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(54) **SURFACE CONTROLLED DOWNHOLE SHUT-IN VALVE**

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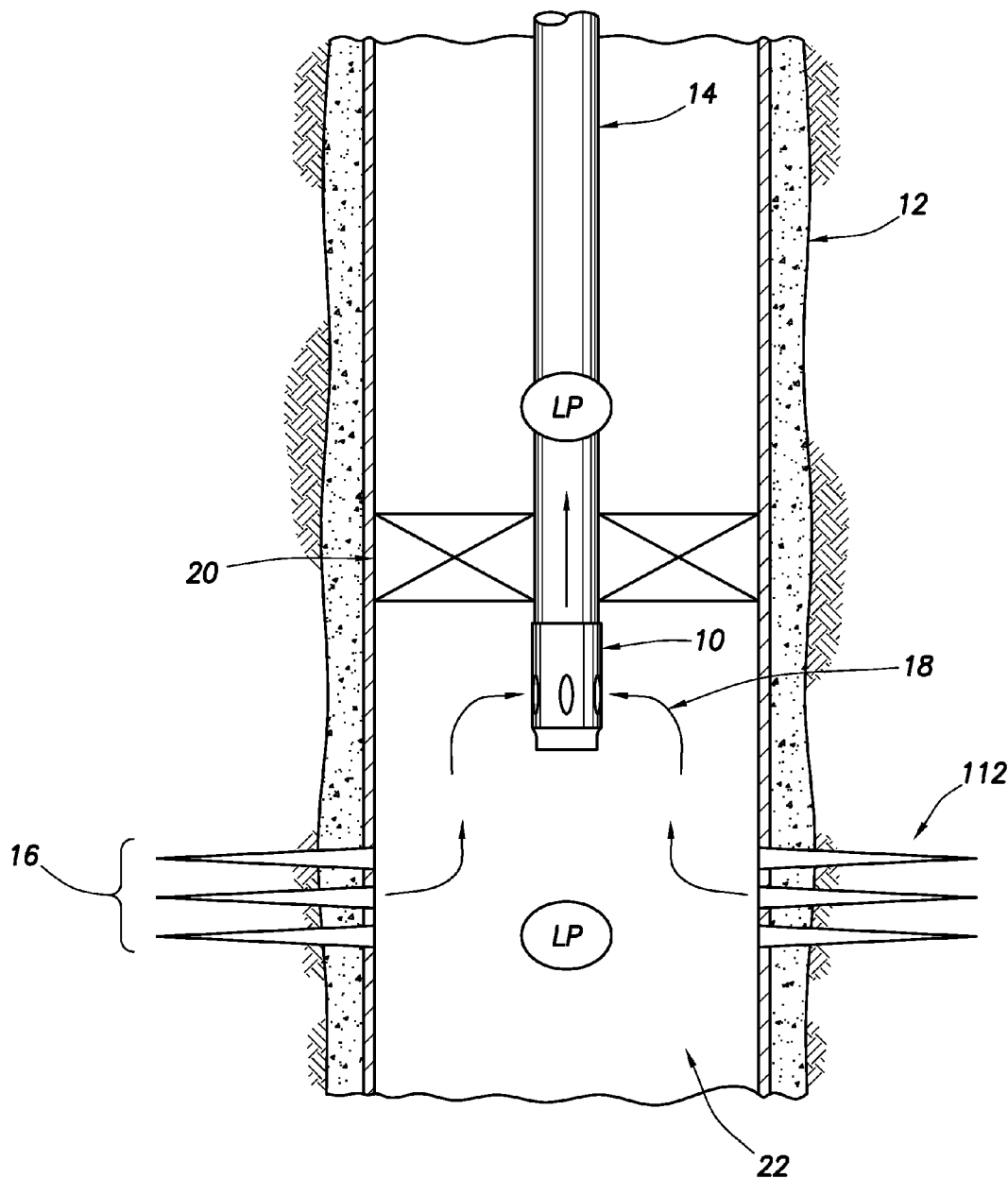
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(57) **ABSTRACT**

A tool assembly having a downhole shut-in valve, a packer, and one or more ports. The downhole shut-in valve may be configured to selectively permit flow from a conduit to a target zone of a wellbore. The packer may be configured to isolate the target zone of the wellbore. The ports may be between the conduit and the target zone. The downhole shut-in valve may be configured to close in about 5 seconds or less.

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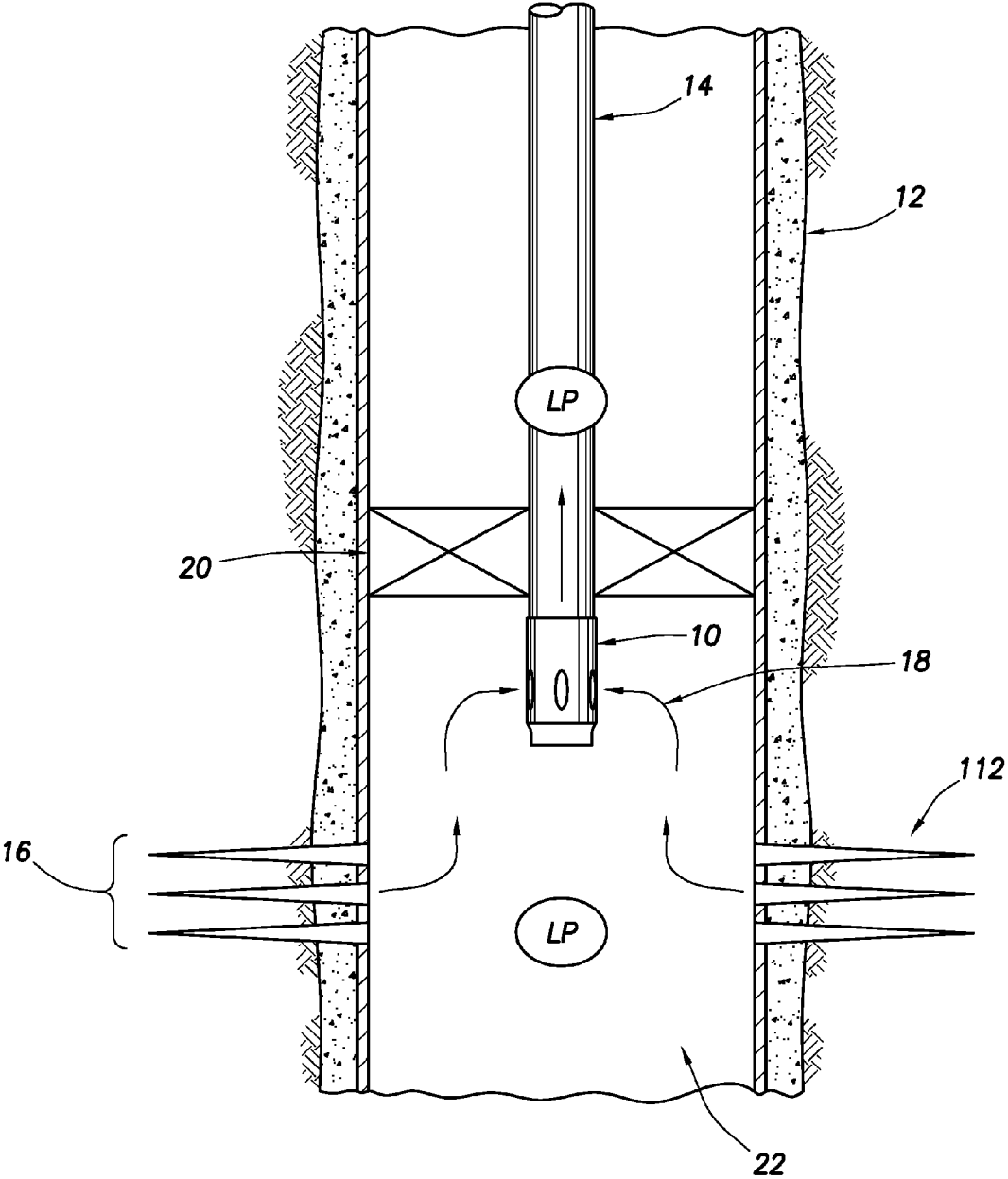


