



US 20160160620A1

(19) **United States**

(12) **Patent Application Publication**  
**AL-GOUHI**

(10) **Pub. No.: US 2016/0160620 A1**

(43) **Pub. Date: Jun. 9, 2016**

(54) **METHOD AND SYSTEM FOR DEPLOYING PERFORATING GUN FOR MULTIPLE SAME LOCATION RESERVOIR PENETRATIONS WITHOUT DRILLING RIG**

*E21B 17/20* (2006.01)

*E21B 43/119* (2006.01)

(52) **U.S. Cl.**

CPC ..... *E21B 43/117* (2013.01); *E21B 43/119* (2013.01); *E21B 23/03* (2013.01); *E21B 17/20* (2013.01)

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(21) Appl. No.: **14/561,053**

(22) Filed: **Dec. 4, 2014**

**Publication Classification**

(51) **Int. Cl.**

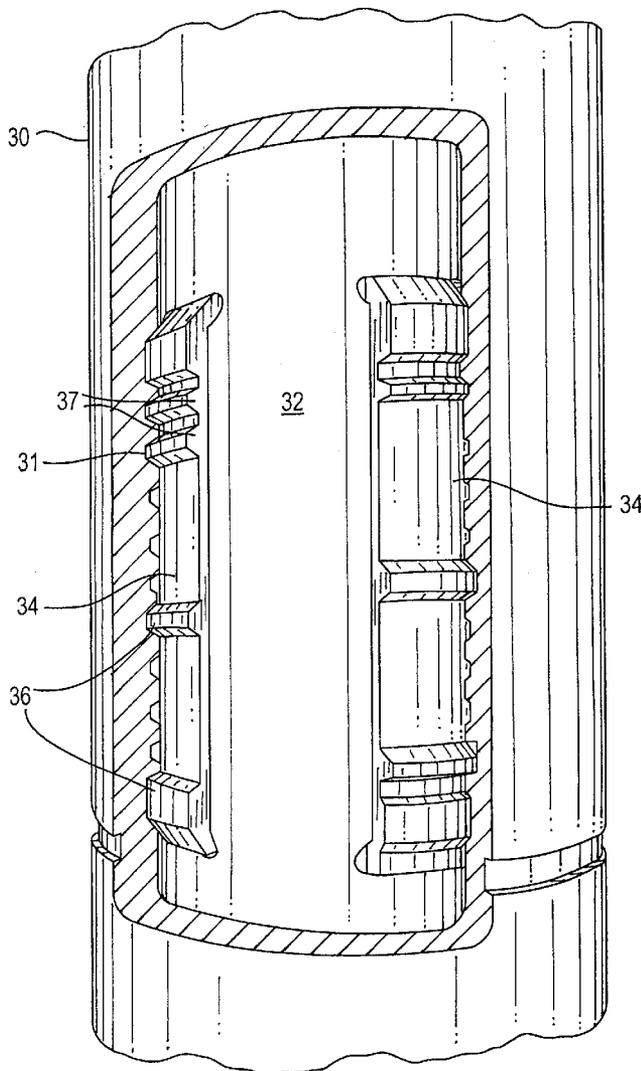
*E21B 43/117* (2006.01)

*E21B 23/03* (2006.01)

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**ABSTRACT**

Methods and apparatus are provided for conducting multiple successive same-location firings of a number of shaped charges carried by a perforating gun attached to an orienting tool that is, in turn secured to the length of coiled tubing that is lowered into the wellbore by a coiled tubing unit and precisely positioned by engagement with a fixed receiving member that is secured proximate the end of a length of producing tubing to align its charges with the penetration created by the first fired-charges in order to produce deeper and larger diameter penetrations that result in enhanced hydraulic fracturing of the reservoir and increased gas production from the completed well.



