the member 25 is fractured, there will be no tendency of the parts thereof to remain above the plugs 19. Instead, the fractured parts of the member 25 will fall downwardly into the central recess 16*e* of the member 16 and will be clear of the plugs 19 after the member 25 is fractured.

In FIGS. 1 and 2, a screen 27 having openings 27*a* therethrough is connected to the lower end of the closure plug or member 16 by the engagement of its threads 27*b* with the threads 16*m*, or any other suitable connection means. The screen 27 permits the inflow of fluid under pressure to the openings 16*a*, but it serves to filter or screen any foreign particles or debris which might clog or close the openings 16*a* when flow through the openings 16*a* occurs.

The frangible retainer member 25 illustrated in FIGS. 1 and 2 may be fractured or broken into a number of pieces by any type of weighted member or go-devil commonly used in oil field operations. Go-devils and similar members are adapted to be dropped through the tubing, with or without a wire line attached thereto, and the impact of the go-devil or other weighted member with the retainer member 25 is sufficient to fracture or shear the member 25 into several pieces so that it falls downwardly into the recess 16*e* or is otherwise displaced from its position above the test port plugs 19. In FIG. 3, an example of a go-devil is shown in conjunction with another form of the invention. The go-devil shown in FIG. 3 is designated with the letter G and it includes a weight or solid bar 30 which is provided with a fishing neck 31 at its upper end. The weighted bar 30 of the go-devil G preferably has a plurality of guide lugs 31 welded or otherwise secured thereto which are of such a diameter that they maintain the weight or bar 30 in substantially the central portion of the tubing T and the central portion of the mandrel or body 15 so that such go-devil G contacts the central portion of the frangible member 25 when it is dropped thereon. The go-devil G is also utilized for knocking the plug 16 out of the bore of the mandrel or tubular body 15, as will be more fully explained hereinafter, but in some instances, after the test port plugs 19 have been removed or released so that fluid communication is established through the passages 16*a*, the go-devil G and the plug 16 tend to drop or settle prematurely, and if such should occur, the go-devil G is provided with a means to catch the go-devil G in the tubular mandrel or body 15. Such structure is illustrated in FIG. 3 wherein the go-devil G is illustrated as having hinged or pivoted fingers 32 which are pivoted at 32*a* and which are urged outwardly by a spring 33 or any other equivalent spring means so that the fingers 32 engage the inside surface of the tubing T. A recess 35 which is formed so as to provide a lower lateral annular shoulder 35*a* is provided in the tubing T or in the body of the tool A so that the fingers 32 engage the shoulder 35*a* when the go-devil G has prematurely dropped as explained. Thus, the go-devil G is caught in the tubing T or the body of the tool A and is prevented from falling so that it can be retrieved with a suitable type of known overshot or fishing tool which is adapted to engage the fishing neck 31 in a known manner.

In the operation or use of the form of the invention shown in FIGS. 1 and 2, the well test-completion tool A of this invention is positioned in the well casing C at the lower end of the tubing T or an any other suitable location therein so that the lower open end of the mandrel 15 is exposed to the fluid pressure below the packer P. Therefore, the lower end of the plug 16 is exposed to the fluid pressure of the well which serves to apply a fluid pressure force which acts to urge the plug 16 upwardly in the mandrel or tubular body 15 so that its upper end contacts the shoulder 15*c* as shown in FIG. 1. Since the tubing T is ordinarily run empty in the use of this tool A, there is therefore a fluid pressure differential acting across the plug 16 since the pressure externally of the body 15 is greater than the pressure internally thereof above the plug 16.

When it is desired to obtain a test sample from the well fluid which is below the packer P, the retainer means 25 must be fractured so as to release or remove same from the upper ends of the plugs 19. Such fracturing of the member 25 is accomplished with the go-devil G or other similar weighted member which is dropped or lowered with considerable force into contact with the member 25. Since the member 25 is formed of a material which is frangible and readily cracks or shatters, the member 25 is caused to crack or shatter by the impact of the go-devil G and the pieces of the member 25 ordinarily fall into the recess 16*e* of the plug 16. The test port plugs 19 are then released and the fluid pressure in the well can then act on the plugs 19 to move same upwardly out of the enlarged ports or openings 16*b* so as to open the test ports or openings 16*a* for establishing fluid communication from the area externally of the mandrel or tubular body 15 to the area internally thereof above the plug 16. The fluid pressure across the plug 16 is therefore equalized above and below the plug 16.