FIG. 1

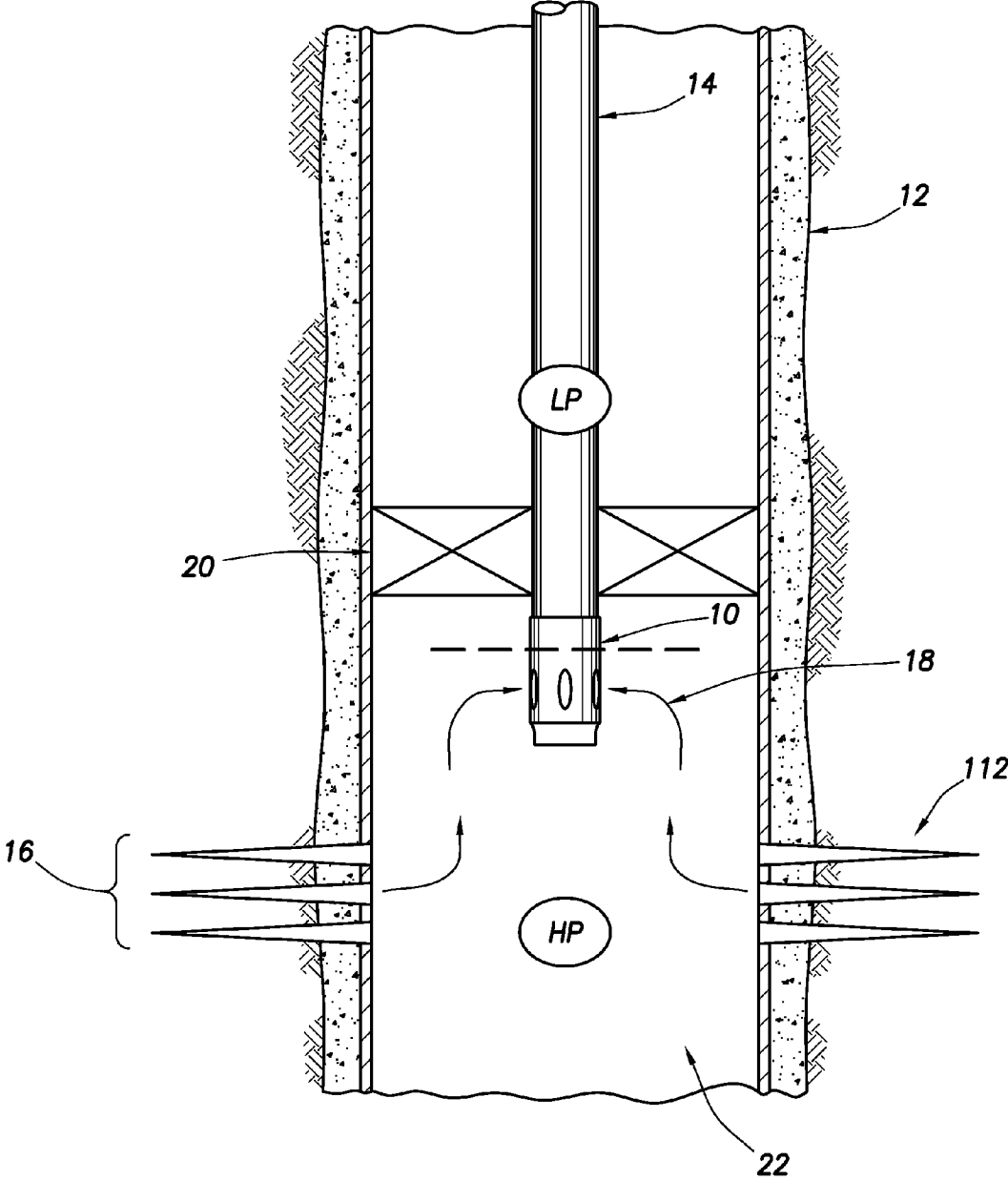


FIG.2

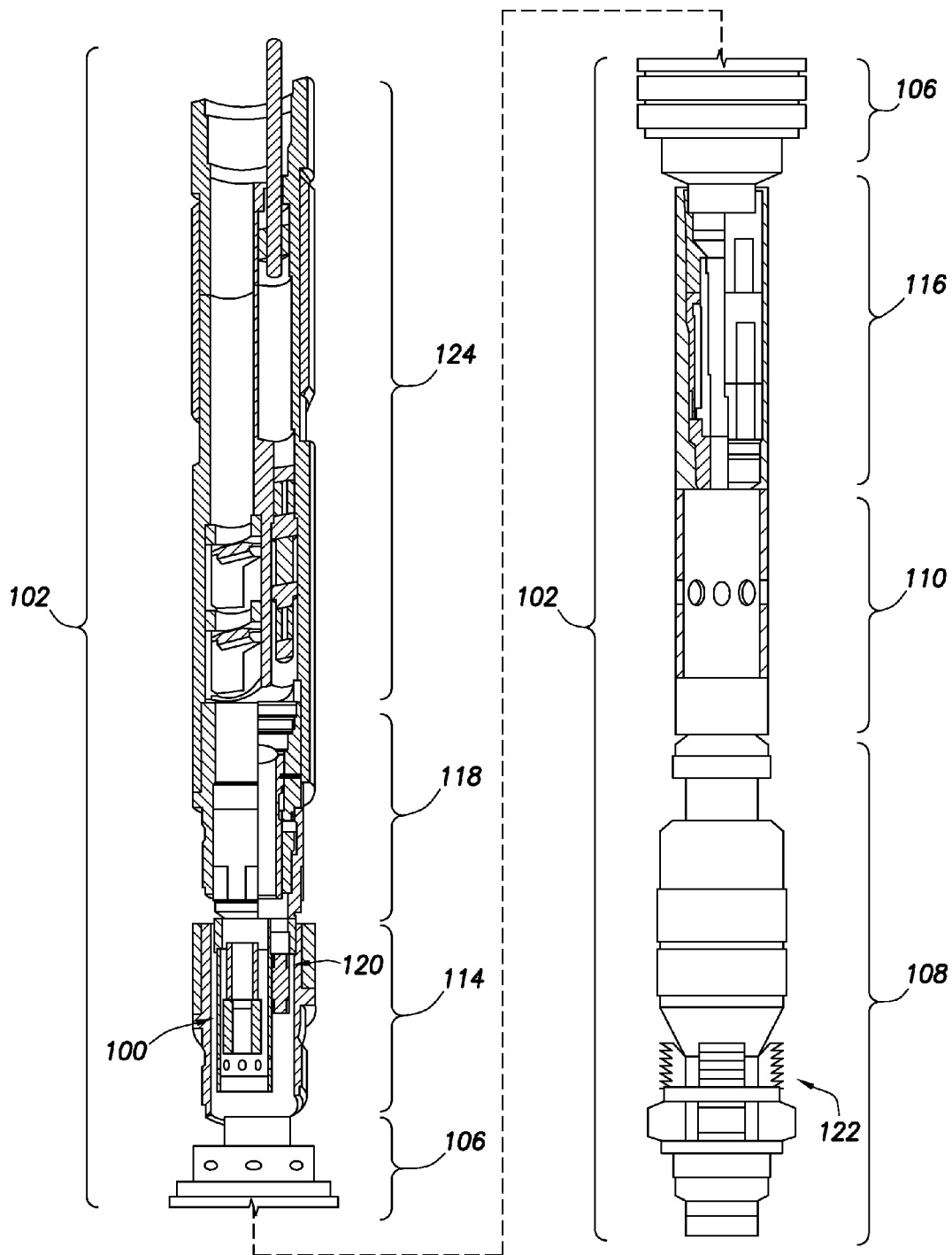


FIG.3