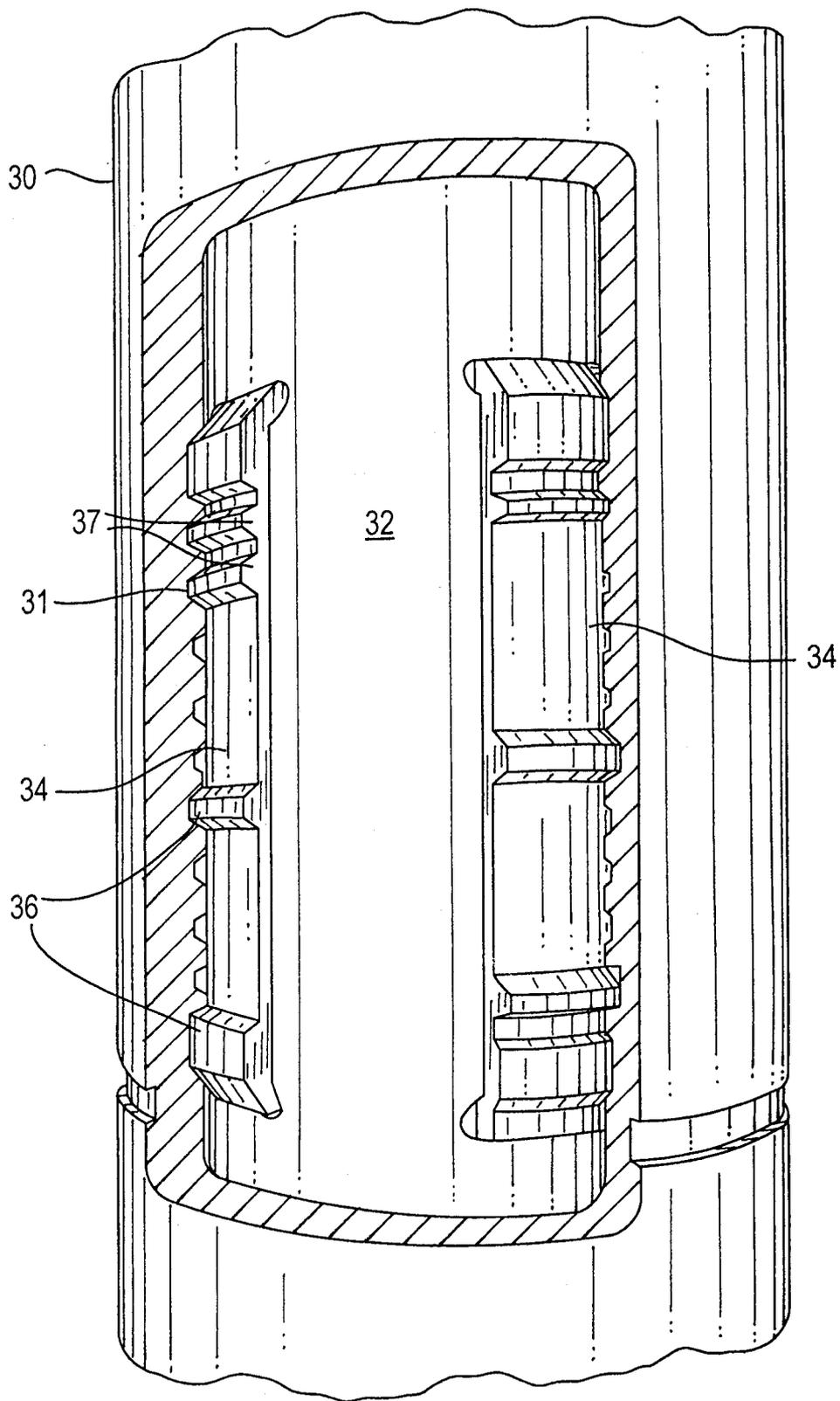
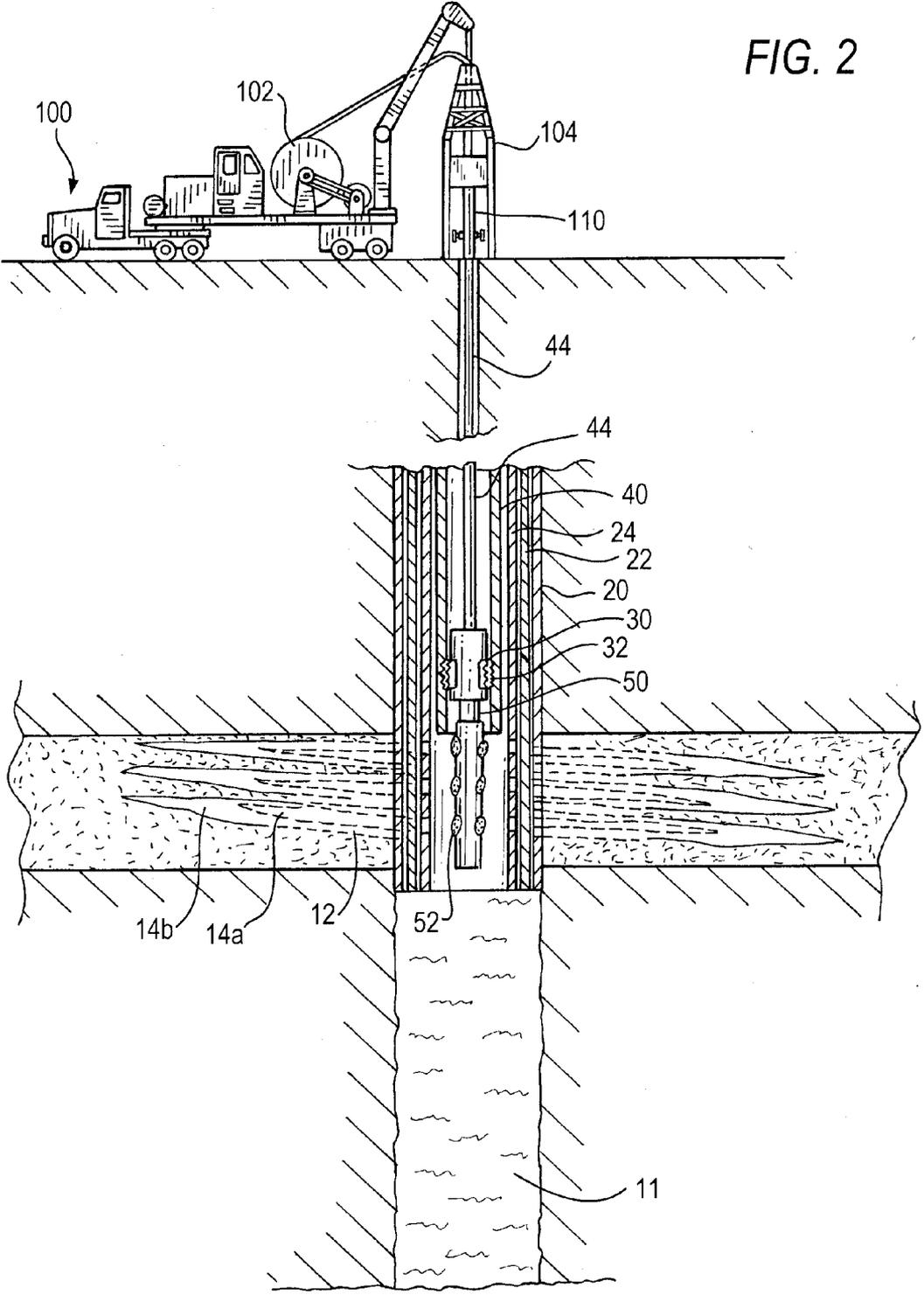


