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(54) ONE TRIP COMPLETION METHOD AND ASSEMBLY

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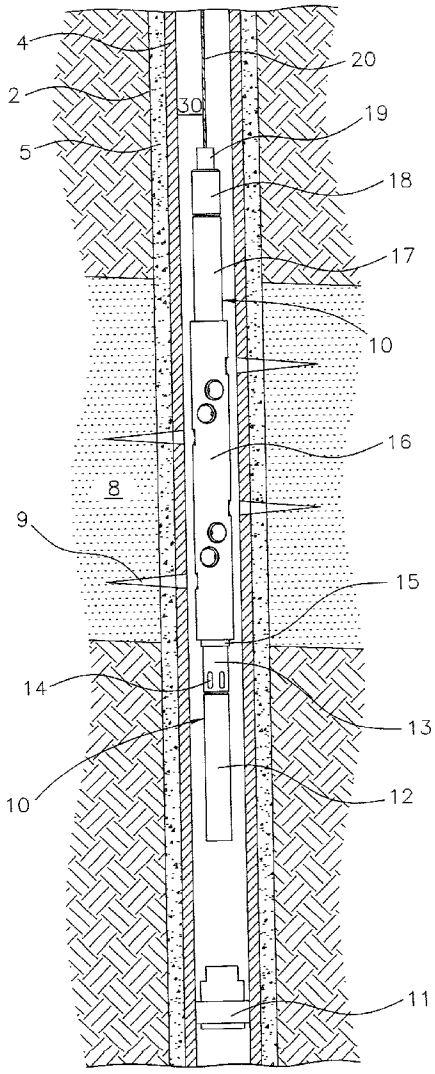
(57) **ABSTRACT**

A method and assembly for accurately positioning and safely deploying a packer and at least one tool, such as a perforating gun(s), in a subterranean well during a one-trip completion operation. The assembly comprises an expandable packer, a location device(s), such as a gamma ray probe and/or a collar locator, and at least one tool, such as a perforating gun and/or formation logging tool. The assembly is lowered into a subterranean well on electric line and the packer is accurately positioned in the well by means of the location device(s), and thereafter, is expanded. The remaining assembly is automatically released from the expanded packer and accurately repositioned to a new location within the tubular by means of the electric line and location device(s). The tool is then activated to perform the desired operation, and thereafter, the assembly is removed from the well.