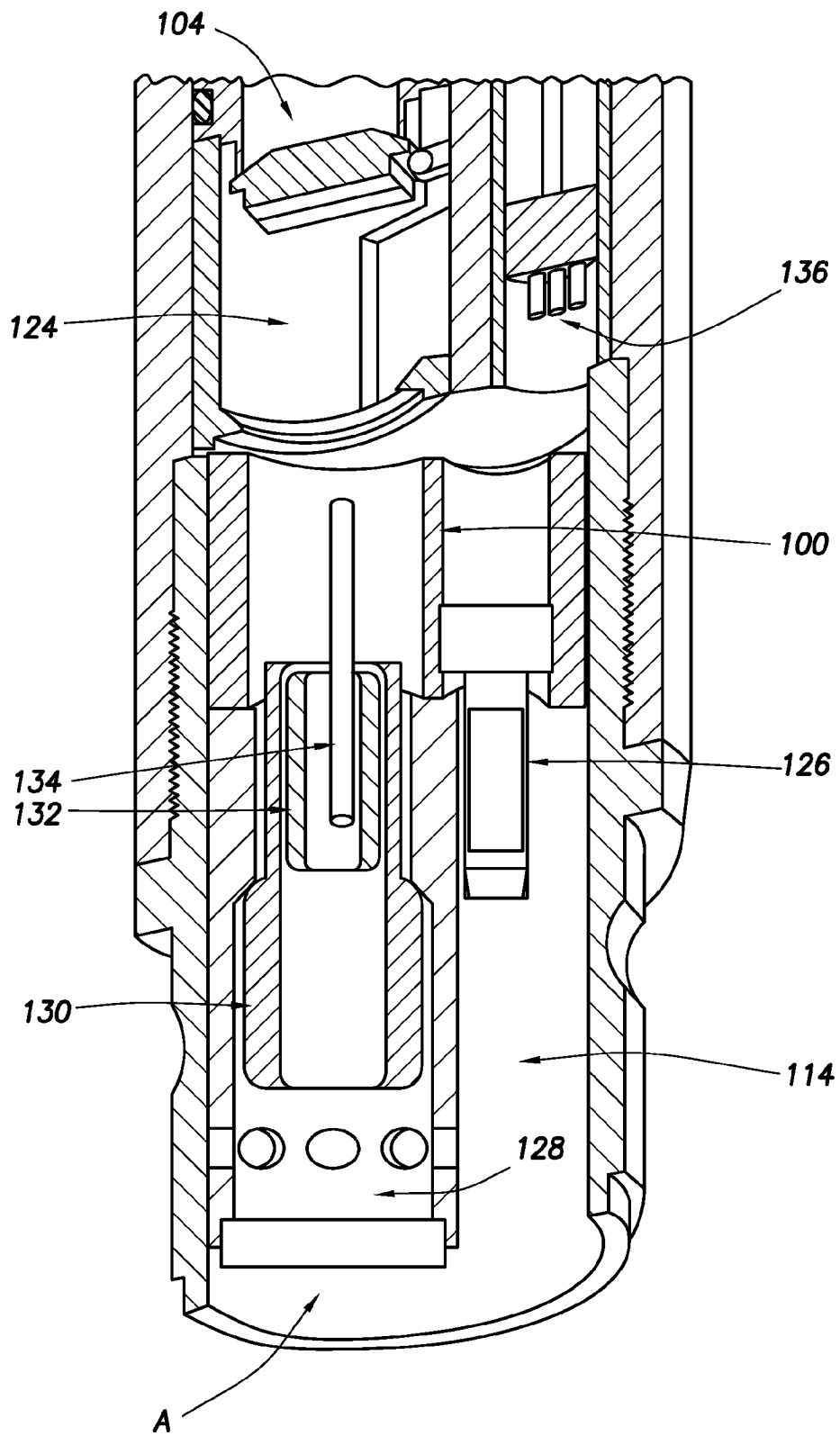


FIG. 4

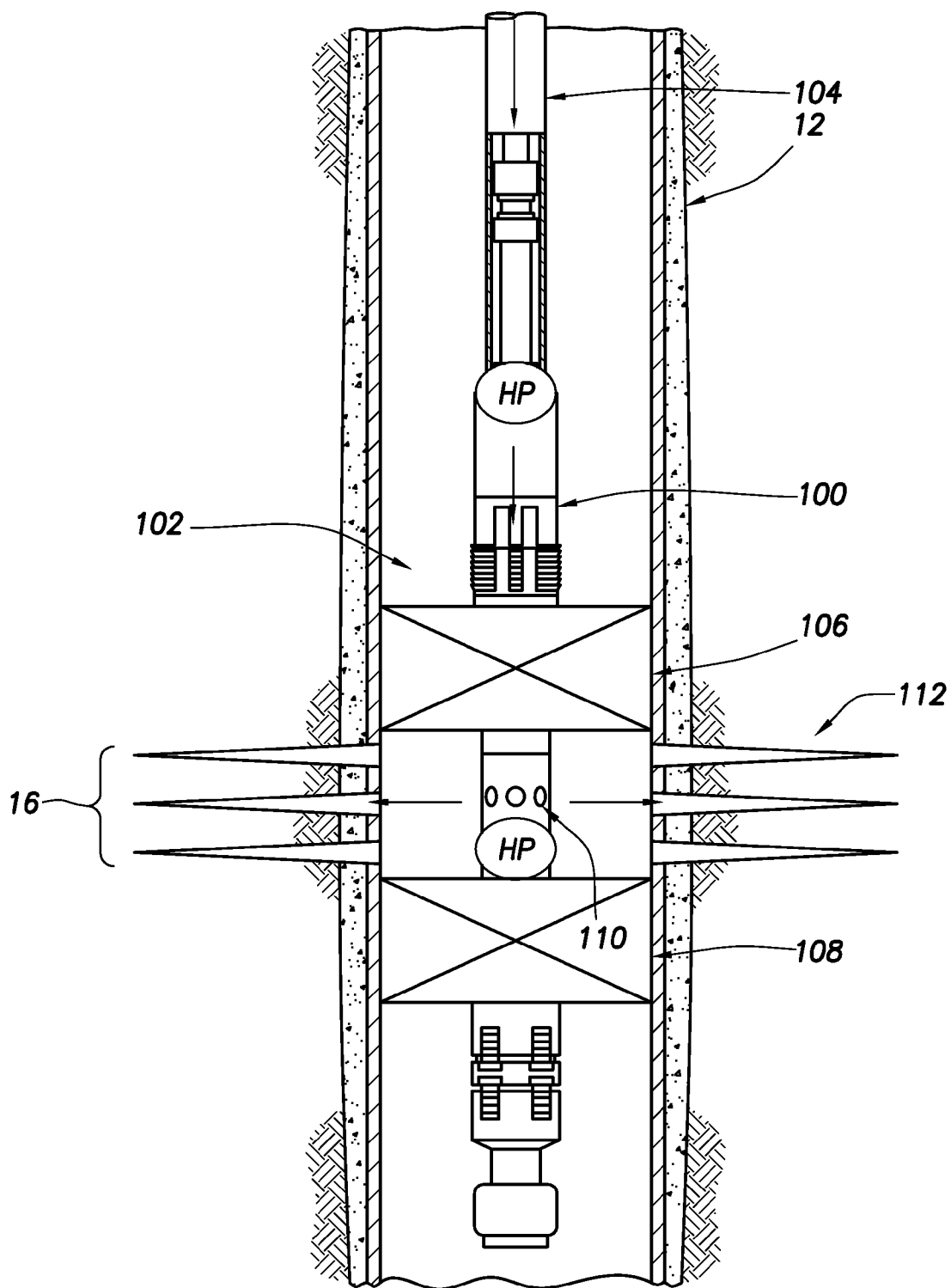


FIG.5

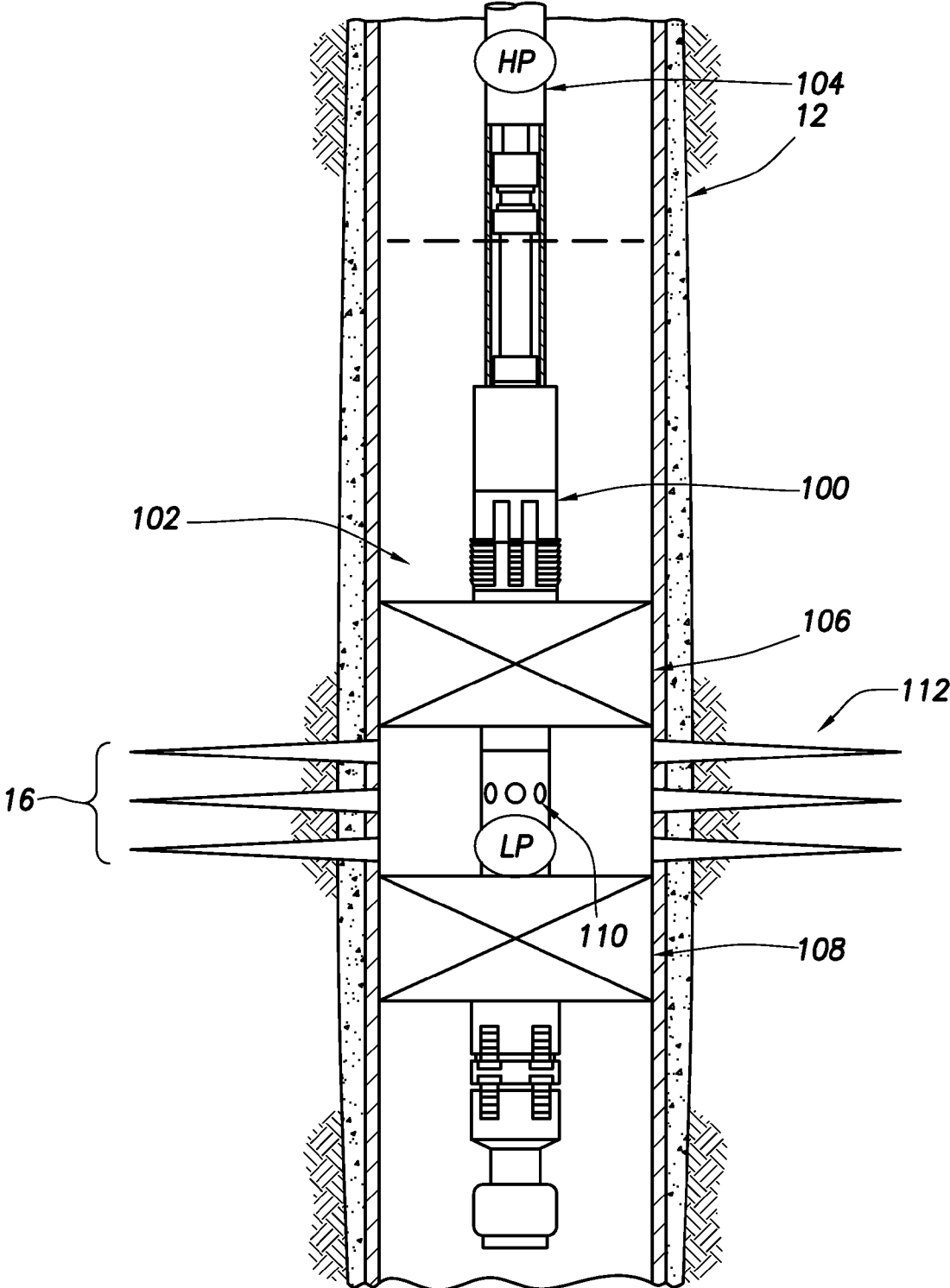