FIG. 1



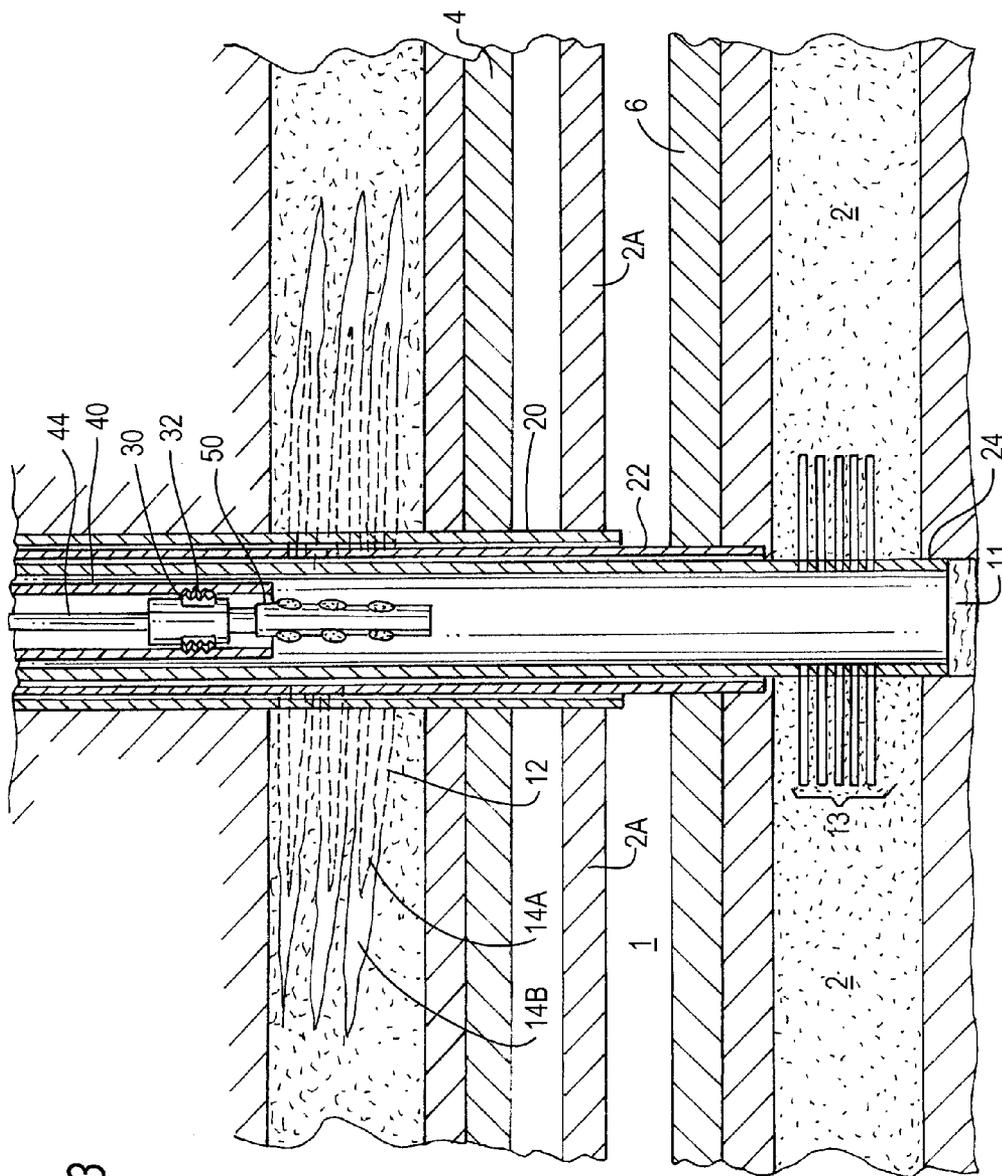


FIG. 3

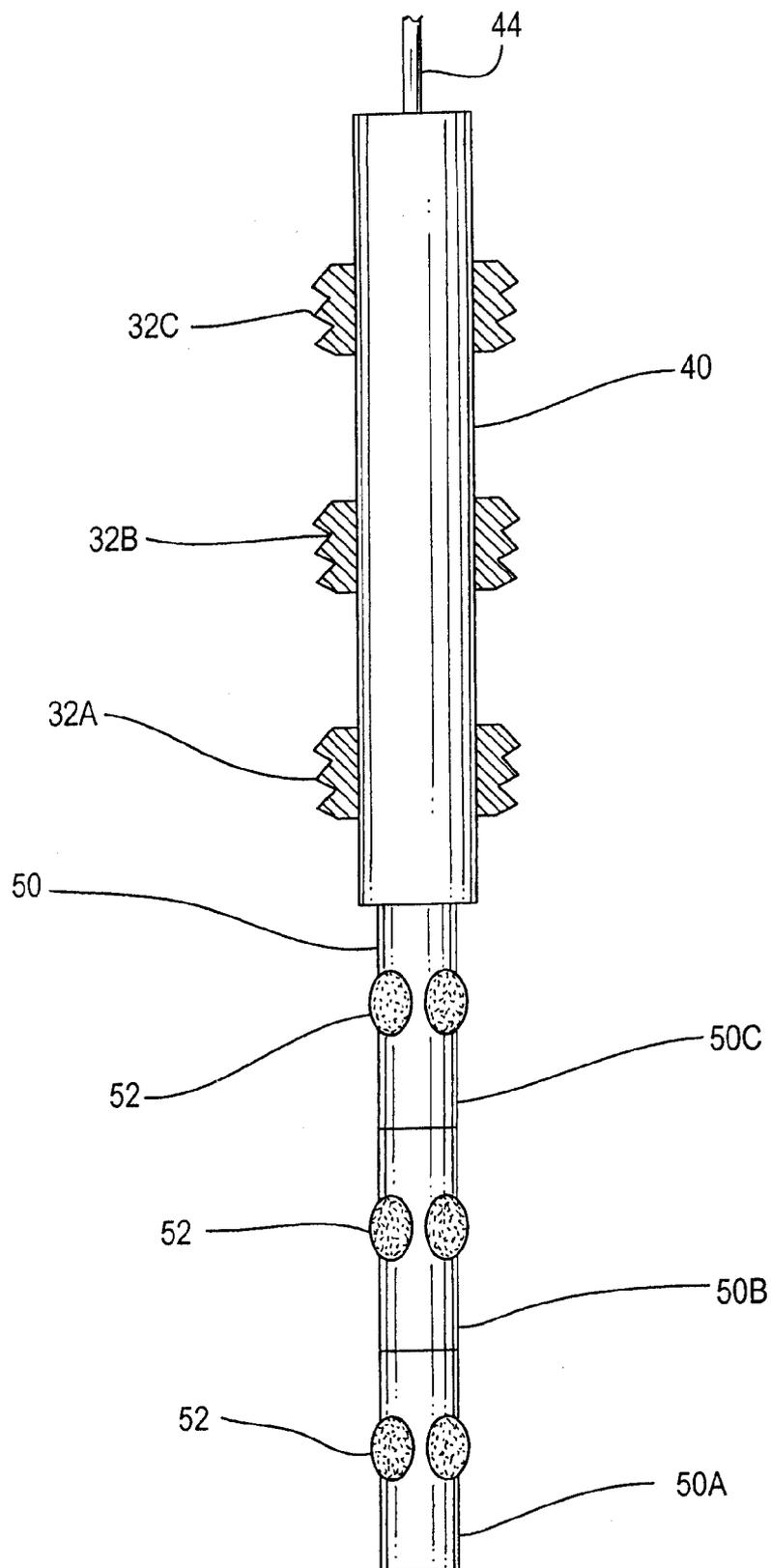


FIG. 4

**METHOD AND SYSTEM FOR DEPLOYING PERFORATING GUN FOR MULTIPLE SAME LOCATION RESERVOIR PENETRATIONS WITHOUT DRILLING RIG**

**RELATED APPLICATION**

[0001] No related applications.

**FIELD OF THE INVENTION**

[0002] This invention relates to the use of perforating guns for perforating multiple casings and the surrounding tight reservoir formations, e.g., in preparation for hydraulic fracturing of the formation in the absence of a drilling rig at the well.

**BACKGROUND OF THE INVENTION**

[0003] Tight gas formations, such as Khuff carbonate, pre-Khuff sandstone and shale gas formations with high compressive strength require hydraulic fracturing procedures in order to open the reservoir formation and enhance the flow of gas to the well bore for production. In such tight gas-containing reservoir formations, a perforating gun is used to initiate formation breakdown by detonating high-performance deep-penetrating shaped charges that maximize perforation length and entry hole size to start the hydraulic fracturing or “hydrofracking”, in order to enhance hydrocarbon production and optimize well flow. Existing methods and systems have not reliably produced deep penetrations into the surrounding formation when the region includes a completion with more than two casings and intermediate cement.

[0004] A system and method for positioning a perforating gun in wellbore completions for performing multiple same location reservoir penetrations is disclosed in published application US 2014/0020896, the disclosure of which is incorporated herein by reference. When a drilling rig is present at the well site, the apparatus of this prior art system consists principally of the gun positioned below a latching tool that is attached to the end of a length of tubing. The latching tool and gun assembly is run into the well until it engages a latch coupling secured to the end of a section of fixed well casing at a predetermined position above the interval that is to be penetrated by the sequential firing of a plurality of shaped charges contained in the gun.

[0005] In the method and system of the prior art, the latch coupling is positioned in the casing. The latching tool with the gun attached below is secured to the end of the tubing and run into the casing until the latching tool engages the latch coupling. The gun is then fired to perform the multiple same location reservoir penetrations. A rig positioned at the well is required for all operations. When the multiple penetrations have been completed, the production tubing is run to finally complete the well before the rig is released. The production tubing is usually equipped with a profile nipple for landing the pressure and temperature gauge for taking reservoir pressure and temperature measurements from time to time using a coiled tubing or a wireline device in rigless operations.