If a "dry test" of the type previously described is to be conducted, then any flow of fluid into the tubing T will indicate that the cement in the well is unsatisfactory or defective so that subsequent well operations will be indicated. On the other hand if the well is to be tested to determine whether it is flowing adequately and is producing the proper fluid for the full production of the well, the test sample or flow into the tubing T through the test port or ports 16*a* will be used to determine whether or not subsequent well operations are necessary before the well is opened for full production.

If well performance is determined to be unsatisfactory and if additional productive zone in the well is to be opened to the well tubing, then an overshot of known construction, one of which is schematically illustrated in FIG. 6 and is identified by the letter S, is lowered on a wire line W for engaging the fishing neck 31 of the go-devil G so as to retract the fingers 32 (FIG. 6). Then, the weight of the go-devil G and the overshot S are both utilized by lowering them together on the wire line into contact with the plug 16 so as to force same downwardly to the lower end of the mandrel or tubular body 15 to remove such plug 16 from the bore of the mandrel or body 15. Since the pressure above and below the plug 16 has previously been equalized by the opening of the ports or openings 16*a*, the frictional resistance provided by the plug 16 within the mandrel or body 15 is the only force necessary to be overcome by the impact of the go-devil G against the plug 16. After the plug 16 has been removed from the bore of the mandrel or body 15 of the tool A, then the go-devil G is lifted out of the hole with the overshot S on the wire line. The full open bore of the tubing T is then exposed through the mandrel or tubular body 15 so that any well tool which is normally lowered through a tubing string T can also be lowered through the tubular body or mandrel 15. Furthermore, in view of the fact that the bore of the tubing can thus be opened after the test of the well formation is obtained without requiring the removal of the tubing T from the well, the Christmas tree (not shown) can be bolted down and a flow line (not shown) can be hooked up at the surface of the well prior to the time that the go-devil is dropped to break the retainer member 25 so that when the bore of the mandrel 15 is opened by removing the plug 16, the well is under control without requiring a "killing" of the well with heavy mud or fluid.

Thus, with the bore of the tool A open, a perforating gun of the type which is normally lowered through tubing can be dropped or run downwardly through the tubing and through the tubular body 15 of the tool A to a position below the lower end thereof and the casing can be reperforated at the desired depth. If the well is to be

swabbed after the obtaining of the test flow through the ports **16***a*, or if the well flows satisfactorily during such test, the tool A is left in the well as described above with the full bore thereof open for well production of the oil or other fluid from the exposed formation below the packer P.

If it is necessary or desirable to fracture, acidize, squeeze cement or perform similar well operations after the test of the well formation by the flow of fluid through the port or ports **16***a*, the plug **16** is pumped out of the mandrel or tubular body **15** with fluid pressure applied from the internal area of the tubing T above the plug **16** and then such well operations are performed through the bore of the mandrel or body **15**. It should be noted that when pressure work such as is utilized in the fracturing or squeeze cementing of a well is employed, the packer P must be of the type having means therewith to hold the packer P against upward movement as will be understood.

In FIGS. 3 and 4, a modified tool A–**1** is illustrated. The tool A–**1** has a mandrel or tubular body **115** which corresponds with the mandrel or tubular body **15** of FIGS. 1 and 2. The mandrel or tubular body **115** has an upper bore portion **115***a* which is of substantially the same diameter as the internal diameter of the tubing T thereof. The mandrel or body **115** also has an enlarged internal bore **115***b* so as to provide a shoulder **115***c* extending annularly. The mandrel or body **115** may be modified as compared to the mandrel or body **15** by including the recess **35** shown in FIG. 3 for the purpose previously described, but of course, as previously explained, the annular groove **35** and the shoulder **35***a* could be incorporated with the tool A also. A further modification of the mandrel or tubular member **115** as compared to the mandrel or tubular body **15** resides in the provision of one or more test ports or openings **115***d*. These ports or openings **115***d* extend laterally through the wall of the mandrel or body **115** and preferably are just below the shoulder **115***c*. These openings **115***d* correspond with the test ports or openings **16***a* of the tool A. Each of the ports or openings **115***d* has a test port plug **119** positioned therein for closing fluid flow from the area externally of the mandrel **115** to the area internally thereof. The plugs **119** correspond with the plugs **19** of the tool A except that they are constructed with a shoulder **119***a* which engages with the inside bore **115***b* and prevents the plugs **119** from passing outwardly through the openings **115***b*. Seal rings or O-rings **120** are preferably included with each of the plugs **119**. In the illustrations of FIGS. 3 and 4, four plugs **119** are employed, although it will be evident that the number of such plugs may vary depending upon the circumstances and conditions of use.