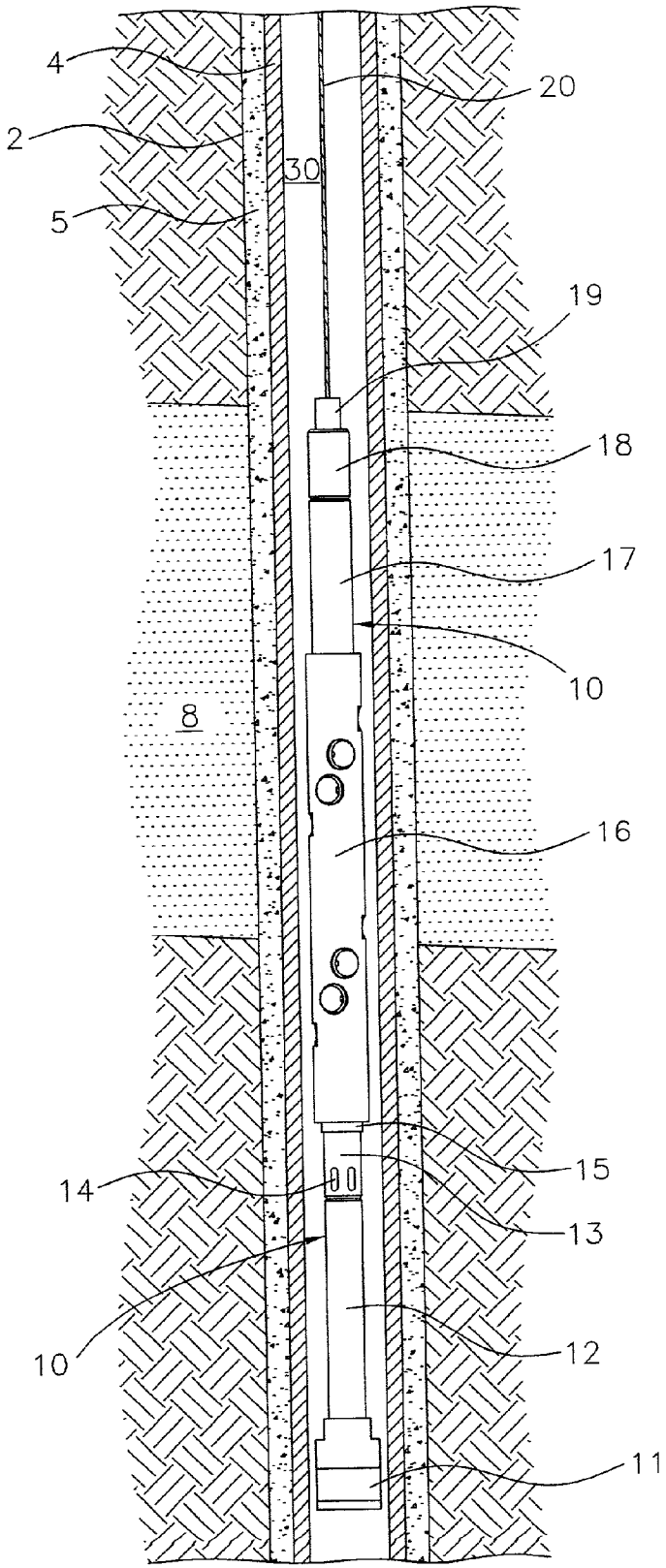


FIGURE 1

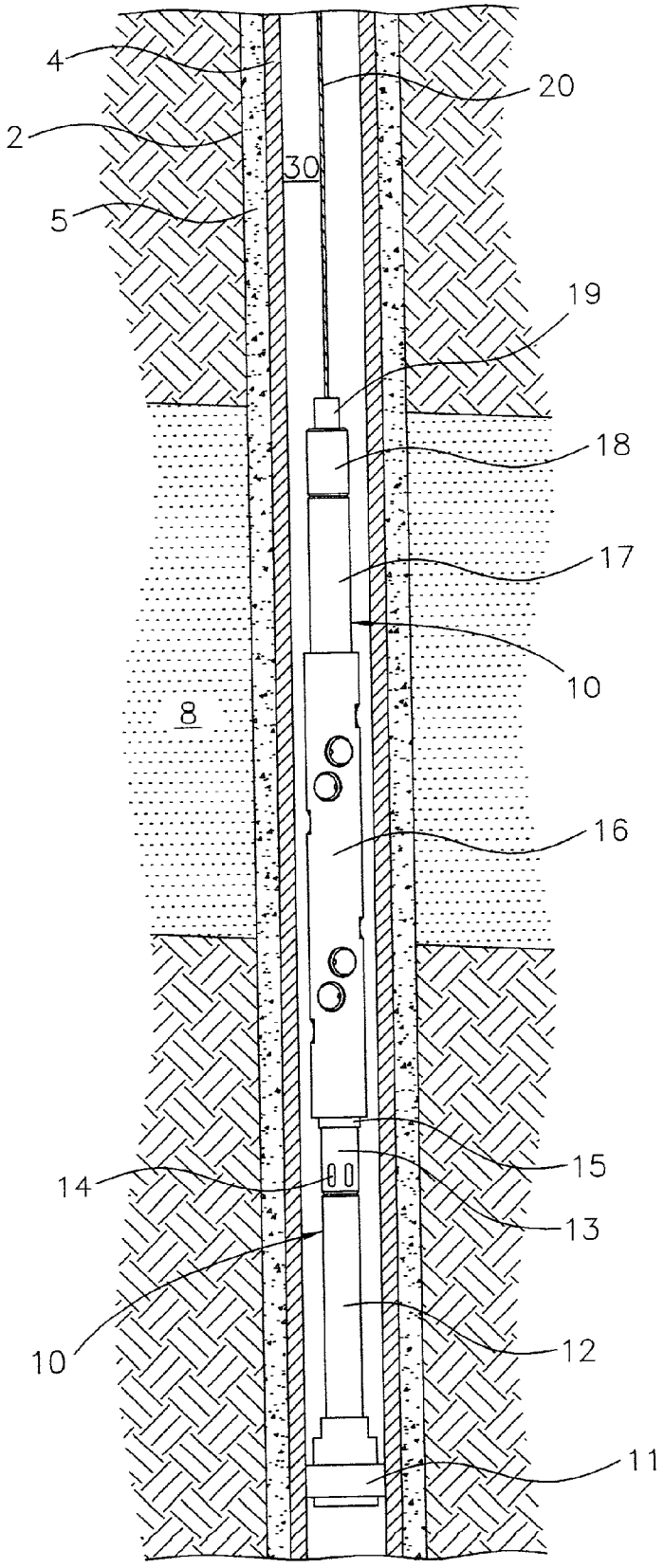


FIGURE 2

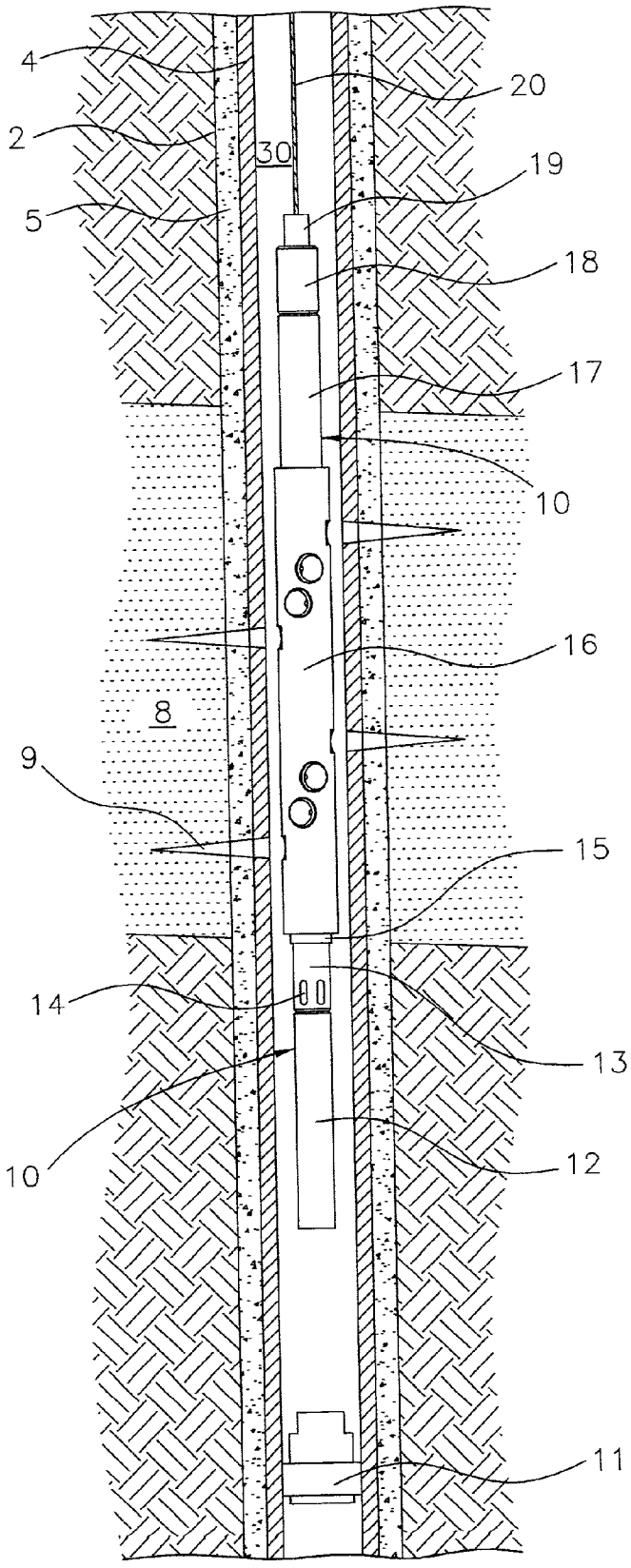


FIGURE 3

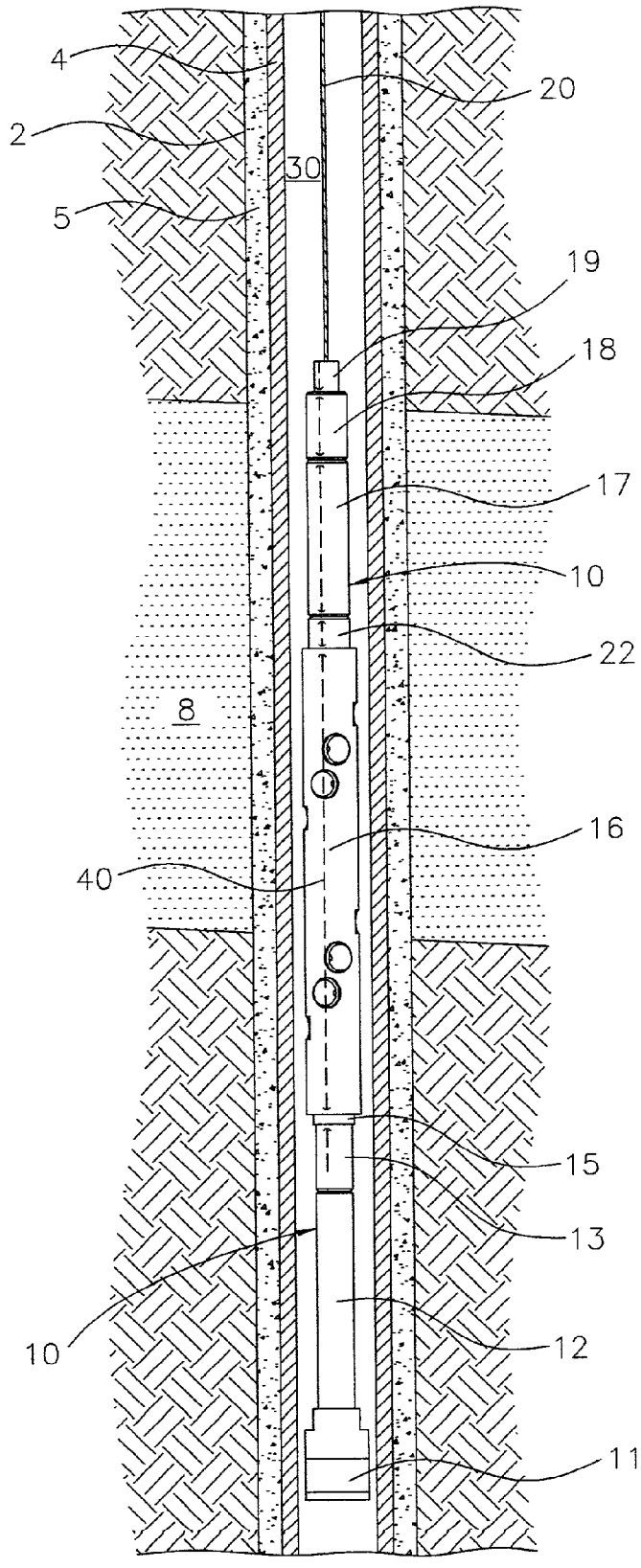


FIGURE 4

ONE TRIP COMPLETION METHOD AND ASSEMBLY

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates generally to a method and assembly for positioning and setting a packer or bridge plug in a subterranean well and positioning and detonating at least one perforating gun and/or other tool in the well during a single trip, and more particularly, to such a method and assembly wherein the packer or plug and at least one perforating gun and/or other tool are accurately positioned and safely deployed on electric line during such single trip into the well.

