



US 20170298715A1

(19) **United States**

(12) **Patent Application Publication**
McConnell et al.

(10) **Pub. No.: US 2017/0298715 A1**

(43) **Pub. Date: Oct. 19, 2017**

(54) **METHOD AND APPARATUS FOR ADAPTING
STANDARD END CAP ASSEMBLIES OF A
PERFORATING GUN TO FUNCTION AS
TUBING CONVEYED PERFORATING END
CAP ASSEMBLIES**

Publication Classification

(51) **Int. Cl.**
E21B 43/116 (2006.01)
(52) **U.S. Cl.**
CPC **E21B 43/116** (2013.01)

(71) Applicants: **Taylor McConnell**, Wexford, PA (US);
Scott S. Brunner, St Mary's, PA (US);
Alan R. Keniston, St Mary's, PA (US)

(57) **ABSTRACT**

(72) Inventors: **Taylor McConnell**, Wexford, PA (US);
Scott S. Brunner, St Mary's, PA (US);
Alan R. Keniston, St Mary's, PA (US)

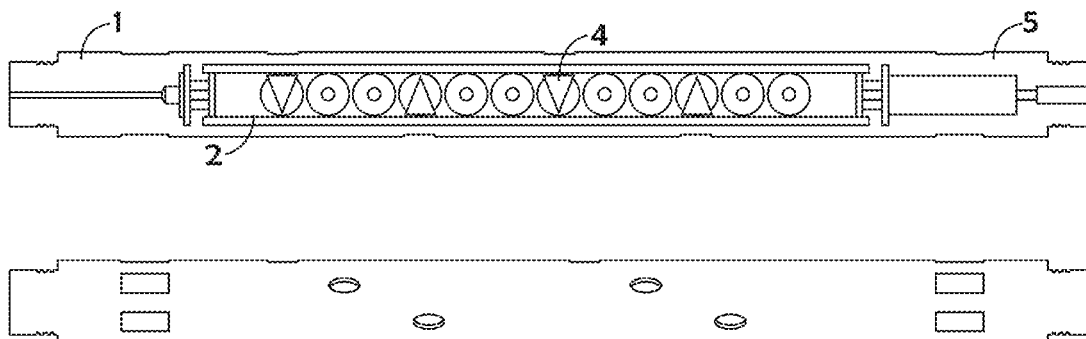
Method and apparatus for adapting a Standard End Cap assembly of a perforating gun to function as a Tubing Conveyed Perforating end cap assembly of a perforating gun. The method includes inserting an inner end cap into an opening of a Standard End Cap, and positioning the inner end cap such that the inner end cap and Standard End Cap become interlocked without the need of a snap ring. The apparatus includes an inner end cap that may include anchors or receivers, and a Standard End Cap that may include anchors or receivers, such that the anchors in one component correspond to the receivers in the other component to facilitate the interlocking of the two components.

(21) Appl. No.: **15/453,152**

(22) Filed: **Mar. 8, 2017**

Related U.S. Application Data

(60) Provisional application No. 62/305,666, filed on Mar. 9, 2016.