The plugs **119** are held in the test ports or openings **115***d* by means of a retainer member or plate **125** which is substantially circular except for four flat surfaces **125***a* which are positioned adjacent to and in contact with the plugs **119** (FIG. 4). The member or plate **125** also has a central opening **125***b* therethrough for fluid passage.

The retainer member or plate **125** is prevented from moving downwardly because it rests upon the upper edge of a plug **116** which corresponds with the plug **16** of the tool A. The plug **116** has seal rings or O-rings **117** and **117***a* which are formed of rubber or other resilient material for sealing between the plug **16** and the body or mandrel **115**. The plug **116** is formed with notches or recesses **116***a* in its upper edge, the number of which corresponds with the number of plugs **119**. Therefore, in the illustration, there would be four recesses or notches **116***a*. The notches **116***a* are provided so that when the member **125** is fractured and removed from the area behind the plugs **119**, and therefore when the plugs **119** are permitted to be moved out of the openings **115***d* by fluid pressure, then the plug **116** can move upwardly into contact with the shoulder **115***c* to limit the upward movement of the plug **116** while providing the spaces of the notches **116***a* through which fluid may flow into the interior of the mandrel or body **115** (FIG. 5). As previously explained in connection with the tool A, when the test port or ports are opened, the fluid pressure above and below the plug **16** is equalized. The same equalization of the fluid pressure across the plug **116** is obtained when the test ports **115***d* are opened. In order to assist in maintaining the plug **116** in a raised or closed position with its upper end in contact with the shoulder **115***c* after the plugs **119** are removed from the openings **115***d*, it is desirable to provide the lower lateral surface **116***b* with a greater surface area exposed to the fluid pressure therebelow than the lateral surface on the upper side of the plug **116** which is exposed to the fluid pressure within the tubing T. With such arrangement, even though the fluid pressure across the plug **116** is equalized, there is a greater upward force acting upon the plug **116** than is acting downwardly thereon so that the plug **116** is maintained in position within the mandrel **115** until some additional force or pressure is applied to the plug **116** from thereabove. To accomplish the increased lateral surface area at **116***b* as compared to the lateral surface area of the plug **116** thereabove, the external diameter of the plug **116** is decreased as indicated at **116***c* as compared to the external diameter **116***d* therebelow and the seal **117***a* is positioned for preventing fluid leakage or flow from the area thereabove to the area therebelow. It should also be noted that the plug **116** is provided with a central recess **116***e* into which the pieces of the retainer member **125** may collect or fall when such member **125** is fractured or cracked.

The operation or use of the tool A–**1** of FIGS. 3 and 4 is substantially identical with that described above in connection with the tool A. The packer P is set in the well if it is a permanent completion type packer or a wire line packer and then the tubing T is lowered into the well with the tool A–**1** thereon. If the packer P is a hookwall type packer, it is generally lowered with the tubing T. The Christmas tree (not shown) is installed and if the packer P is lowered with the tubing T, the packer is set before bolting the Christmas tree down and hooking up the flow line. Thereafter, the go-devil G is dropped into the tubing so that it strikes the frangible retainer member **125** and fractures or cracks same into pieces so that it is removed from its position behind the plugs **119**. The fluid pressure in the casing C below the packer P then forces the plugs **119** inwardly and the well fluid flows into the interior of the tubing T above the plug **116**. Depending upon the results of such test sampling or flow, the plug **116** is thereafter either knocked out of the lower end of the tool A–**1** with the go-devil G and an overshot such as S illustrated in FIG. 6, or the go-devil G is removed and the plug **116** is pumped out of the lower end of the tool A–**1** with fluid under pressure from within the tubing string T. The various well operations previously referred to and those others that may be desired may then be carried out or conducted through the open bore of the tubing T and the mandrel or tubular body **115**. It should be noted that FIG. 5 illustrates the position of the plug **116** after the member **125** has been fractured and the plugs **119** have been forced out of the openings **115***d*. It will be noted that the plug **116** has moved upwardly so that its upper edge is in contact with the annular shoulder **115***c* so that it is limited in its upward movement while the notches **116***a* are aligned with the openings **115***d* to permit the flow of the well fluid into the mandrel or body **115** above the plug **116**. The illustration of FIG. 6 shows the removal of the plug **116** from the mandrel or tubular body **115** with the go-devil G on the lower end of the overshot S as they are lowered together on a wire line W.