FIG.6

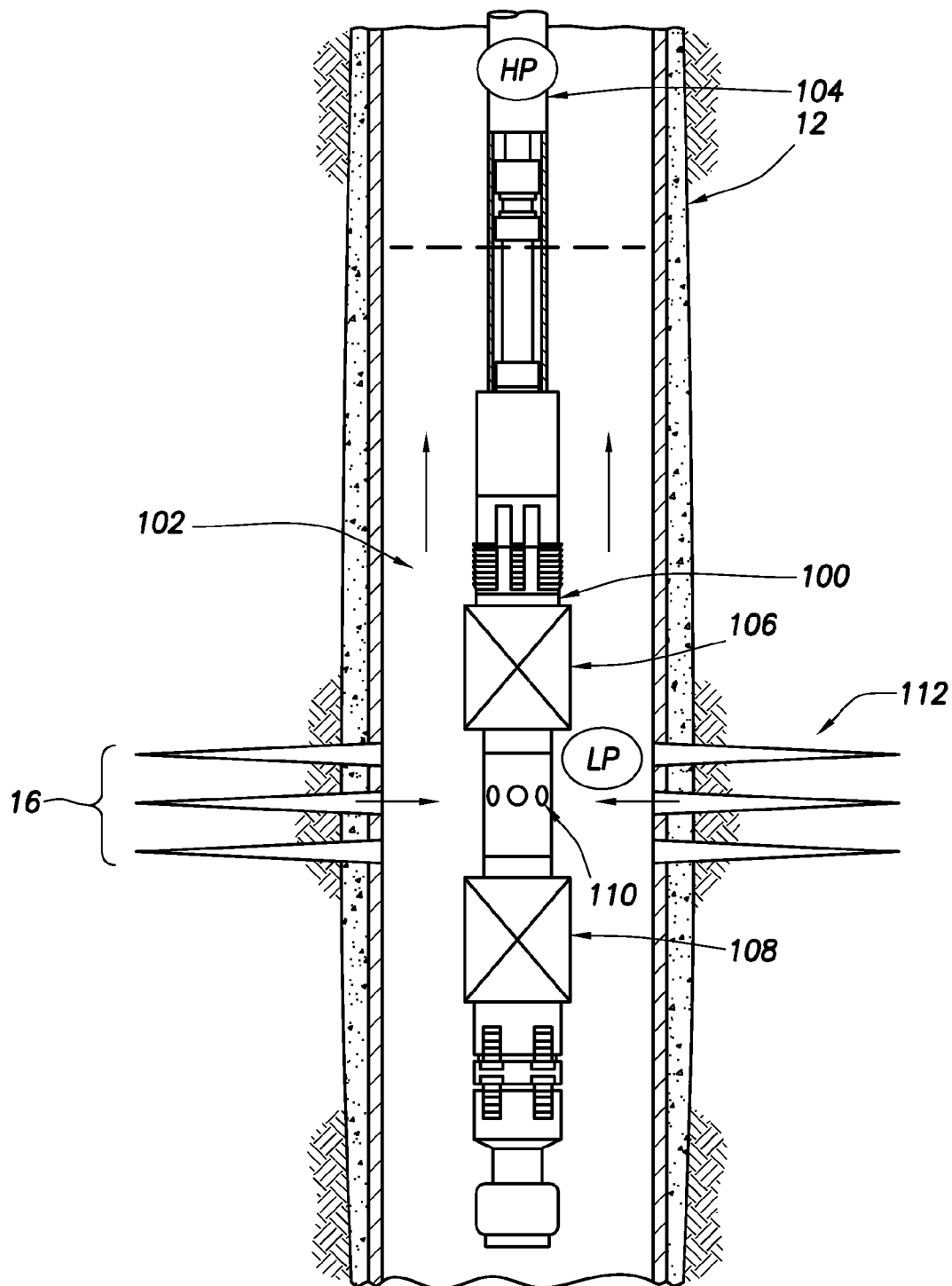


FIG.7



**SURFACE CONTROLLED DOWNHOLE SHUT-IN VALVE**

**BACKGROUND**

[0001] The present invention relates to shut-in valves, and more particularly, to surface controlled downhole shut-in valves.