[0003] 2. Description of Related Art

[0004] Conventionally, packers and bridge plugs have been run into a subterranean well on electric wireline to rapidly place and deploy such apparatus in the well. After setting the packer or bridge plug in a well, the electric wireline is removed and a separate trip is made into the well to convey one or more perforating guns on either electric line or tubing. The explosive charges that are contained in the perforating gun are then detonated thereby perforating casing, that is positioned and cemented in the well bore, and the adjacent subterranean formation. In this manner, the well is completed by providing fluid communication between the interior of the well and the subterranean formation of interest. However, the multiple trips associated with such conventional techniques for placing and deploying packers and perforating guns in a well are time consuming and expensive.

[0005] U.S. Pat. Nos. 5,611,401 and 6,142,231 describe a one-trip system for running a packer and a perforating gun into a well. A perforating gun and packer are lowered into the well on coiled or rigid tubing and a setting tool that is connected to and supports the packer is actuated by a pressure pulse or an acoustic signal to set the packer. The setting tool is constructed to automatically release from the packer upon actuation and is retrieved therefrom by manipulation of the coiled or rigid tubing. The perforating gun is then positioned in the well and fired to complete the perforating procedure. The gun and setting tool are then removed from the well. Several disadvantages exist to the one-trip procedure described in these patents. In order to accurately position tools or devices in a subterranean well, it is necessary to run a gamma ray logging tool or a tubular collar locator probe on electric line. In order to accurately locate the packer and perforating gun of U.S. Pat. Nos. 5,611,401 and 6,142,231, it would be necessary to lower such logging tool(s) and/or probes on electric line through the rigid or coiled tubing to a point near the packer or perforating gun. This additional procedure adds unnecessary expense to the operation and is time consuming. In addition, it may be desired to run other apparatus, such as pressure and/or temperature gauges, in the well during the completion operation that would not be possible without the use of additional wireline equipment at the well head. Further, certain of the methods disclosed in U.S. Pat. Nos. 5,611,401 and 6,142,231 use different pressures to rupture disks in the setting tool in order to set the packer and by necessity utilize an impact type detonator for the perforating gun which requires dropping a rod from the well head through the rigid or coiled tubing so as to detonate the perforating gun. In these instances, an operator cannot determine with certainty if the packer has set or if the gun has detonated thereby creating safety problems when removing the apparatus from the well.

[0006] Thus, a need exists for methods and assemblies for accurately positioning and safely deploying a packer and perforating gun(s) in a subterranean well during a one-trip completion operation. A further need exists for positioning and operating other equipment such as logging probes and/or pressure and/or temperature gauges during a one-trip completion operation.

SUMMARY OF THE INVENTION

[0007] To achieve the foregoing and other objects, and in accordance with the purposes of the present invention, as embodied and broadly described herein, one characterization of the present invention may comprise a one-trip well completion method comprising transporting an assembly comprising at least one location device, at least one tool and a packer on an electric line in a tubular. The packer is accurately positioned at a first location in the tubular and expanded into sealing engagement with the tubular. The at least one tool is released from the expanded packer and accurately positioned at a second location in the tubular.

[0008] In another characterization of the present invention, a one-trip well completion method comprises transporting an assembly having at least one location device, at least one tool and a packer on an electric line in a tubular that is positioned in a subterranean well bore. The packer is accurately positioned at a first location in the tubular and expanded into sealing engagement with the tubular. Thereafter, the at least one tool is released from the expanded packer and accurately positioned at a second location in the tubular.