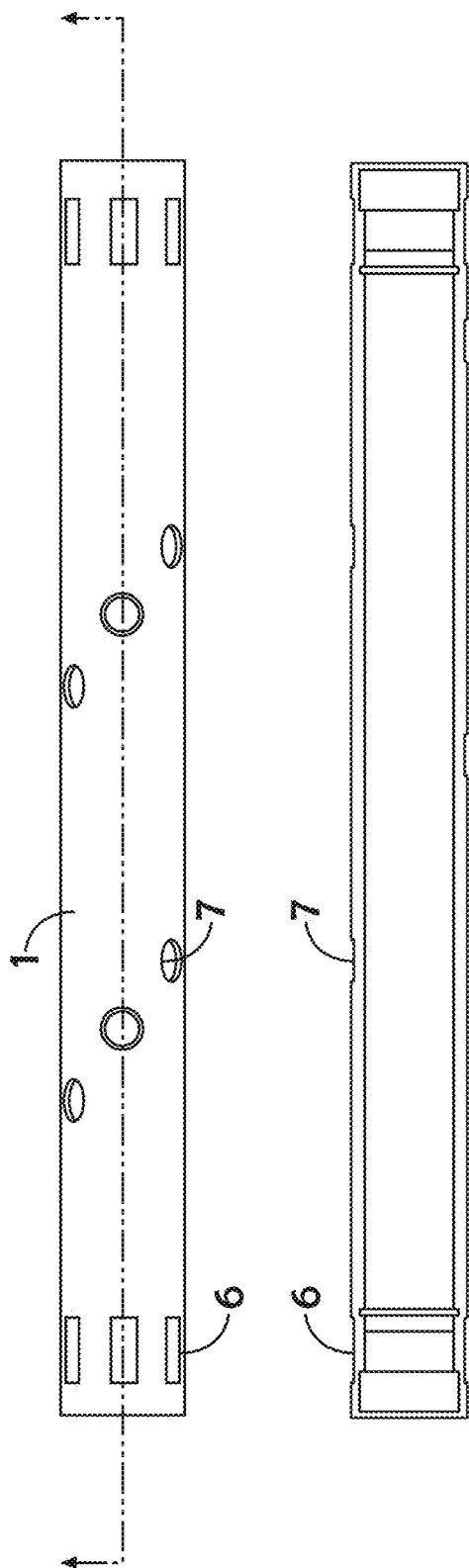


FIGURE 1

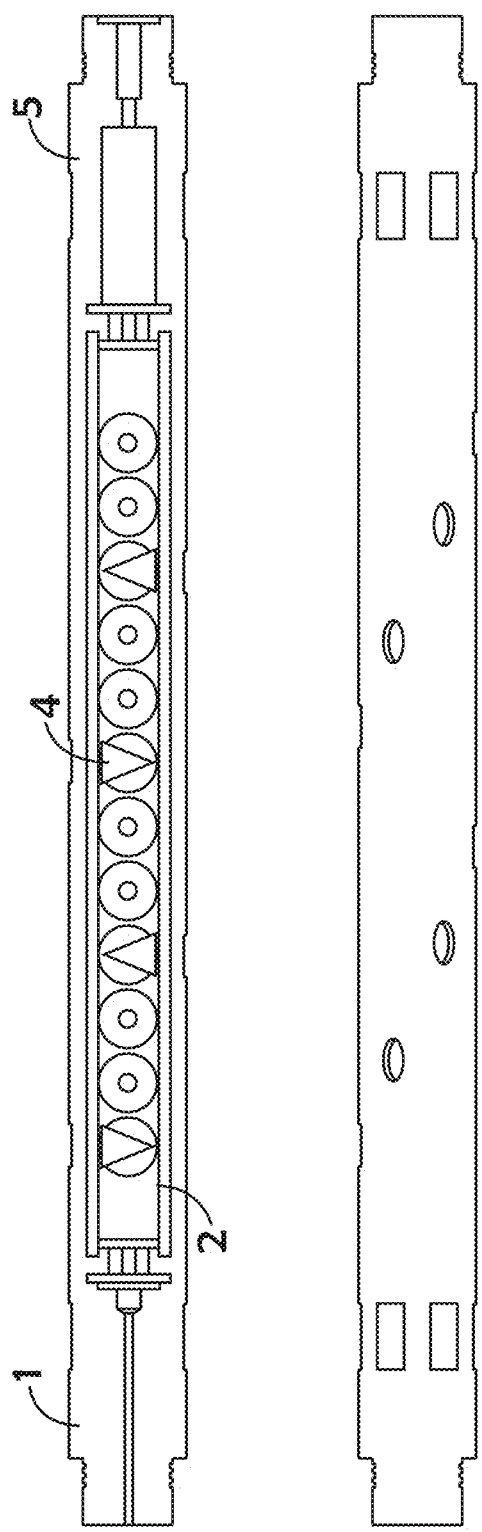


FIGURE 2

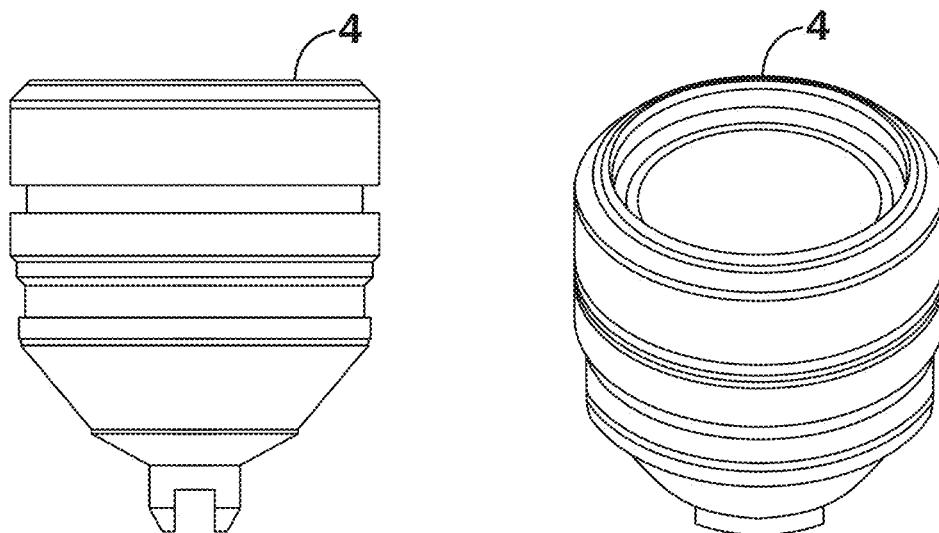


FIGURE 3

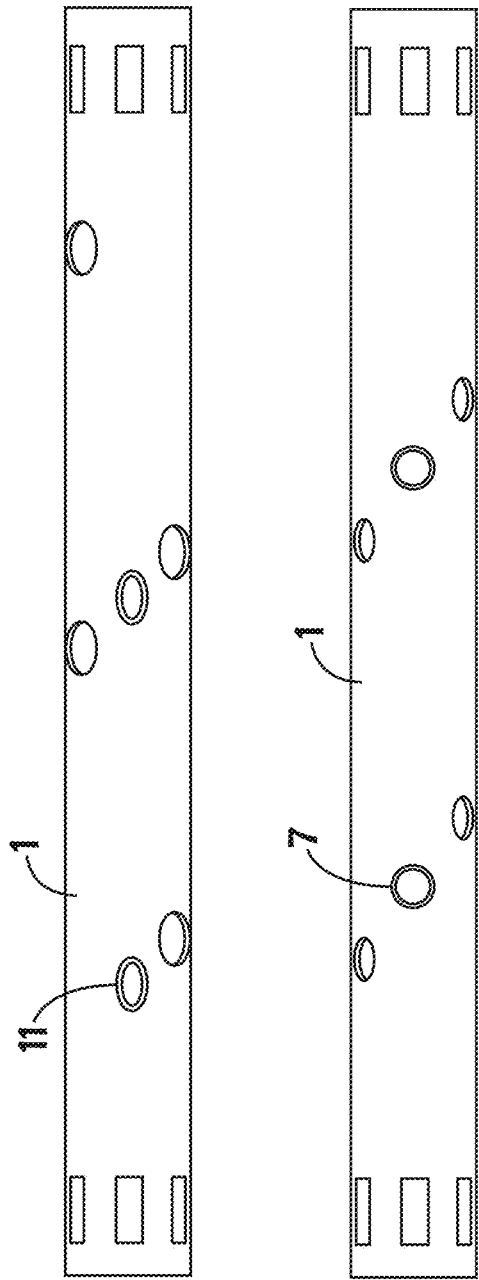


FIGURE 4

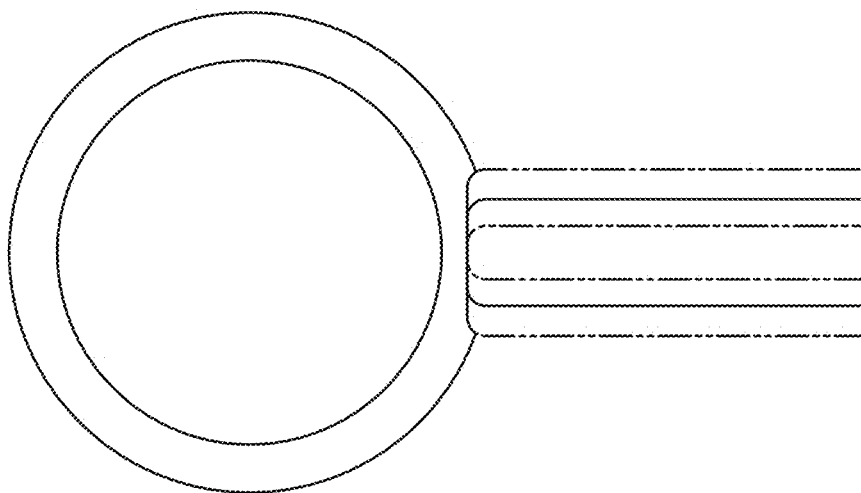


FIGURE 5

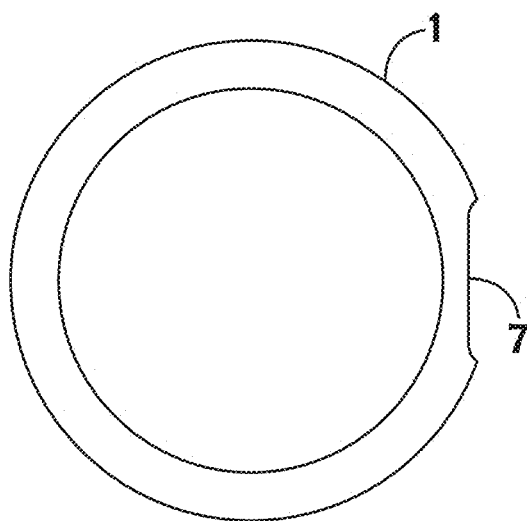


FIGURE 6

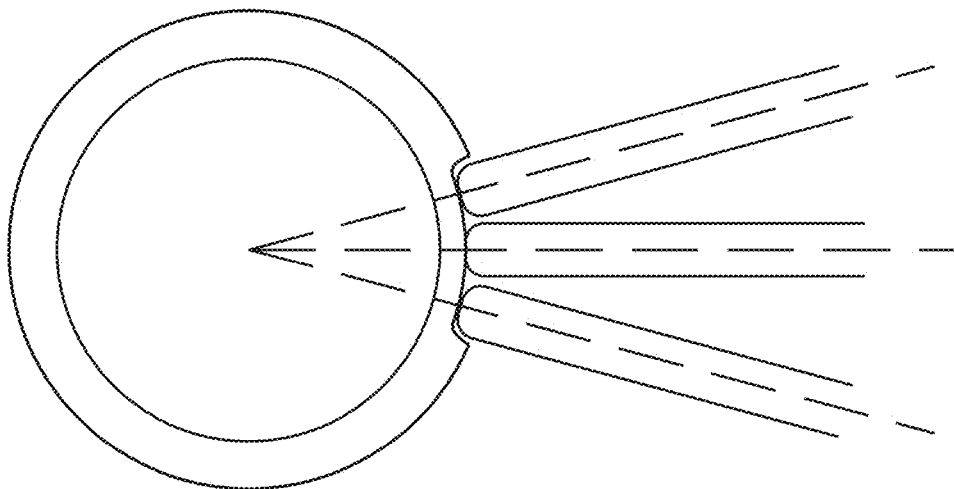


FIGURE 7

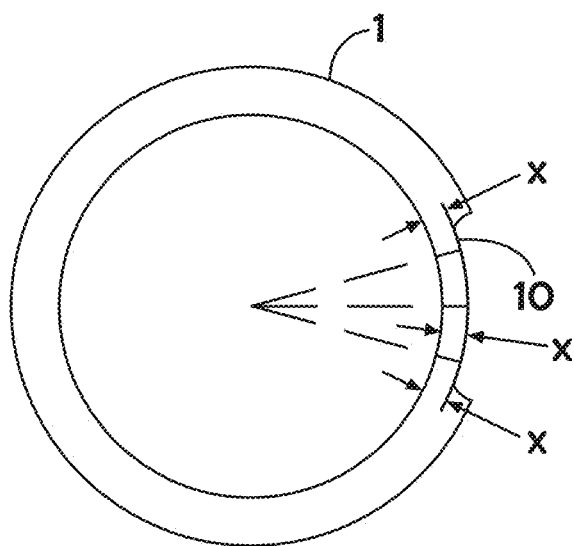


FIGURE 8

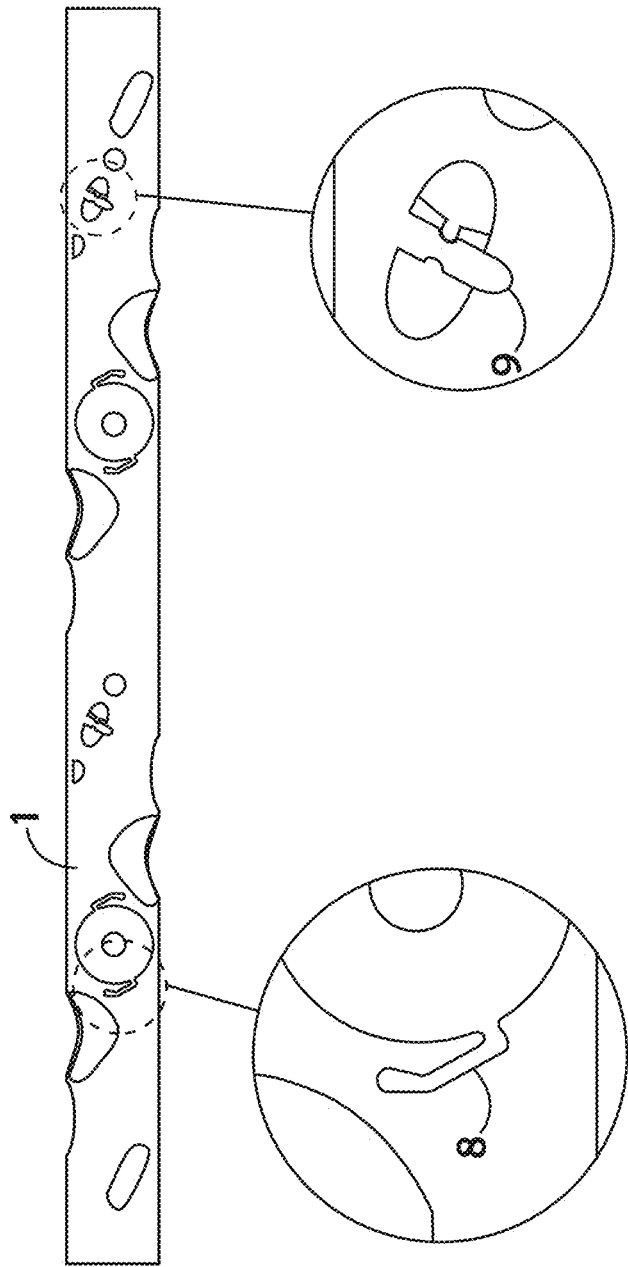