[0006] In order to improve and simplify the method for rigless operations, before the rig is released from the well site, the production tubing is equipped with a latch coupling similar to the one used in the casing in order to be able to perform the rigless operation without the need of the more complex completion described in the prior art. In order to perform the method of the prior art without a rig, i.e., a rigless operation,

a downhole motor, directional tags and a directional survey tool are required for the precise positioning of the gun for the multiple same location penetrations. This specialized assembly can then be run into and withdrawn from the profile nipple in the production tubing using a wireline or coiled tubing, neither of which require a rig. However, in order to control the gun direction after landing, it was necessary that a motor and directional control tools be operated by personnel at the surface. These additional pieces of apparatus as well as their operation and foreseeable maintenance costs also make this rigless method of the prior art relatively expensive to operate.

[0007] Use of the tubing-conveyed perforating (TCP) gun and latching tool of the prior art requires a drilling rig at the surface in operation to handle the tubing that conveys the gun to the desired depth in the well bore. Although perforating guns are available in various configurations and in each case, the key objective in the selection of the gun and the size, nature and set up of the shaped charges is to create a predetermined pattern of perforations over a predetermined well-bore interval.

[0008] The creation of deep perforations with large diameters has been a problem when the gun is separated from the target zone by two or more concentric casing sections. The problem addressed by the present invention is how to minimize the time and therefore the cost, of accurately repositioning the gun for multiple penetrations at the same location that must penetrate two more sections of casing and produce the hydrocarbons from the surrounding formation in a rigless operation.

[0009] A related problem to be solved is how to provide an improved, more cost-effective system and method for initiating the hydraulic fracturing in tight gas reservoirs at a deeper point of penetration having a larger diameter without a rig, i.e., in a rigless operation. It would be highly advantageous to provide a rigless system and method employing robust apparatus and without electronic controls and orienting elements capable of efficiently completing a plurality of reservoir perforations or penetrations at the same position to produce a deeper penetration with a larger diameter before the hydraulic fracturing is commenced.

[0010] The problem can also be stated as how to more quickly and economically position and maintain the gun at the same location for successive or repeated reservoir penetration shots in wells operating without a rig, and to avoid the more complex assemblies that require surface controls and trained technicians to reposition the complex assemblies used with the perforating guns that are deployed by wireline and/or a coiled tubing unit.