[0009] In yet another characterization of the present invention, an assembly is provided for insertion into subterranean well during a one-trip completion method on an electric line. The assembly comprises at least one location or measurement probe adapted to be connected to the electric line, a packer assembly, and a perforating gun that is connected at one end thereof to the at least one location or measurement probe and at the other end thereof to the packer assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The accompanying drawings, which are incorporated in and form a part of the specification, illustrate the embodiments of the present invention and, together with the description, serve to explain the principles of the invention.

[0011] In the drawings:

[0012] **FIG. 1** is a partially sectioned, perspective view of one embodiment of the method and assembly of the present invention as positioned in a subterranean well;

[0013] **FIG. 2** is a partially sectioned, perspective view of the embodiment of **FIG. 1** wherein the packer that is utilized in the assembly of the present invention is set;

[0014] **FIG. 3** is a partially sectioned, perspective view of the embodiment of **FIG. 1** wherein the packer is set and the remaining assembly of the present invention is repositioned within the subterranean well for further operation; and

[0015] **FIG. 4** is a partially sectioned, perspective view of another embodiment of the method and assembly of the present invention as positioned in a subterranean well.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] Referring to **FIG. 1, a** subterranean well **2** is illustrated as penetrating at least one subterranean zone or formation of interest **8** and extends to the surface of the earth or to another well (not illustrated). Preferably, a string of tubulars **4**, such as casing or tubing, is positioned in well **2** in a manner as will be readily apparent to a skilled artisan so as to provide a flow path for fluids to the surface of the earth and/or another well. Where the tubular string is casing, it is preferably secured in well **2** by means of cement **5**. The assembly of the present invention is illustrated generally as **10** and comprises a packer **11**, hydraulic setting tool **12**, a pressure activated firing head **13**, an adapter and spacer/shock sub **15**, a perforating gun **16**, a gamma ray probe **17**, a collar locator probe **18** and a monocable or multicable head **19**. These components are readily secured together as will be evident to a skilled artisan, e.g. by mating screw threads. The dimensions of the components employed may vary depending upon the size of the tubular string **4** into which the assembly will be positioned and the exact operation to be performed. Packer **11** may be any commercially available hydraulic packer, for example a hydraulic packer available from Baker Oil Tools, Inc. of Houston, Tex. under the trade name designation Model D. Any suitable hydraulic setting tool, such as the model 5, 10 or 15 hydraulic setting tools that are commercially available from Baker Oil Tools, Houston, Tex., may be used in the assembly and method of the present invention. Examples of other components suitable for use in the assembly and method of the present invention are a pressure activated firing head commercially available from Owen Oil Tools, Inc. of Fort Worth, Tex., a spacer and shock sub commercially available from Bowen Tools, Inc. of Houston, Tex., a perforating gun commercially available from Owen Oil Tools, Inc. of Fort Worth, Tex., a gamma ray probe commercially available from Applied Electronic Systems of Lafayette, La., a collar locator probe commercially available from Applied Electronic Systems of Lafayette, La. and a monocable or multicable head commercially available from Applied Electronic Systems of Lafayette, La.

[0017] As sequentially connected together in accordance with the present invention, the assembly **10** is lowered into tubular **4** from the surface of the earth on a monoconductor or multiconductor electric cable **20** which is secured to cable head **19**. The assembly **10** is lowered to the position at which packer **11** is to be set. The exact location of the assembly in tubular **4** is correlated by means of the gamma ray locator probe **17** and/or the collar locator probe **18** to ensure accurate placement of packer **11**. Tubular **4** is then substantially filled with fluid **30**, such as brine, if such fluid is not already present in the tubular. Sufficient pressure, e.g. 500 psi, is applied to fluid **30** by means of, for example, pump(s). This pressure enters ports **14** in firing head **13** thereby initiating a reaction within the firing head which reacts with a conventional explosive charge. These hydraulic and explosive pressures are communicated to the setting tool **12** thereby initiating a packer setting mechanism as will be readily evident and understood by a skilled artisan. Such mechanism causes the elastomeric element in the packer **11** to expand into contact with the tubular **4** so as to seal the annulus defined between the packer **11** and tubular **4** to fluid flow. Upon setting of the packer, the setting tool **12** is designed to automatically disconnect from the packer.