FIG. 7 shows a modification of the closure plug which is used in the tool A or the tool A–**1**. The closure plug **216** of FIG. 7 is modified to include a check valve **40**

which is adapted to seat in a valve opening **41** to close flow through such opening **41**. A coil spring **42** acts against a shoulder **43** on the plug **216** and also against a washer **44** which is attached by any suitable means to the lower end of a shaft **45** on the valve **40**. Therefore, the spring **42** normally maintains the valve **40** in a closed position and the spring **42** is of sufficient strength to normally hold the valve **40** in the closed position except when seating the apparatus in a permanent type packer. In such instances, fluid lock may develop so that the tool cannot be properly seated in the permanent type packer and in such instance, the valve **40** will open to release the fluid lock and admit a small amount of fluid into the interior of the tool A above the plug **216** without otherwise affecting the operation or function of the tool of this invention. The remainder of the structure of the plug **216** is identical with that illustrated in connection with FIG. 3 and is shown as including a seal ring **217** which corresponds with the seal ring **117** of FIG. 3. However, as explained, the check valve could be utilized with the closure plug **16** in FIG. 1 if desired. In FIG. 8 of the drawings, the tubular body or mandrel **215** is modified as compared to the tubular body or mandrel **115** and **15** shown in FIGS. 3 and 1 of the drawings, respectively. In FIG. 8, the mandrel or tubular body **215** is formed of two sections **215***a* and **215***b* which are threaded together at **215***c* and which have the same internal diameters. A recess **215***d* is formed in the bore of the section **215***a* and such annular shoulder **215***d* is just above the upper end **215***e* of the lower section **215***b* so that an annular groove or recess is actually formed between the shoulders **215***d* and **215***e*. The plugs **219** fit within test ports or openings **215***f* to close same. The ports **215***f* correspond with the ports **115***d* of FIG. 3. The plugs **219** are held in the ports **215***f* by a retainer member or plate **225** which corresponds with the retainer or plate **125** of FIG. 3. However, the retainer member **225** is not supported on a closure plug such as the closure plug **116**, but instead the member **225** is supported in the annular recess between the surfaces **215***d* and **215***e* as best seen in FIG. 8. Therefore, the plug such as the plug **116** can be disposed at some point considerably below the plate or retainer member **225**.

In FIG. 9, a modified mandrel or tubular body **315** is shown in part to illustrate a modified portion of the tool. The mandrel or tubular body **315** is substantially identical with the mandrel or tubular body **115** except that the bore **315***a* is substantially equal to the bore **315***b* so that an annular recess **315***c* is provided rather than a shoulder **115***c* as in FIG. 3. The mandrel **315** is formed with at least two diametrically aligned test ports **315***d* and **315***e*. The test port **315***d* is of a reduced diameter as compared to the recess **315***c*, but the port **315***e* is of the same diameter as the annular recess **315***c*. The port or opening **315***d* is adapted to receive a plug **319** which has an enlarged head or shoulder **319***a* thereon for engagement with the recess **315***c* to prevent outward movement of such plug **319** with respect to the opening or port **315***d*. On the other hand, the opening **315***e* has a plug **319'** which is of substantially the same diameter as the opening **315***e* throughout its length. The frangible member or retainer member **325** is a rod of substantially the same diameter as the opening **315***e* and it is formed with suitable crack initiating grooves or scoring **325***a* to facilitate fracturing thereof with a go-devil such as the go-devil G of FIG. 3. The plugs **319** and **319'** are inserted into the position shown in FIG. 9 by initially positioning the plug **319** in its opening **315***d* and then the retainer member **325** is pushed through the opening **315***e* until it is in engagement with the head or shoulder **319***a* of the plug **319** and is confined by the recess **315***c*. The plug **319'** is then placed in the opening **315***e* and the fluid pressure externally of the mandrel or tubular body **315** is relied upon to keep the plug **319'** in position since the retainer member **325** prevents the plug **319'** from moving inwardly into the bore of the mandrel **315**. It will be evident that if a closure plug such as the plug **16** or **116** is utilized with the form of the invention shown in FIG. 9, it would be positioned below the rod **325**. Also, it should be understood that if more than two inlet test ports or openings are desired, they can be longitudinally spaced with respect to each other so that a plurality of retainer rods **325** would be utilized in retaining the plugs in position in the test ports. Test ports are opened by fracturing or shattering the retainer rod **325** in the same manner as previously described in connection with the fracturing or shattering of the retainer member **125** in FIG. 3.