**SUMMARY OF THE INVENTION**

[0011] The above problems are solved and other advantages are achieved by the method and apparatus of the present invention in which a latching tool with the perforating gun removably attached below are secured to the end of a roll of coiled tubing and are lowered into the wellbore to engage a latch coupling secured to a section of the production tubing proximate the predetermined interval in the wellbore that is to be perforated. Withdrawal after the first firing and recharging of the gun, followed by its return by the coiled tubing and engagement of the latching tool with the latch coupling to perforate tight formations repeatedly and at the same position results in extending the depth of the initial lateral perforations further into the surrounding formation. The greater depth and the larger diameter of the penetrations will enhance hydro-

carbon recovery by extending the penetration past any damaged areas in the wall of the wellbore. As will be explained below, the arrangement of the latch coupling and latching tool in accordance with the method and system of the present invention provides a consistent, reproducible reference at the predetermined depth and orientation for repeated use of the perforating gun in vertical and lateral wells without the need of maintaining a drilling rig at the well site. The much less expensive alternative of enabling a coiled tubing unit to position and withdraw the TCP gun results in a significant cost savings as compared to the prior art system that relied on a rig to move the gun.

**[0012]** As used in this description and the claims, the term “coiled tubing unit” has the customary trade-recognized meaning of a truck or other mobile mounting, or an apparatus that is skid-mounted and that can be positioned at the well-head to dispose coiled tubing from a roll into, and withdraw it from the well production tubing.

**[0013]** In the practice of the method and system of the present invention, the latch coupling is positioned on the production tubing that is run as the final completion of the well and before the rig is released. After the rig is released, the gun that is secured below the latching tool is run by means of coiled tubing or wireline in a rigless operation.

**[0014]** The practice of the method of the invention without a rig will be described. Following installation of the well casings, a latch coupling is assembled to the end of the production tubing, and the production tubing is lowered by the rig to a position above and proximate the target zone. The top of the gun is secured to a latching tool that is configured to mate with the latch coupling. The latching tool in turn is attached to the free end of a coiled tubing unit. The gun is then run inside the production tubing with the coiled tubing in a rigless operation. With the latching tool and the gun inside the production tubing, at the latch coupling depth the latching tool can engage the latch coupling in only one mating position. The engagement of the latching tool with the fixed stationary latch coupling assures that the gun is at the same fixed depth and that the gun charges are oriented in the same direction after each gun reload trip to perform multiple penetrations of the same location.

**[0015]** A latch coupling that is suitable for use in the invention is sold by Halliburton under the brand name “SperryRite”. It is designed for use in an advanced reservoir drainage multilateral system. It allows full-bore unrestricted access to the main bore and provides a consistent, repeatable reference for the depth and orientation of multilateral tools. The construction of this Halliburton SperryRite tool and its mode of operation will be described to facilitate an understanding of its use in the present invention. The latching tool is constructed with four (4) spring-loaded keys that are located on the lower section of the tool. These keys are driven in the ID of the casing wall with great force. When the tool is run into the well casing, a force of 8000 to 12000 pounds is required to push the tool into the well. The keys will only expand when the correct key segment is in the correct recess in the latch coupling. Unless the keys are fully expanded into the correct recesses, the tool will not hold much more weight than that which is required to push the tool into the well. In addition, the square shoulders of the latch keys will not allow rotation once they have “found” and expanded into the correct recesses in the latch coupling. The tool is set to release at about 40,000 pounds of straight pulling force, according to the manufacturer’s specifications.

**[0016]** In an embodiment suitable for the practice of the invention, the novel apparatus is assembled in accordance with the following procedure:

**[0017]** 1. The latch coupling is secured to the production tubing to form an integral part of the last section of production tubing and is placed so that it will be positioned above and in close proximity to the target zone that has been targeted for multiple penetration.

**[0018]** 2. The latching tool is secured to the end of coiled tubing and the gun is secured to the downhole end of the latching tool and is run in, or lowered into the hole by the coiled tubing, e.g., using a coiled tubing unit.

**[0019]** 3. As the gun and the latching tool are run into the production tubing and reach the latch coupling depth, the latching tool engages the latch coupling and sets the gun in a fixed position at the predetermined interval.

**[0020]** 4. The shaped charges previously loaded into the gun are fired and the casings and reservoir rock behind them are perforated for a first time at a plurality of lateral positions.

**[0021]** 5. With appropriate over-pull force on the coiled tubing from the surface, the latching tool is released from the latch coupling and pulled out of the hole with the gun for re-loading with new charges for the second run.

**[0022]** 6. By running the gun more than one time with the same gun charge orientation and spacing, the engagement of the latching tool with the fixed latch coupling will provide a repeatable accurate reference for the depth and orientation of the gun. As a result, the casings and the reservoir behind them can be perforated more than once at precisely the same positions, thereby providing deeper openings at each penetration point.

**[0023]** 7. The latching tool and gun are again disengaged by an upward force on the coiled tubing and withdrawn from the wellbore, and the gun is removed from the latching tool.

**[0024]** In another embodiment of the invention which avoids the necessity of running the perforating gun repeatedly into and out of the well, stacked latching tools are secured to the production tubing at predetermined positions on the coiled tubing above the gun, and the gun is constructed with multiple drop firing sections. The latching tool, latch coupling and the gun are modified for this embodiment. The modified latching tool has the capability of unlatching with a downward force in addition to the current and conventional mode of operation in which unlatching is effected by a predetermined upward force.

**[0025]** For example, if the same interval in the reservoir is to be penetrated three times, the top of the gun will be assembled with three latching tools and the shaped charge portion of the gun will include three firing sections. The lower-most latching tool after engagement in the latch coupling will position the lower-most firing section of the gun opposite the target interval in the reservoir that is to be perforated for the first time. After firing the first charge in this lower-most section, the section will drop to the bottom of the well which is known as the “rat hole”. The rat hole is additional footage drilled in the well below the production zone to dispose of redundant tools and avoid the cost of retrieving them. The gun is then lowered by the application of a downward force to cause the second latching tool to engage with the latch coupling and to position the next or second firing section at the same location as the first gun section. The

second gun section will penetrate deeper in the same openings created by the first gun section and after firing it will also drop to the bottom of the well. The sequence is repeated for the third section of shaped charges that are fired in the same location to further extend the depth of the penetration and enlarge the holes. The second and third set of shaped charges that are fitted into the gun are designed and configured to effect the second and subsequent shot into the penetration created by the first shot, the second shot effecting a deeper penetration into the formation and enlarging its diameter. The selection and placement of the shaped charges in the gun are well within the skill of the art.