[0018] Once the packer is accurately positioned within the tubular **4** and sealingly engaged with tubular **4**, the remaining assembly, i.e. hydraulic setting tool **12**, pressure activated firing head **13**, adapter and spacer/shock sub **15**, perforating gun **16**, gamma ray probe **17**, collar locator probe **18** and monocable or multicable head **19**, is lifted by means of electric cable **20**. The remaining assembly **20** is then accurately positioned to perform the next operation. In the embodiment illustrated in **FIG. 1**, the perforating gun **16** is accurately positioned adjacent the subterranean formation and/or zone **8** of interest (**FIG. 2**) by means of the gamma ray probe **17** and/or collar locator probe **18**. In this manner, the method of the present invention ensures that the succeeding operation is precisely carried out at the required position within tubular **4**. In the embodiment illustrated in **FIG. 1**, electrical current is supplied via electric cable **20** to perforating gun **16** so as to detonate one or more shaped charges that are contained with the gun thereby creating perforations **9** through tubular **4**, cement **5** and into formation **8** (**FIG. 3**). Once this operation is complete, the assembly is withdrawn from tubular **4** and the operation of the assembly of the present invention is complete. The well **2** may then be produced or subject to further operations in accordance with oil field practice.

[0019] Although the perforating gun is illustrated as having explosive charges uniformly spaced along the length of the gun, it is within the scope of the present invention that these charges may be located at different positions along the length of the gun so as to penetrate different portions of formation or zone **8**. It is also within the scope of the present invention that more than one perforating gun **16** may be employed to perforate the same or different subterranean formations and/or zones. Further, the explosive charges contained within the perforating gun(s) **16** utilized in the present invention may have configurations other than spiral, such as linear or random patterns.

[0020] As illustrated in **FIG. 4**, an alternative embodiment of the assembly of the present invention comprises the same sequence of component parts as that illustrated in **FIG. 1** except that a voltage polarity sensitive switch **22** is positioned between and secured to the gamma ray measuring probe **18** and the perforating gun **16**. The voltage polarity sensitive switch **22** is also constructed to switch polarity upon some preset threshold amount of voltage being applied to the switch. Also, the firing head **13** is an electrically activated device, such as is commercially available from Baker Oil Tools, instead of the hydraulically activated device used in the embodiment of **FIG. 1**. An electric current capable wire **40** is installed in a straight through configuration so as to allow an electrical impulse to travel from the electric line **20** through each of the component parts to the electrically activated firing head **13**. The operation of the assembly of the present invention illustrated in **FIG. 4** is as described above with respect to the embodiment of **FIG. 1** with the following differences. With electrical current being applied in an amount less than the threshold of polarity switch **22**, current is supplied via line **20** and wire **40** to gamma ray measuring probe **17** and/or collar locator probe **18** and the packer **11** is accurately positioned in tubular **4**

using probes **17** and/or **18**. The voltage of the current that is applied from the surface to assembly **10** via line **10** is then increased past the threshold amount such that switch **22** connects firing head **13** via wire **40**. The firing head is then initiated using an electrical impulse from electric line **20**. The packer **11** is then set by means of the activated setting tool **12** in a manner as described above with respect to **FIG. 1**. After the packer is set and the remaining assembly accurately repositioned by applying current to probes **17** and **18** at less than the threshold amount. The perforating gun may then be detonated by again increasing the voltage of the applied current such that switch **22** switches polarity so as to connect with the perforating gun **16**.