In FIG. 10 a diagrammatic illustration is shown to illustrate the use of a retainer member that can be moved within the mandrel or tubular body **415** without fracturing same but while still accomplishing the opening of the test ports or openings. Thus, in FIG. 10 plugs **419** are held in test ports or openings **415***a* by a retainer member **425** which is longitudinally movable in the mandrel or tubular body **415**. The retainer member **425** is limited in its upward movement by engagement with an annular internal shoulder **415***b* so that the external surface of the retainer member **425** is behind the plugs **419** to prevent their inward movement into the interior of the tubular body or mandrel **415**. However, when the retainer member **425** is moved downwardly with the go-devil G or any other weighted member, the plugs **419** are then released. When the plugs **419** are released the openings **415***a* are of course open and the member **425** is preferably held in the lowered position by the go-devil G. Once the fluid pressure above and below the member **425** is equalized there is no tendency for the member **425** to move in either direction by the action of the fluid pressure thereon so that if the member **425** is once positioned below the openings **415***a*, it normally will remain there. To prevent a premature lowering of the retainer member **425** with respect to the body **415**, a shear pin or other similar means (not shown) could be utilized to hold the member **425** in the position shown in FIG. 10 behind the plugs **419**. Therefore, when the go-devil G contacted the member **425** it would sever the shear pin and move the member **425** downwardly sufficiently for the plugs **419** to be forced inwardly to permit the fluid to thereafter flow through the openings **415***a*. The closure plug **416** may be of the type shown in FIG. 1 or FIG. 3 or any of the other types illustrated in this application and it can be seen that such plug **416** is positioned well below the retainer member **425** and it is prevented from moving upwardly in the mandrel **415** above a shoulder **415***b*. Such arrangement for the closure plug **416** could be utilized in connection with the forms of the invention shown in FIGS. 8 and 9 of the drawings.

The closure plug **416** can of course be knocked out of the mandrel **415** with the go-devil G in substantially the same manner as described previously in connection with FIG. 1 or it can be pumped out with the pressure fluid from within the tubing T as also explained previously in connection with FIG. 1.

It should be pointed out that the go-devil G or similar weighted means, the closure plug **16** and the other closure plugs should be made of a drillable material so that they can be drilled out with a drill bit if it becomes necessary to later drill the well deeper.

The foregoing disclosure and description of the invention are illustrative and explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction, may be made within the scope of the appended claims without departing from the spirit of the invention.

What is claimed is:

1. A test tool for use with a well tubing positioned in a well casing wherein a well packer is located between the tubing and the casing, comprising a tubular body having an axial bore therethrough, a closure plug positioned in said axial bore for closing same, said closure

plug having a test port for establishing fluid communication from the area in said tubular body above said closure plug to the area below said plug, a test port plug mounted with said closure plug for closing said test port, and frangible means for holding said test port plug against upward movement away from said test port until said frangible means is fractured.

2. The structure set forth in claim 1, including a screen on said closure plug to prevent the entry of material or debris into said test port which might close same.

3. The structure set forth in claim 1, including lock means on said closure plug for holding said frangible means against upward movement until said frangible means is fractured.

4. A well test-completion tool for use with a well tubing positioned in a well casing wherein a well packer is located between the tubing and the casing, comprising a tubular body having an axial bore therethrough, closure means closing said axial bore, said tubular body having a test port located above said closure means for admitting fluid into said tubing from the area below said packer and externally of said tubing, plug means closing said test port, and means in said body supporting said plug means in position closing said test port and movable from said plug means to permit removal of said plug means from said test port.

5. The structure set forth in claim 4, including means for moving said movable means from said plug means whereby said plug means is released from said test port by fluid pressure acting on said plug means from externally of said tubular body.

6. A test tool for use with a well tubing positioned in a well casing, comprising a tubular body having an axial bore therethrough, a closure plug positioned in said axial bore for closing same, said closure plug having a test port for establishing fluid communication from the area in said tubular body above said closure plug to the area below said plug, a test port plug mounted with said closure plug for closing said test port, and frangible means for holding said test port plug in said test port until said frangible means is fractured.