[0002] Ancillary operations may be useful during completion and/or recompletion of oil and gas wells. For example, testing may assist in monitoring the operability of equipment used during the drilling process or evaluating the production capabilities of formations intersected by the wellbore. After drilling a well or well interval, zones of interest may be tested to determine weather and/or how to optimize production. Formation properties such as fracture gradient, pore pressure, formation pressure, and fall-off characteristics may be tested.

[0003] Conventionally, many tests, such as Nitrogen Fracture Injection Test (NFIT), Diagnostic Fracture Injection Test (DFIT), and Refracture Nitrogen Fracture Injection Test (RFIT) can only be performed with stick pipe and slick-line tools, which result in a very inefficient process and uneconomical operations. These processes require time to rebuild tubing pressure between stages, which may be costly, both in terms of time and in terms of nitrogen, or other testing fluids.

[0004] Conventional shut-in valves use pressure build-up from the well and are run in the well as part of a completion string. A battery-controlled timer typically actuates conventional shut-in valves. Waiting on the timer, when conditions are adequate for an accurate test, may consume valuable (rig) time, because the battery-controlled timer actuates the conventional shut-in valve at a preset interval. The timer functioning out of sequence with the job parameters can result in aborting a test. Likewise, batteries must be replaced routinely to avoid critical failure due to battery. Further, current tools do not have an instantaneous shut-in capability, resulting in inaccurate measurements during the time when the conventional shut-in valve is neither fully open nor fully closed.

**SUMMARY**

[0005] The present invention relates to shut-in valves, and more particularly, to surface controlled downhole shut-in valves.

[0006] In some embodiments, a tool assembly may comprise a downhole shut-in valve configured to selectively permit flow from a conduit to a target zone of a wellbore, a packer configured to isolate the target zone of the wellbore, and one or more ports between the conduit and the target zone. The downhole shut-in valve may be configured to close in about 5 seconds or less.

[0007] In some embodiments, a method of testing a target zone of a well may comprise lowering a tool assembly comprising one or more packers, conduit, and a downhole shut-in valve to the target zone, setting the packers so as to isolate the target zone, allowing fluid to pass from within the conduit into the isolated target zone, closing the downhole shut-in valve, and monitoring pressure in the isolated target zone. Monitoring pressure in the isolated target zone may be performed after closing the downhole shut-in valve.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0008] FIG. 1 is a side view of a conventional shut-in valve in an open position.

[0009] FIG. 2 is a side view of the conventional shut-in valve of FIG. 1, in a closed position.

[0010] FIG. 3 is a cross-sectional view of a tool assembly in accordance with one embodiment of the present invention.

[0011] FIG. 4 is a cross-sectional view of a portion of the tool assembly of FIG. 3, illustrating a downhole shut-in valve in detail, in accordance with one embodiment of the present invention.

[0012] FIG. 5 is a side view of a tool assembly having shut-in valve in an open position, in accordance with one embodiment of the present invention.

[0013] FIG. 6 is a side view of the tool assembly having a shut-in valve of FIG. 4, in a closed position, in accordance with one embodiment of the present invention.

[0014] FIG. 7 is a side view of the tool assembly of FIGS. 5 and 6, having a shut-in valve in a closed position, with packers unset, in accordance with one embodiment of the present invention.

**DETAILED DESCRIPTION**

[0015] Referring now to the drawings and more particularly to FIG. 1, conventional shut-in valve 10 may be lowered into wellbore 12 at end of completion string 14 until shut-in valve 10 is proximate target zone 16 of the well. As illustrated in FIG. 1, conventional shut-in valve 10 may be open, such that flow 18 into conventional shut-in valve 10 is unobstructed. Thus, when conventional shut-in valve 10 is open, fluid may flow from target zone 16 into conventional shut-in valve 10 and up through completion string 14.

[0016] Referring now to FIG. 2, packer 20 may be set above conventional shut-in valve 10. A battery timer (not shown) set to actuate conventional shut-in valve 10 at a preset interval may cause conventional shut-in valve 10 to cycle to a closed position (indicated by dotted line), such that flow 18 into conventional shut-in valve 10 is blocked. Once conventional shut-in valve 10 closes, over time, formation 112 provides pressure in lower portion 22 of the well that is higher than pressure within completion string 14. After a preset interval, the battery timer actuates conventional shut-in valve 10 to move to an open position again. The pressure differential between lower portion 22 of the well and completion string 14 will result in fluid moving from formation 112 into lower portion 22 of the well, through conventional shut-in valve 10, and into completion string 14. During this process, a pressure-reading device (not shown) takes measurements. Once measurements have been taken, the pressure within completion string 14 may be bled off, so further tests may be conducted, or equipment removed from the wellbore.

[0017] Referring now to FIG. 3, tool assembly 102 may test multiple zones for a variety of purposes. Tool assembly 102 may be useful for any of a number of diagnostic pumping tests, including multiple-interval completions to assess asset performance, determine primary fracture effectiveness and evaluate targets for re-frac operations, evaluate perforated sections of wells that have been stimulated with or without limited entry, older wells that had large gross intervals stimulated, or any other operation where it may be desirable to test the pressure fall-off data to determine reservoir pressure, effective fracture length, fracture conductivity, near-wellbore choke effect, or other parameters. Tool assembly 102 may be a thru tubing downhole service tool and may include carrier 114, downhole shut-in valve 100, packers 106 and 108, one or more ports 110, spacer section 116, disconnect 118, and/or data acquisition module 120 connected to tubing 104 at cable

head assembly with flow bypass **124**. Cable head assembly with flow bypass **124** provides power and/or control to downhole shut-in valve **100** and/or data acquisition module **120**, and provides a flow bypass open between the tubing and a lower assembly in one embodiment of the present invention, and furthermore can transmit gathered data to surface.

[0018] Tubing **104** is the means by which equipment is deployed in the wellbore. Furthermore, it will provide the conduit through which fluid or gas may be pumped or produced in order to test. For example, tubing **104** may be coiled tubing, jointed pipe, or other tubular members, or any combination thereof.