FIGURE 9

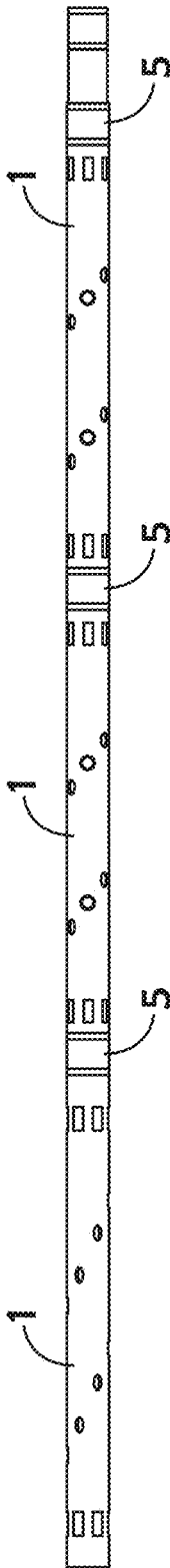


FIGURE 10

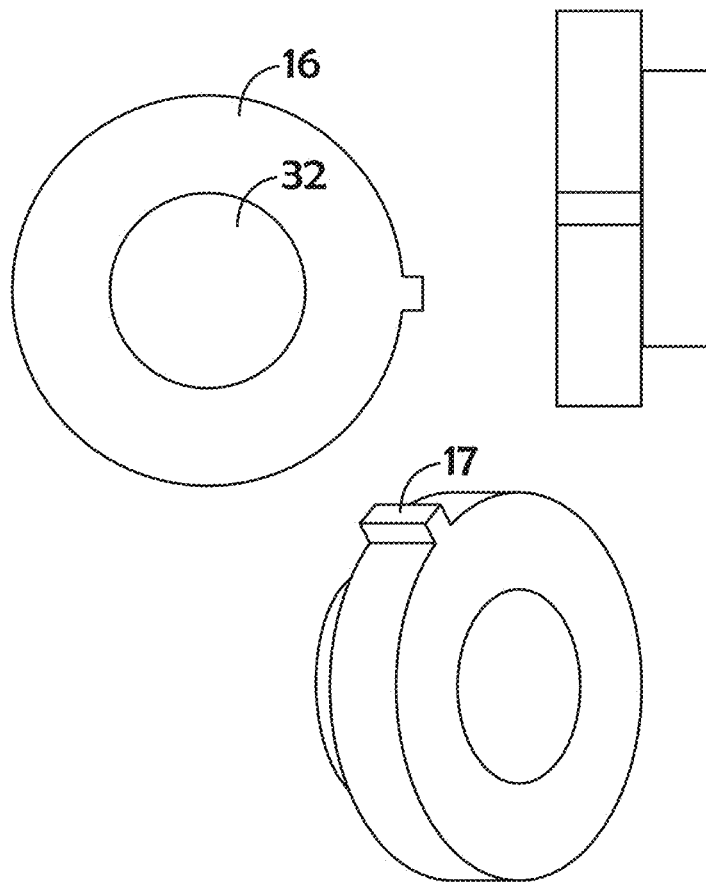


FIGURE 11

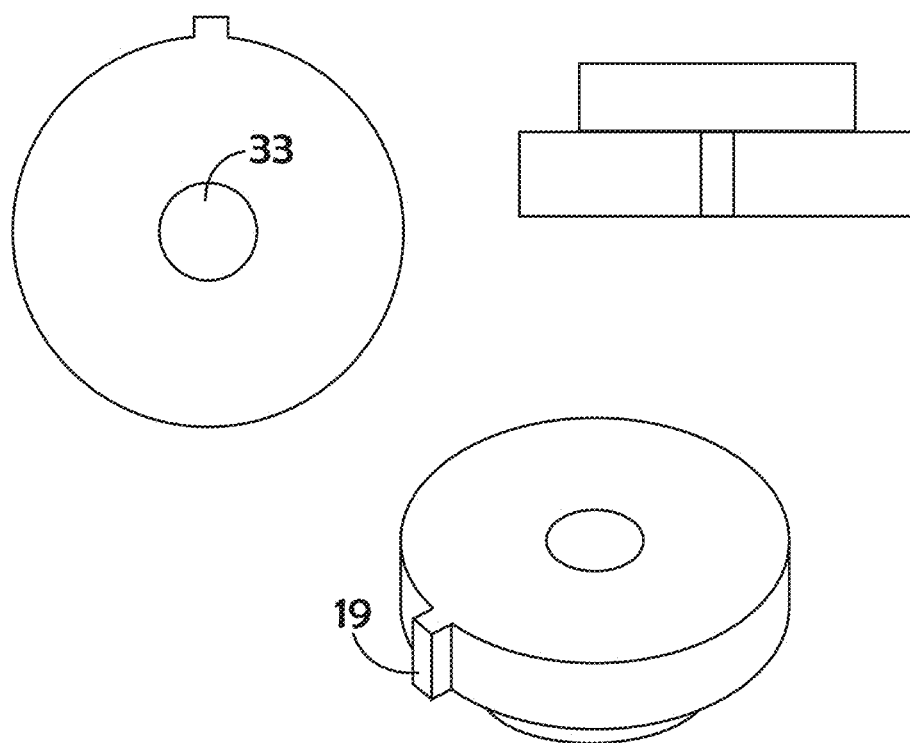


FIGURE 12

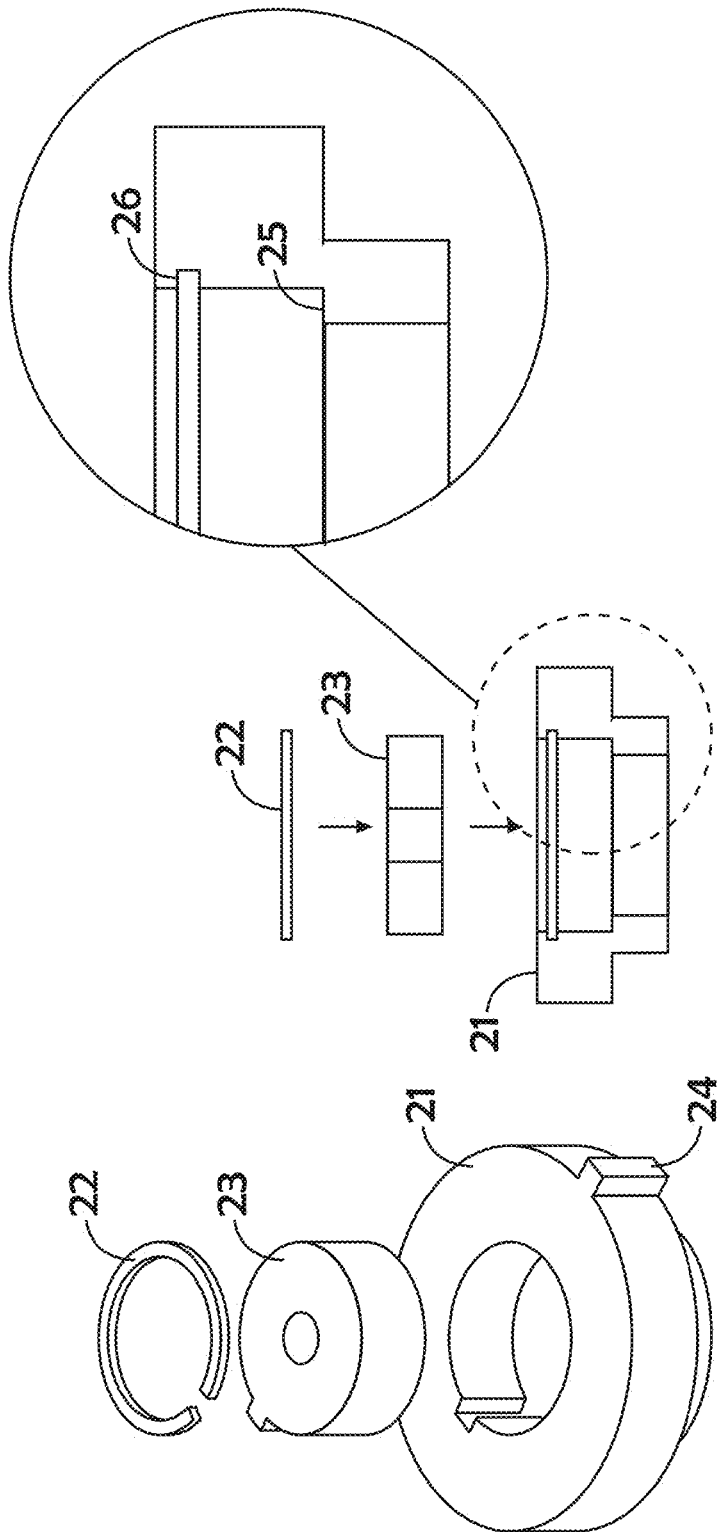


FIGURE 13

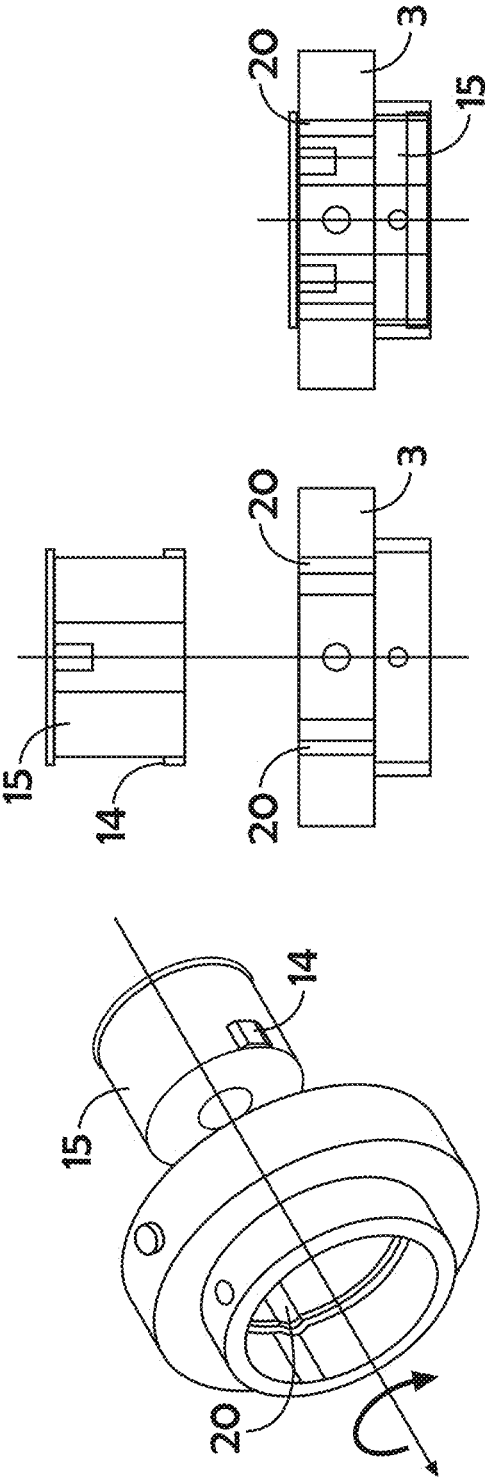


FIGURE 14

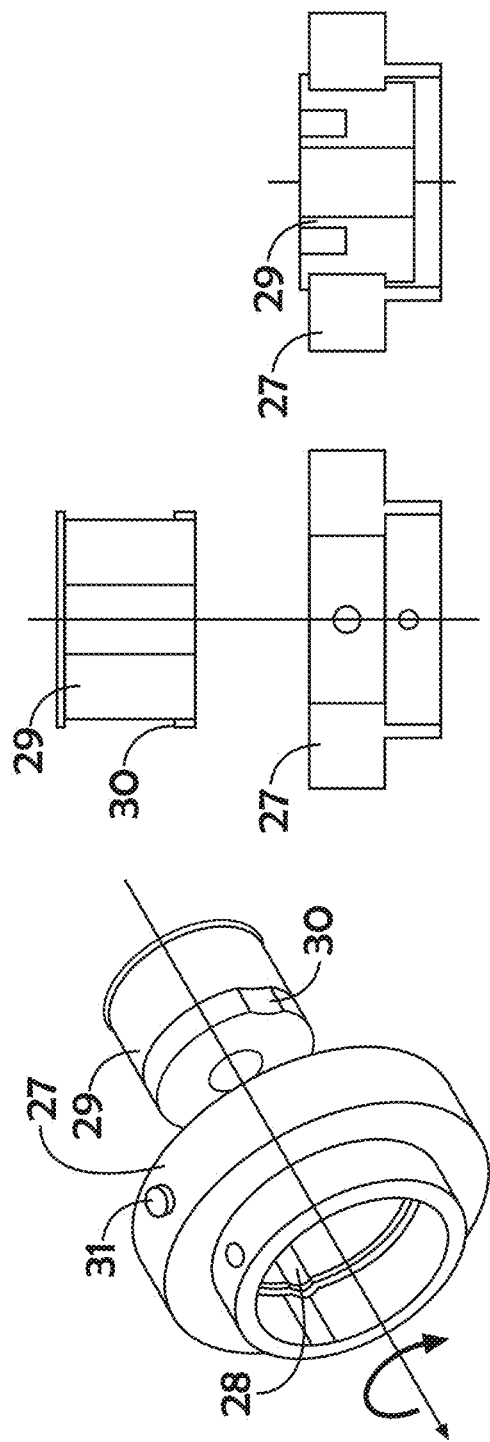


FIGURE 15

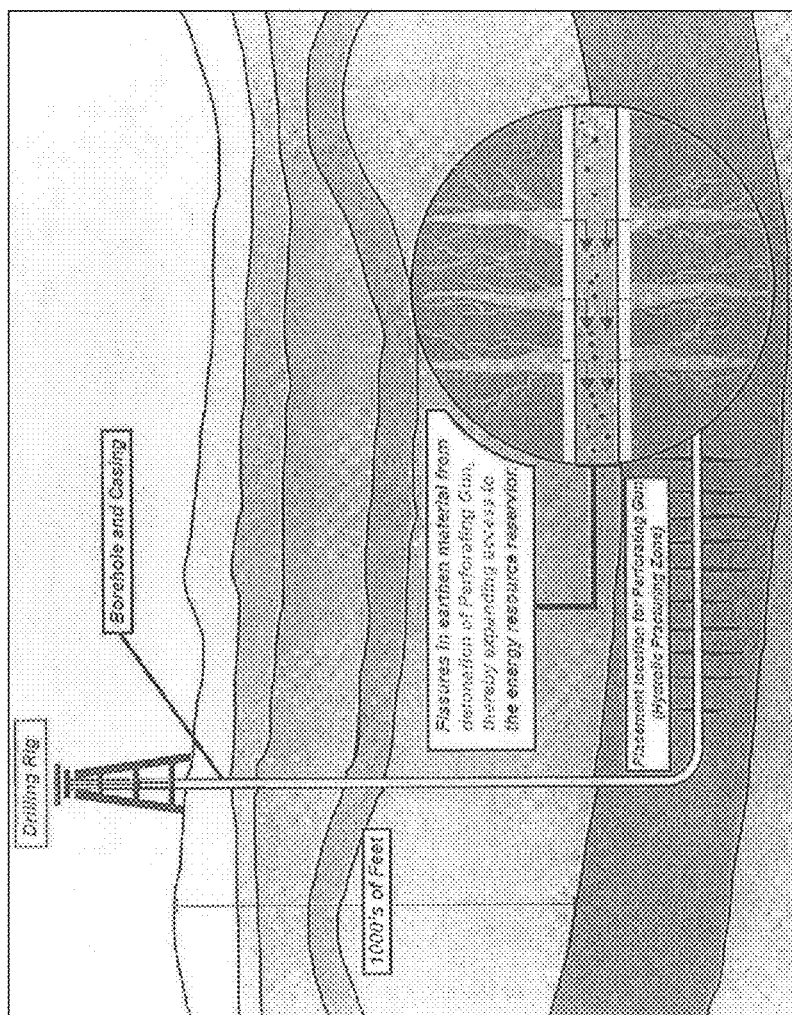


FIGURE 16

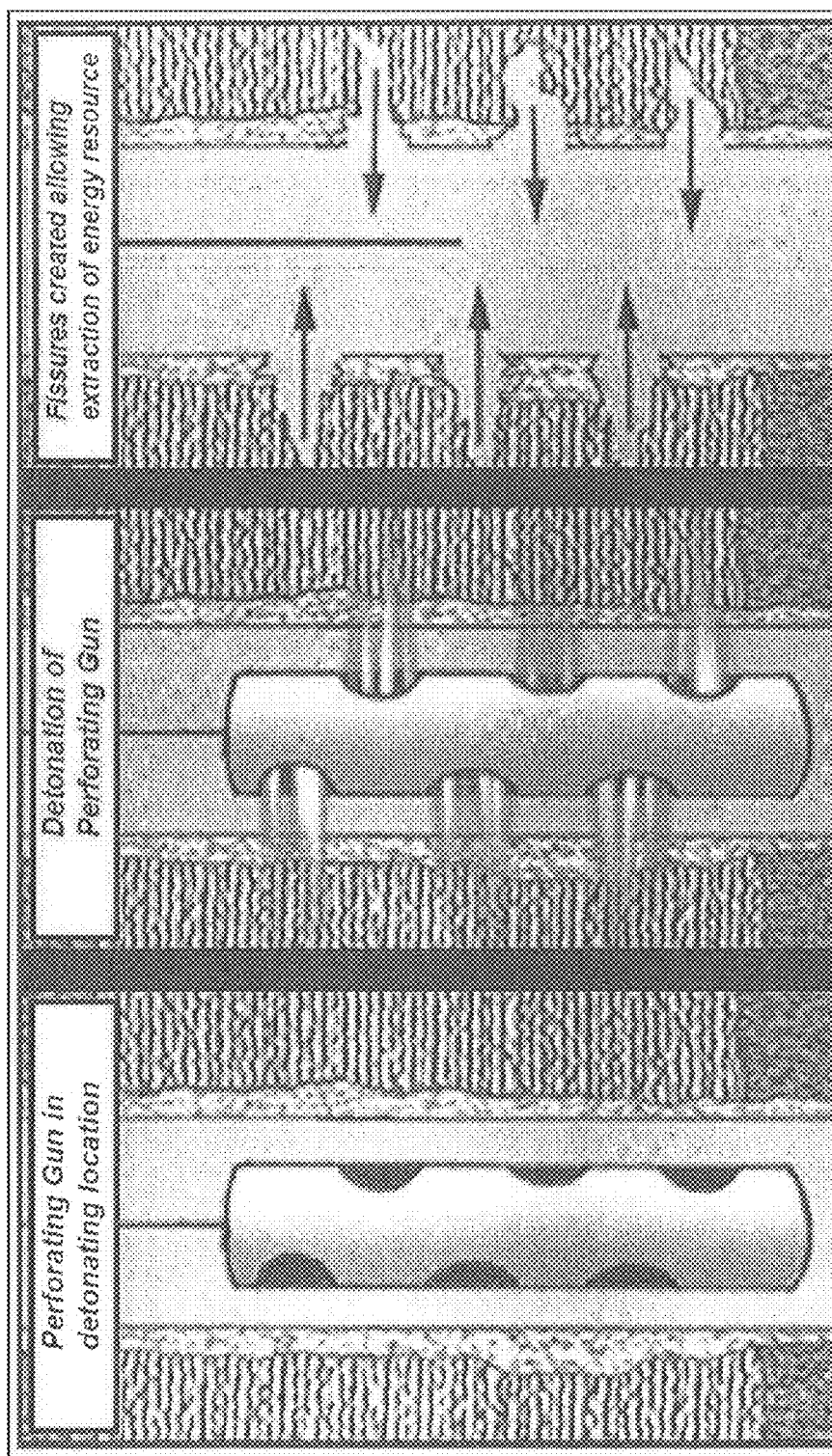


FIGURE 17