**[0026]** The gun can also be modified to provide the capability of firing in multiple vertical locations. This enables the gun to be lowered to a different interval in the wellbore that is displaced below the first interval. As modified in accordance with the present invention, the gun also has the capability of completing multiple series of discrete firings at the same and different intervals in the reservoir.

**[0027]** In another embodiment, the perforating gun is configured to receive a plurality of first shaped charges and a plurality of second shaped charges and functions in a manner similar to that described above, with the exception that after firing the first and second shaped charges into the perforations in a first interval, the gun is moved to a second interval where the first and second firing procedure is repeated. As will be understood by one of ordinary skill in the art, the ability to create deep penetrations by positioning the gun for a first and second firing at the same location without retrieving the gun to the surface for reloading will result in a significant cost savings in bringing the well into production.

**[0028]** As will be understood from the above description, the ability to perform repeated perforations at the same location without maintaining a rig at the well during the time required to complete the multiple penetrations will enable the rig to be moved to commence work on another well. The improvement in the productivity of the drilling crews and use of equipment in the field will increase greatly, and the overall production costs for produced products will be reduced. The embodiments of this invention obviate the need for the more complex equipment configurations of the prior art in rigless operations. Use of the invention provides deeper perforations that penetrate several casings and bypass any near-wellbore damaged zone. The present invention provides the large and deeper holes needed to reach the virgin part of the reservoir for higher well or well infectivity and/or productivity in less time, with less equipment and provides significant cost-savings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0029]** The invention will be described in more detail below and with reference to the attached figures in which the same or similar elements have the same number, and where:

**[0030]** FIG. 1 is an illustration, partly in section, showing a latching tool in an engaged position with a latch coupling which combination would be suitable for use in the practice of this invention;

**[0031]** FIG. 2 is a simplified schematic illustration of a rigless completion in accordance with the present invention in which a coiled tubing unit is positioned at the earth's surface to run and withdraw the perforating gun for multiple penetrations of the reservoir;

**[0032]** FIG. 3 is a schematic illustration of an apparatus of the invention in which a perforating gun is positioned for penetration of three layers of casing pipes and any cement present between them; and

**[0033]** FIG. 4 is a simplified schematic illustration of a perforating gun in accordance with the invention fitted with first, second and third gun sections and their corresponding latching tools for effecting multiple penetrations without having to retrieve the gun for reloading at the surface.

#### DETAILED DESCRIPTION OF INVENTION

**[0034]** Referring to the partial sectional view of FIG. 1, there is shown a typical latch coupling **30** and latching tool **32** of the prior art that is suitable for use in the practice of the present invention. The spring-loaded projecting members **34** of the latching tool include projecting members **36** that engage openings **31** in the latch coupling to assure consistent, repeatable alignment of these elements. The projecting members **36** have flat surfaces **37** that prevent the latch coupling from rotating once engaged in the mating openings **41** in the latch coupling **30**. The latch coupling is configured to receive and engage the latching tool consistently in the same orientation.

**[0035]** Referring now to the schematic diagram of FIG. 2, a well completion is shown in which the latch coupling **30** is secured adjacent to the downhole end of production tubing **40**. A latching tool **32** secured to a multi-charged gun **50** is shown as lowered by coiled tubing **44** into its engaged position with latch coupling **30**. In the well completion illustrated in FIG. 2, the production tubing has been passed through a 4½ inch liner **24**, which is in turn positioned inside of a 5½ inch expandable tubular, which in turn is inside of a 7 inch liner **20**. In accordance with standard procedures, the annular regions between the inner casings, and the space between liner **20** and the reservoir **1** are cemented.

**[0036]** As also illustrated in FIG. 2, a truck-mounted coiled tubing unit **100** is positioned adjacent established wellhead **110** at the earth's surface. In accordance with well known procedures, a continuous roll of coiled tubing **102** is passed through guide **104** and into the annulus of the production tubing **40** which is surrounded by the conventional completion casings, including those described above. As will be understood by those of ordinary skill in the art, the movement of the coiled tubing in the production tubing is controlled by an operator stationed on the coiled tubing unit. When the latching tool **32** is securely engaged and positioned in latch coupling **30**, the gun **50** is in position for firing.

**[0037]** The firing of the penetration gun is controlled from the surface by conventional means. The first firing is sufficient to penetrate the three concentric casings and penetrate the formation **1** to a first depth **12** as depicted by the broken lines in FIG. 2. The operator of the coiled tubing unit **100** applies a sufficient upward force to release the spring-loaded engagement means on the latching tool and the assembly with the spent gun charges is withdrawn from the well. Once the gun and latching tool have cleared the wellhead **110**, the gun **50** can either be removed from the latching tool **32** and replaced with an identical gun having fresh shaped charges, or the spent elements can be removed and replaced with fresh shaped charges **52** for the second run. The procedure described above with reference to the first firing is repeated for the second firing and a third firing. The resulting second penetration **14a** and third penetration **14b** following the third run of the gun are illustrated by the respective regions shown

in broken and solid lines in FIG. 2. As will be apparent to one of ordinary skill in the art, the same results can be achieved using the method and system of the present invention utilizing a wireline unit which also obviates the need for a rig at the wellhead. In addition to operating more cost-effectively, the ability to repeatedly run the gun into the well and withdraw it for reloading greatly expedites the operation as compared to the prior art method of removing production tubing using a rig. The apparatus required for the present invention is also much simpler than that required for the prior art rigless operation.