[0019] Packers **106** and **108** may be a straddle-packer or other isolation device or devices configured to provide a seal to isolate target zone **16** from remainder of the annulus. In some embodiments, packer **106** may be connected to a lower end of carrier **114** and an upper end of spacer section **116**, and packer **108** may be connected to a lower end of ports **110**. These packers may be configured with a fixed or variable straddle length.

[0020] Slips **122** engage the wellbore and allow packer **108** to set. This may be done hydraulically, mechanically, electronically, or with a combination of methods.

[0021] Ports **110** may be on a ported sub, as illustrated in FIG. 5. Ports **110** may be slits or openings allowing selective fluidic or gas communication between tubing **104** and target zone **16**. If configured with a flexible straddle, ports **110** may be replaced by a running/retrieving head through which flow may pass.

[0022] Spacer section **116** may be fixed or variable. The length of spacer section **116** may be changed to accommodate the length of target interval **16** or to accommodate multiple or all zones of interest in the well.

[0023] Disconnect **118** may be useful in configurations using coiled tubing as tubing **104**. Disconnect **118** is purely a precautionary device, which may be used to disconnect tubing **104** from the bottomhole assembly, if necessary. Disconnect **118** may be actuated hydraulically, via ball-drop sleeve, or any other method.

[0024] Data acquisition module **120** may include pressure measuring device(s), temperature measuring device(s), gamma, Casing Collar Locator (CCL), acoustic telemetry, or any other device useful in acquiring testing information. This data may be stored in memory or transmitted to surface electronically, acoustically, by a combination, or by any other means.

[0025] Carrier **114** may be a carrier sub, as illustrated in FIG. 3. Referring now to FIG. 4, carrier **114** may include downhole shut-in valve **100** and one or more pressure gauges **126**, or other data acquisition components. In some embodiments, carrier **114** may be formed with cable head assembly with flow bypass **124**. In other embodiments, carrier **114** may be connected to a lower end of cable head assembly with flow bypass **124**. A special downhole shut-in valve gauge carrier may be used to allow flow to enter target zone **16** while preventing flow from tubing **104** to target zone **16** during fall-off testing.

[0026] Downhole shut-in valve **100** may be inside carrier **114** and may include outer body **128** disposed about inner sleeve **130**. Inner sleeve **130** may be disposed about sleeve activator **132**, which may be disposed about sleeve activator arm **134**.

[0027] Referring now to FIG. 5, tool assembly **102** may be picked up and run through tubing (e.g., tubing **104**), jointed

pipe, casing, liner, or other wellbore configuration or conduit. As tool assembly **102** is run into the well, downhole shut-in valve **100** may be in an open position, such that flow is free to pass through tubing **104**, through inner sleeve **130** of downhole shut-in valve **100** and on to lower bottom hole assembly, indicated at "A" in FIG. 4. Tool assembly **102** may be lowered to target zone **16** of the well, which may correspond to a position proximate an open set of perforations, a natural fracture, or any other zone of interest or target zone **16**. Once tool assembly **102** reaches target zone **16**, packers **106**, **108** may be set to isolate target zone **16** of the well, such that ports **110** lie within target zone **16**. In one embodiment, packer **108** may be set by picking up tubing **104** and lowering tubing **104** to cause slips **122** to engage wellbore **12** and packer **108** to set. Pressure or set weight may then be applied to tubing **104** to set packer **106**, which will then trap pressure in target zone **16** and keep packers **106** and **108** set. Other methods of setting packers **106** and **108** may be used, depending on the particular conditions and circumstances in which tool assembly **102** is used. Alternatively, if packer **108** is omitted, target zone **16** may simply extend downward to the bottom of the wellbore.

[0028] Once packers **106** and **108** have been expanded across target zone **16**, a desired fluid and/or gas volume may be pumped to target zone **16**. Alternatively, in the event downhole shut-in valve **100** is run into the well in a closed position, once target zone **16** is isolated, downhole shut-in valve **100** may be opened as described below, allowing nitrogen, water, acid, brine, oil, or any other test fluid or gas useful for well applications, to pass from within tubing **104** into isolated target zone **16** of the well.

[0029] This configuration may use DFIT, RFIT, or NFIT analyses. In some applications, a short but high rate stream of test fluid may be pumped into tubing **104** near the surface and move through open downhole shut-in valve **100** and into the well above frac gradient and at a constant rate. The injection of test fluid may continue for some period after observation of fracturing pressure. The amount of test fluid injected into target zone **16** may be pre-determined by the formation characteristics taken from logs or any other previous data.

[0030] Referring now to FIG. 6, once sufficient test fluid has been injected into target zone **16**, downhole shut-in valve **100** may be closed on demand, or at will, causing the well to be shut-in, eliminating wellbore storage effect.

[0031] The instantaneous closure of downhole shut-in valve **100** may be triggered by a signal from the surface transmitted via cable bypass **136**, such as e-line, electric line inside coiled tubing or other tubing string, acoustically via a telemetry signal, wireless data transmission, a combination of methods, or by any other method used to transmit signals from the surface to a downhole tool. Tool assembly **102** may use the test fluid driving force to instantaneously close downhole shut-in valve **100**, shut-in the well, and isolate target zone **16** from the pressure in tubing **104**. In some embodiments, the instantaneous closure of downhole shut-in valve **100** may occur in about 5 seconds or less, in about 3 seconds or less, in about one second or less, or in a range of approximately 1 to 5 seconds, 1 to 3 seconds, or 3 to 5 seconds.

[0032] Upon signal from cable bypass **136**, acoustic telemetry, or any other method, a valve control may release sleeve activator arm **134** and flow pressure from tubing **104** may rapidly force sleeve activator **132** downward. The force from sleeve activator **132** may instantly slam inner sleeve **130** to a downward position, closing downhole shut-in valve. Thus, flow from tubing **104** may be blocked from entering carrier

**114** to communicate with target zone **16** straddled by packers **106** and **108**. Tubing **104** may not lose fluid and/or gas pressure during testing (e.g., NFIT, DFIT, RNFIT).

[0033] Instantaneously closing downhole shut-in valve **100** allows for testing to begin on a known volume and pressure with a known start time. Thus, changes in pressure, temperature, or other variables may be attributed to conditions within target zone **16**, and not to conditions of test fluid within tubing **104** that may “leak” through downhole shut-in valve **100** during the time it takes for a slow acting valve to close.