**METHOD AND APPARATUS FOR ADAPTING
STANDARD END CAP ASSEMBLIES OF A
PERFORATING GUN TO FUNCTION AS
TUBING CONVEYED PERFORATING END
CAP ASSEMBLIES**

CLAIM OF PRIORITY

[0001] This utility application claims the benefit of U.S. Provisional Patent Application No. 62/305,666, which was filed Mar. 9, 2016.

FIELD OF THE INVENTION

[0002] This invention relates to perforating guns and, more specifically, to adapting Standard End Cap assemblies of a perforating gun to function as a Tubing Conveyed Perforating end cap assembly of a perforating gun.

BACKGROUND OF THE INVENTION

[0003] Perforating guns are devices that are commonly used within the energy industry in order to facilitate the extraction of energy resources from the ground. Energy resources, such as oil and natural gas, are generally found in underground reservoirs. In order to extract the oil or gas, a drill is often used to drill a long vertical hole from the ground surface downward into the reservoir. By “tapping” the reservoir in this way, the oil or natural gas contained in the reservoir can be brought to the surface through the newly-made vertical hole using methods well known in the art.

[0004] Energy resource reservoirs, however, often span large horizontal distances. A single reservoir may occupy many square acres or even many square miles of underground space. Reservoirs also occupy a certain vertical space underground; by way of example, the “top” of a reservoir may be located two hundred (200) feet below the surface, but the “bottom” of the reservoir may be located eight hundred (800) feet below the surface. A drill that bores a vertical hole can access all “heights” of a reservoir; to extract oil or gas located deeper in the ground (i.e., more toward the reservoir’s “bottom”), the person operating the drill need only drill deeper.