7. A test tool for use with a well tubing positioned in a well casing wherein a well packer is located between the tubing and the casing, comprising a tubular body having an axial bore therethrough, closure means positioned in said axial bore for closing same, one of said tubular body and said closure means having a test port for admitting fluid into said tubular body from the area below said packer and externally of said tubular body, plug means closing said test port, means for releasably supporting said plug means in position closing said test port and movable therefrom to permit release of said plug means from said test port to open same to admit fluid into said tubular body, and means for supporting said closure means in said body for movement from said tubular body after the plug means is released to open said axial bore for conducting a well operation therethrough.

8. A test tool for use with a well tubing positioned in a well casing wherein a well packer is located between the tubing and the casing, comprising a tubular body having an axial bore therethrough, closure means positioned in said axial bore for closing same, said closure means having a test port for admitting fluid into said tubular body from the area below said packer and externally of said tubular body, plug means closing said test port, means for releasably supporting said plug means in position closing said test port and movable therefrom to permit release of said plug means from said test port to open same to admit fluid into said tubular body, and means for supporting said closure means in said body for movement from said tubular body after the plug means is released to open said axial bore for conducting a well operation therethrough.

9. A test tool for use with a well tubing positioned in a well casing wherein a well packer is located between the tubing and the casing, comprising a tubular body having an axial bore therethrough, closure means positioned in said axial bore for closing same, said tubular body having a test port for admitting fluid into said tubular body from the area below said packer and externally of said tubular body, plug means closing said test port, means for releasably supporting said plug means in position closing said test port and movable therefrom to permit release of said plug means from said test port to open same to admit fluid into said tubular body, and means for supporting said closure means in said body for movement from said tubular body after the plug means is released to open said axial bore for conducting a well operation therethrough.

10. A test tool for use with a well tubing positioned in a well casing, comprising a tubular body having an axial bore therethrough, closure means positioned in said axial bore for closing same, one of said tubular body and said closure means having a test port for admitting fluid into said tubular body from the area externally of said tubular body, plug means closing said test port, means for releasably supporting said plug means in position closing said test port and movable therefrom to permit release of said plug means from said test port to open same to admit fluid into said tubular body, and means for supporting said closure means in said body for movement from said tubular body after the plug means is released to open said axial bore for conducting a well operation therethrough.

11. The structure set forth in claim 10, wherein said mandrel has means at its upper end for connection with tubing, and wherein the least diameter of the bore of said mandrel is as large as the diameter of the bore of said tubing so that there is no restriction to the passage of well tools through the mandrel when said closure means is removed from said bore of the mandrel.

12. The structure set forth in claim 10, wherein said lateral surface of said closure means which is exposed to the fluid pressure below the closure means is greater than the lateral surface of the closure means exposed to the fluid pressure in the mandrel thereabove so that the closure means is held against downward movement in the mandrel even though the pressures above and below said closure means are equalized.

13. The structure set forth in claim 10, including means for admitting pressure fluid above said closure means after said plug means has been released for thereby equalizing the fluid pressure above and below said closure means.

14. A well test completion tool connected to a well tubing positioned in a well casing, comprising a tubular body having an axial bore therethrough, a closure plug closing said axial bore, said closure plug having a test port for admitting fluid into said tubing from the area externally of said tubular body, a test port plug in said test port for closing same, retainer means retaining said plug in said test port, and means for fracturing said retainer means to permit the removal of said test port plug from said test port by fluid pressure from externally of said tubular body.

15. The structure set forth in claim 14, including coacting surfaces on said closure plug and said tubular body for limiting upward movement of said closure means in said tubular body.

16. The structure set forth in claim 14, wherein said means for fracturing said retainer means is a weighted member which is adapted to be dropped in the tubing for contact with said retainer means.

17. The structure set forth in claim 14, wherein said means for fracturing said retainer means is a weighted member which is adapted to be dropped in the tubing for contact with said retainer means, and wherein said weighted member has guide means thereon for guiding it

into contact with substantially the central portion of said retainer member.

18. The structure set forth in claim 14, including means on said closure means for contacting said retainer means to limit the upward movement of said retainer means relative to said closure means.

19. The structure set forth in claim 14, wherein said means for fracturing said retainer means is a weighted member which is adapted to be dropped in the tubing for contact with said retainer means, and wherein said weighted member and said tubular body have coacting means for catching the weighted member to limit the extent of its downward movement after said retainer means has been fractured.

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