[0034] Once downhole shut-in valve **100** is closed, pumping of test fluid into tubing **104** may continue for a short period to provide a positive indication that downhole shut-in valve **100** is, in fact, closed. Pumping of test fluid into tubing **104** may then cease, and pressure in tubing **104** may be maintained. Pressure trapped in target zone **16** between packers **106** and **108** may be allowed to fall-off or bleed off into formation **112**. Thus, pressure loss may be prevented inside tubing **104** while monitoring changes in target zone **16** of the well. As pressure bleeds off into formation **112**, pressure and temperature monitoring may be performed. Pressure monitoring; for example, may be done by taking measurements with a pressure-reading device such as pressure gauge **126**, every second, over a period of time and recording fall-off pressure data. Temperature, and other monitoring may be done in a similar fashion, and corresponding signals may be sent to the surface via e-line, electric line inside a coiled tubing or other tubing string, acoustically via telemetry signal, wireless data transmission, a combination of methods, or by any other method used to transmit signals from a downhole tool to the surface for analysis either in real time on location and/or offsite. In some instances, this may be done through real-time telemetry. In other instances, the reading device(s) may include memory gauges for later retrieval and or quality verification.

[0035] Referring now to FIG. 7, once all desired monitoring, evaluation, and/or testing is complete in target zone **16**, a signal may be sent to open downhole shut-in valve **100**, retract sleeve activator **132**, and pull inner sleeve **130** to an open position. Thus, downhole shut-in valve **100** may be in an open position and reset for the next interval or target zone **16**. Flow may again be free to pass through tubing **104** to lower bottom hole assembly at “A.” Packers **106**, **108** may be disengaged as pressure is equalized between tubing **104** and the annulus. Tool assembly **102** may be moved to the next target zone **16** and the procedure may be repeated as necessary. Depending on the conditions, it may be desirable to equalize pressure between target zone **16** and other portions of the well prior to unsetting packers **106** and **108**. However, as tool assembly **102** is moved, downhole shut-in valve **100** may remain closed, retaining pressure within tubing **104** for testing in subsequent target zones. In this manner, downhole shut-in valve **100** may allow for equalizing pressure, so that packers **106**, **108** can be unset and tool assembly **102** can move to subsequent target zones, while maintaining pressure in tubing **104**, reducing the amount of wasted time and test fluid needed to rebuild tubing pressure for the next fall-off test. Thus, fluid may be retained in tubing **104**, and downhole shut-in valve **100** may act as a fluid control valve. Once a subsequent target zone is reached, the process may be repeated. Note, the process for opening (and for subsequently opening and closing) downhole shut-in valve **100** may be similar to the process for closing downhole shut-in valve **100** described above, or the process may be another process for

opening or closing valves, as will be appreciated by those having ordinary skill in the art. After testing is complete, depending on testing results, additional stimulation and/or other completion operations may be performed.

[0036] The methods and apparatus of this disclosure may allow for more accurate pressure fall-off tests, based on higher data quality. Additionally, the ability to instantaneously shut-in (or close) downhole shut-in valve **100** may prevent the need to bleed off tubing pressure between testing of target zone **16** and subsequent target zones, increasing efficiency. Savings may result by eliminating the need to bleed off tubing pressure between zones. Additional savings may be realized by maintaining tubing pressure, and thus reducing any need to rebuild pressure with additional nitrogen, or other testing fluid. Further, pressure may be equalized as needed, resulting in greater control of the process.

[0037] Therefore, the present invention is well adapted to attain the ends and advantages mentioned as well as those that are inherent therein. The particular embodiments disclosed above are illustrative only, as the present invention may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular illustrative embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the present invention. Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee.

What is claimed is:

1. A tool assembly, comprising:
  - a downhole shut-in valve configured to selectively permit flow from a conduit to a target zone of a wellbore;
  - a packer configured to isolate the target zone of the wellbore; and
  - one or more ports between the conduit and the target zone; wherein the downhole shut-in valve is configured to close in about 5 seconds or less.
2. The tool assembly of claim 1, wherein the downhole shut-in valve is configured to close in about one second or less.
3. The tool assembly of claim 1, wherein the downhole shut-in valve comprises an outer body, an inner sleeve, a sleeve activator, and a sleeve activator arm.
4. The tool assembly of claim 1, comprising a pressure gauge.
5. The tool assembly of claim 1, comprising a spacer section.
6. The tool assembly of claim 1, comprising a second packer.
7. A method of testing a target zone of a well, comprising:
  - lowering a tool assembly comprising one or more packers, conduit, and a downhole shut-in valve to the target zone;
  - setting the packers so as to isolate the target zone;
  - allowing fluid to pass from within the conduit into the isolated target zone;
  - closing the downhole shut-in valve; and
  - monitoring pressure in the isolated target zone; wherein monitoring pressure in the isolated target zone is performed after closing the downhole shut-in valve.
8. The method of testing of claim 7, wherein allowing fluid to pass from within the conduit into the isolated target zone comprises opening the downhole shut-in valve.

**9.** The method of testing of claim **8**, wherein opening the downhole shut-in valve is performed prior to closing the downhole shut-in valve.

**10.** The method of testing of claim **7**, wherein the conduit is coiled tubing and wherein lowering the tool assembly comprises running the tool assembly on the coiled tubing.

**11.** The method of testing of claim **7**, wherein closing the downhole shut-in valve comprises transmitting a signal from the surface to the downhole shut-in valve.

**12.** The method of testing of claim **11**, wherein the signal causes the downhole shut-in valve to close instantaneously.

**13.** The method of testing of claim **7**, wherein monitoring pressure in the isolated target zone comprises taking multiple

measurements within the isolated target zone and sending the measurements to the surface for analysis.

**14.** The method of testing of claim **13**, comprising taking measurements every second over a period of time.

**15.** The method of testing of claim **7**, wherein the downhole shut-in valve retains fluid in the conduit, thereby acting as a fluid control valve.

**16.** The method of testing of claim **7**, wherein the downhole shut-in valve is opened and/or closed at will.

**17.** The method of testing of claim **16**, wherein opening and/or closing the downhole shut-in valve comprises transmitting a signal from the surface to the downhole shut-in valve.

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