[0038] Referring now to FIG. 3, an alternative well completion is illustrated that represents an advantage associated with the employment of the method and system of the invention.

[0039] The size of the wellbore drilled in tight gas reservoir rock depends upon the overall well design from the surface to the reservoir target zone. In some wells, the target zone is drilled with a 8<sup>3</sup>/<sub>8</sub>" hole; in other wells, the target zone is drilled with a 5<sup>7</sup>/<sub>8</sub>" hole. The 8<sup>3</sup>/<sub>8</sub>" hole is cased with 7" pipe liner. The 5<sup>7</sup>/<sub>8</sub>" hole is cased with a 4<sup>1</sup>/<sub>4</sub>" liner. In an open hole, or OH completion, the hole drilled in the target zone is left open without a cemented pipe liner. In a closed hole, or CH completion, the target zone is provided with a cemented pipe liner. The liner extends from the bottom of the OH to +/-300 feet inside the casing above the open hole. The casing extends to the earth's surface. The design of the well will take into consideration the size and positioning of the various tools and fittings required in the practice of the invention as described.

[0040] Again referring to FIG. 3, the original well design called for the positioning of the 7-inch liner 20 at the target zone 2 in the reservoir formation 1. It is clearly preferable to perforate only one casing element at the target zone and this is the general case in planning the well. However, in some cases, e.g., because of unexpected drilling difficulties and/or formation conditions, an additional and unplanned pipes, e.g., a casing, liner or expandable must be run to overcome the difficulty in order to enable the continuation of drilling to reach the main target zone. After reaching the target zone, if a shallower zone is found to be of interest and it is behind more than two casings, the well engineer is faced with an additional challenge to making deep penetrations into the formation. Current perforation practice suffers from providing deep perforations into the formation, especially where the target zone is behind more than two casings. The present invention overcomes the limitations and difficulties of conventional perforation practices to perforate more than two casings and can achieve deep perforations that bypass near wellbore damage in a formation with high compressive strength.

[0041] With further reference to FIG. 3, a first trouble zone 4 forced the termination of the run of liner 20 at the depth illustrated. A second trouble zone 6 was also encountered at a greater depth and a 5<sup>1</sup>/<sub>2</sub> inch expandable tubular 22 was put in place to extend the casing 20 towards the target zone 2. A 4<sup>1</sup>/<sub>2</sub> inch liner 24 was then positioned inside the expanded casing 22 to span the target zone.

[0042] As shown in FIG. 3, the penetration of the formation is achieved by lowering the production tubing 40 with the latch coupling 30 secured proximate its end into the region above the main target zone 2. Thereafter, the coiled tubing 44 to which are secured the latching tool 32 and depending gun 50 with shaped charges are lowered into engagement with the latch coupling 30 and thereby positioned the gun 50 for repeated firing in the main target zone 2 in order to achieve the

desired degree of penetration. A plurality of penetrations 13 are illustrated schematically in zone 2, which required only the penetration of a single casing 24.

[0043] In the embodiment illustrated in FIG. 3, it was also determined that a secondary target zone 2a was located at a shallower depth, but at the position where three concentric sections of casings were in place. However, with the capability provided by the present invention, repeated firings at the same location enable the casings to be penetrated and the surrounding reservoir rock in the secondary target zone 2a to be penetrated to a suitable depth to provide the desired level of production.

[0044] From the above description and illustrations, it will be understood that after the second firing, the gun can be reloaded and returned with the latching tool for engagement with the latch coupling and a third firing to effect even deeper penetration at the same location in the interval. The selection of shaped charges for the second and any subsequent firings of the TCP gun in order to produce the depth and diameter of the penetrations 14 in specific types of reservoir rock are within the skill of the art.

[0045] The method and apparatus of the present invention overcomes tight formation productivity problems because the same interval can be perforated two, three, four or even more times to create the large and deeper holes needed to reach the virgin part of the reservoir for higher well productivity or well injectivity. Additionally, this technique will facilitate stimulation treatment especially in tight formations which are of high compressive strength where achieving deep perforation penetration is particularly difficult. This invention provides for the efficient perforation of tight rock formations to achieve successful hydraulic fracturing treatments.

[0046] Referring now to the schematic diagram of FIG. 4, the novel configuration of gun assembly 50 is adapted for use with wells that are equipped with a modified latch coupling as described above and saves the coiled tubing unit time that would otherwise be required for the multiple gun trips in the practice of the method described in connection with FIGS. 2 and 3. The gun assembly 50 attached to tubing 40 includes first, second and third firing sections 50A, 50B and 50C, respectively, each of which is fitted with a plurality of shaped charges 52. The tubing is also fitted with three latching tools, represented schematically by elements 32A, 32B and 32C, which are adapted to engage a mating fixed latch coupling in the production tubing when the gun assembly is lowered to the wellbore as described above. In the practice of the method of the invention, the gun 50 is lowered so that latching tool 32A engages the fixed latch coupling (not shown) and the first section 50A of the gun is fired, detached and dropped into the rat hole 11 at the bottom of the wellbore 10. Thereafter, the latching tool 32A is disengaged by a downward force and the gun is lowered so that latching tool 32B is engaged with the fixed latch coupling and second section 50B of the gun assembly is in precisely the same position with respect to the first series of penetrations created by the firing of charges 52 in gun section 50A, thereby further penetrating the reservoir. After the second firing and the detachment and dropping of section 50B, the assembly is moved so that latching tool 32C engages the latch coupling and thereby positions the charges of the third section 50C in alignment with the existing penetrations and a third firing is completed. As will be apparent to one of ordinary skill in the art, the spacing of the latching tools 32A, 32B and 32C corresponds to the spacing of the shaped charges on the first through third sections of the gun 50. As

will also be apparent to those of ordinary skill in the art from this description, the gun assembly **50** can consist of two, three or more sections, each of which will have a corresponding latching tool axially distanced and positioned above to assure proper vertical alignment of the charges in the interval to be penetrated.