[**0021**] Although the assembly of the present invention is illustrated in **FIGS. 1 and 4** as containing a perforating gun **16** to perforate the well and a subterranean formation, it is within the scope of the present invention that operations in addition to or other than perforating tubulars positioned within a well may be accomplished after setting packer **11**. For example, a logging probe, such as a cement bond logging tool, a caliper probe and/or a temperature and/or pressure probe, may be incorporated into the assembly of the present invention either in lieu of or in addition to perforating gun **16**, accurately positioned by means of the gamma ray measuring probe **17** and/or collar locator probe **18** and then activated to perform the desired operation.

[**0022**] While the foregoing preferred embodiments of the invention have been described and shown, it is understood that the alternatives and modifications, such as those suggested and others, may be made thereto and fall within the scope of the invention.

We claim:

1. A one-trip well completion method comprising:

transporting an assembly comprising at least one location device, at least one tool and a packer on an electric line in a tubular;

accurately positioning said packer at a first location in said tubular;

expanding said packer into sealing engagement with said tubular at said first location;

releasing said at least one tool from said expanded packer; and

accurately positioning said at least one tool at a second location in said tubular.

2. The method of claim 1 further comprising:

activating said at least one tool at said second location.

3. The method of claim 2 wherein said at least one tool is at least one perforating gun and said step of activating comprises detonating at least one explosive charge that is contained in said at least one perforating gun thereby perforating said tubular.

4. The method of claim 1 wherein said separate steps of accurately positioning said packer and said at least one tool comprise:

activating said at least one location device to determine the exact position a portion of the assembly within said tubular.

5. The method of claim 4 wherein said at least one location device is selected from a collar locator probe, a gamma ray measuring probe or a combination thereof.

6. The method of claim 1 further comprising:

substantially filling said tubular with fluid, said step of expanding said packer into sealing engagement with said tubular being initiated by increasing the pressure of said fluid.

7. The method of claim 1 wherein said step of expanding said packer into sealing engagement with said tubular is initiated by electric impulses via said electric line.

8. A one-trip well completion method comprising:

transporting an assembly comprising at least one location device, at least one tool and

a packer on an electric line in a tubular that is positioned in a subterranean well bore;

accurately positioning said packer at a first location in said tubular;

expanding said packer into sealing engagement with said tubular at said first location;

releasing said at least one tool from said expanded packer; and

accurately positioning said at least one tool at a second location in said tubular.

9. The method of claim 8 further comprising:

activating said at least one tool at said second location.

10. The method of claim 9 wherein said at least one tool is at least one perforating gun, said second location is a subterranean zone of interest, and said step of activating comprises detonating at least one explosive charge that is contained in said at least one perforating gun thereby forming at least one perforation through said tubular and into said subterranean zone.

11. The method of claim 8 wherein said separate steps of accurately positioning said packer and said at least one tool comprise:

activating said at least one location device to determine the exact position a portion of the assembly within said tubular.

12. The method of claim 11 wherein said at least one location device is selected from a collar locator probe, a gamma ray measuring probe or a combination thereof.

13. The method of claim 8 further comprising:

substantially filling said tubular with fluid, said step of expanding said packer into sealing engagement with said tubular being initiated by increasing the pressure of said fluid.

14. The method of claim 8 wherein said step of expanding said packer into sealing engagement with said tubular is initiated by electric impulses via said electric line.

15. The method of claim 8 wherein said tubular is casing.

16. The method of claim 8 wherein said at least one tool is at least one logging formation logging tool.

17. An assembly for insertion into subterranean well during a one-trip completion method on an electric line comprising:

at least one location or measurement probe adapted to be connected to said electric line;

a packer assembly; and

a perforating gun connected at one end thereof to said at least one location or measurement probe and at the other end thereof to said packer assembly.

18. The assembly of claim 17 wherein said packer assembly comprises an expandable packer and a setting tool for expanding said packer in response to a signal.

19. The assembly of claim 18 wherein said signal is an increase in hydraulic pressure in the environment surrounding the packer assembly.

20. The assembly of claim 19 wherein said signal is an electrical impulse transmitted via said electric line.

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