**[0047]** The method and apparatus of the present invention overcomes tight formation productivity problems because the same reservoir interval can be efficiently and economically penetrated two, three or more times without a rig to create the large and deeper holes needed to reach the virgin portion of the reservoir for higher well productivity and/or well injectivity. Additionally, the method facilitates stimulation treatments in especially tight formations of high compressive strength where achieving deep perforation penetration is particularly difficult. This invention provides for the efficient perforation of tight rock formations to achieve successful hydraulic fracturing treatments.

**[0048]** From the preceding description, it will be understood that the present invention provides a cost effective rigless method for implementing more effective and deeper penetration of the reservoir in preparation for hydrofracturing. It also provides a system and method for precise positioning of the gun charges to perforate at the same spot repeatedly after each gun reloading trip that can be implemented relatively quickly employing known robust equipment that is reliable and avoids the need for expensive electronic components operated by skilled technical personnel at the surface.

**[0049]** Although the apparatus and method have been described in detail above and illustrated in the drawings, modifications and variations from this description will be apparent to those of ordinary skill in the art, and the scope of protection for the invention is to be determined by the claims that follow.

1. An apparatus for penetrating a predetermined interval of a tight reservoir rock formation adjacent a well bore, the apparatus comprising a perforating gun containing a plurality of shaped charges releasably attached to the downhole end of an orienting tool, which orienting tool is secured to the end of a length of coiled tubing or a wireline, where the orienting tool is configured to enter into secure releasable mating engagement with a corresponding receiving member that is joined to the end of a length of production tubing and located at a predetermined position above and proximate to the interval that is to be penetrated at the same location by the sequential firing of a plurality of shaped charges contained in the gun.

2. The apparatus of claim 1 where the orienting tool is a latching tool and the receiving member is a latch coupling.

3. The apparatus of claim 2 in which the latching tool and the attached gun are disengaged from the latch coupling by application of a downward force and an upward force, whereby the gun can be disposed to at least a second operable position at a second interval that is to be perforated without withdrawing the gun to the earth's surface.

4. The apparatus of claim 3 in which the latching tool has a plurality of projecting members which are releasably received in a plurality of corresponding recesses in the interior surface of the latch coupling and the respective upper and lower surfaces of the projecting members and recesses are configured to permit axial movement of the latching tool relative to the latch coupling in either direction.

5. The apparatus of claim 4 in which the end of the latching tool opposite the gun is secured to the downhole end of a

length of coiled tubing extending from a coiled tubing unit for control of movement of the latching tool and gun from the earth's surface.

6. The apparatus of claim 5 in which the gun is provided with a first series of charges that are wired for discharge at a first position adjacent a first downhole interval and a second series of charges that are wired for discharge at a second position displaced from the first position, the second position being determined by engagement of the latching tool with a second latch coupling disposed and secured to the production tubing proximate the second position.

7. A method of sequentially performing a plurality of penetrations along a predetermined interval of a wellbore in a tight reservoir rock formation in order to deeply penetrate into the rock, the method comprising:

- a. securing a latch coupling to the downhole end of a length of production tubing that terminates at a predetermined position above and proximate to the interval to be penetrated;
- b. lowering via a coiled tubit unit, a perforating gun that is secured to the downhole end of a latching tool into position adjacent the interval to be perforated, the opposite end of the latching tool being secured to the downhole end of the coiled tubing;
- c. releasably engaging the latching tool with the latch coupling;
- d. firing a first series of charges from the gun to penetrate the reservoir rock along the interval with a first series of openings;
- e. pulling the latching tool upwardly in the wellbore to disengage the tool from the latch coupling;
- f. retrieving the gun from the wellbore, reloading the gun with fresh charges and returning the gun and latching tool to an engaged position with the latch coupling; and
- g. firing a second series of charges from the gun into the formation at the same locations as the first series to provide openings penetrating deeper into the formation than the first series of openings.

8. The method of claim 7, which includes repeating steps (e) through (g) to fire at least a third series of charges to further penetrate the formation.

9. A method of sequentially performing a plurality of perforations at a predetermined interval of a wellbore in a tight reservoir rock formation in order to produce successively deeper penetrations into the rock, the method comprising:

- a. securing a latch coupling to the downhole end of a length of production tubing at a predetermined fixed position above and proximate to the interval to be perforated;
- b. providing a perforating gun comprised of a plurality of sections where each section contains a plurality of shaped charges positioned in the same predetermined array and the arrays are axially and radially aligned with each other;
- c. securing the perforating gun to the downhole end of a supporting member;
- d. securing to the supporting member a plurality of latching tools that correspond in number to the sections comprising the perforating gun, the latching tools being spaced apart axially a distance that corresponds to the axial distance between the shaped charge arrays in the gun;
- e. securing the supporting member to the downhole end of a length of coiled tubing extending from a coiled tubing unit at the earth's surface;

- f. lowering via the coiled tubing unit the first section of the gun into position adjacent the interval to be perforated;
  - g. releasably engaging the latching tool with the latch coupling closest to the gun;
  - h. firing a first series of charges from the gun to penetrate the reservoir rock along the interval with a plurality of openings;
  - i. releasing the engaged latching tool to disengage the tool from the latch coupling and lowering the gun via the coiled tubing unit to engage the adjacent latching tool with the latch coupling to position the second section of the gun adjacent the penetrations;
  - j. firing a subsequent series of charges from the gun into the formation at the same locations as the first series to provide openings penetrating deeper into the formation than the first series of openings; and
  - k. repeating steps (h) and (i) until all of the charges in the gun have been fired into the formation.
- 10.** The method of claim **9** in which the gun is comprised of at least two sections.
- 11.** The method of claim **9** in which the gun is assembled with three sections.
- 12.** The method of claim **9** in which the latching tool is moved vertically by the coiled tubing unit to disengage the tool from the latch coupling.
- 13.** The method of claim **9** in which the gun fires in response to a signal transmitted from the earth's surface.

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