[0005] But a single vertically drilled hole is only able to access a reservoir at one location relative to the reservoir’s horizontal breadth. It is unfeasible to drill scores (or more) of vertical holes in order to access the entirety of a reservoir’s horizontal breadth. One method of accessing a reservoir’s horizontal breadth without drilling multiple vertical holes is to expand the subterranean portion of a vertical hole in a horizontal direction. By expanding the subterranean portion of a vertical hole in a horizontal direction, oil and gas located a horizontal distance from the vertical hole can still be extracted through the vertical hole.

[0006] One method of expanding the subterranean portion of a vertical hole in a horizontal direction is via a controlled subterranean explosion. The controlled subterranean explosion displaces earth (such dirt, rock, or whatever earthen material lines the vertically drilled hole), and by doing so broadens the vertical hole horizontally.

[0007] Perforating guns are a device used to cause and control subterranean explosions to horizontally broaden vertical holes drilled to access energy resources. A drawing of a perforating gun is included herewith at Reference No. 1 in FIG. 1. Perforating guns are typically cylindrical and contain strategically placed indentations known as “scal-

lops.” Scallops are marked by Ref. No. 7 in FIG. 1. Some scallops in a perforating gun (but not necessarily all scallops) are “loaded” with a charge. A charge is explosive material that, as loaded, is positioned below a scallop. A charge situated in a perforating gun below a scallop can be seen at Ref. No. 4 in FIG. 2. FIG. 3 shows a charge standing alone.

[0008] In order to accomplish the controlled subterranean explosion, one or more perforating guns are lowered into the vertical hole that was initially drilled to tap the reservoir. When multiple perforating guns are connected in an end-to-end manner and simultaneously lowered into the same vertical hole, it is commonly known as a “string” of perforating guns. There are a variety of well-known methods in the art for lowering perforating guns into a vertical hole. When perforating guns are lowered to the desired depth, the charges situated beneath the scallops are detonated.

[0009] Because the scallops are an indentation, the thickness of the perforating gun is less at a scallop than at unscalloped parts of the perforating gun. See FIG. 1, Ref. No. 7. As a result of the lesser thickness, when a charge below a scallop is detonated, the force of the detonation from the charge is channeled through and expelled from the scallop. In this way, the indentations that form scallops serve as “holes” that are “punched out” when a charge located below the scallop is detonated (but to be clear, because the indentations that form scallops do not completely penetrate the walls of a perforating gun, scallops are not truly “holes” until the charges beneath the scallops are detonated).

[0010] When the force of a charge detonated below a scallop is channeled through and expelled from the scallop, the channeled force displaces the earthen material located directly adjacent to the scallop, creating fissures in the adjacent earthen material. A series of drawings exemplifying the process by which perforating guns are lowered into a vertical hole and then detonated to create fissures is included herewith as FIG. 16 and FIG. 17.

[0011] One variation of charge used in perforating guns contains an amount of copper situated atop the charge but below the scallop. When the charge is detonated, the copper sitting atop is liquefied as a result of the heat generated by the detonation. In addition to liquefying the copper, the explosive force of the charge expels the molten copper through the scallop. When the molten copper is expelled through the scallop, its function is tantamount to a liquid drill: the molten copper strikes the earthen material adjacent to the scallop from which it was expelled, and in doing so bores through the earthen material to create fissures through which energy resources can flow.

[0012] Ensuring that perforating guns reach a desired depth and are able to detonate their charges are critical concerns when using perforating guns to extract subterranean natural resources. End caps are devices situated on the longitudinal ends of a perforating gun, and they impact the manner by which the perforating gun is lowered into a vertically drilled hole and the method by which perforating gun charges detonate. Because they affect the ability of a perforating gun to reach a desired depth and charge detonation, end caps are a critical component in any perforating gun assembly.

[0013] The industry currently employs two types of end caps: Standard End Caps and Tubing Conveyed Perforating End Caps (“TCP End Caps”). Standard End Caps permit strings of perforating guns to be hydraulically lowered into

a vertically drilled hole and utilize an electrical system to detonate charges. A Standard End Cap can be seen in FIG. 11. The large opening in the Standard End Cap denoted by Ref. No. 32 should be noted.

[0014] However, hydrostatic pressure naturally exists when vertical holes are drilled to create wells. This hydrostatic pressure exerts a force upward from within the well.

[0015] Because this force pushes upward, it opposes strings of perforating guns that are lowered downward into the well. As such, the force pushing downward to lower a string of perforating guns into a well must be able to overcome the hydrostatic force pushing upward opposing the lowering of the perforating guns, otherwise the string cannot be lowered into the well. In the case of Standard End Caps, this means that the hydraulic force used to lower a string into a well must be able to overcome the well's natural hydrostatic force. This, however, is not always possible, which results in instances where perforating guns with Standard End Caps cannot be lowered into a particular well because the available hydraulic lowering force is insufficient to overcome the well's hydrostatic force.

[0016] In instances where hydraulic force cannot overcome hydrostatic pressure, TCP End Caps must be used. Unlike assemblies employing Standard End Caps, perforating gun assemblies that employ TCP End Caps are mechanically lowered into wells, rather than hydraulically. The methods for mechanically lowering TCP End Cap perforating gun assemblies are well known in the industry. These mechanical methods are able to create more force than hydraulic lowering methods, which allows TCP End Cap perforating gun assemblies to be lowered through wells with high hydrostatic pressure where hydraulic lowering would be impossible. TCP End Cap assemblies also utilize a mechanical system to detonate the charges, as opposed to the electrical system used with Standard End Cap assemblies (both detonation systems are well known in the industry). A TCP End Cap can be seen in FIG. 12. It should be noted that the opening in the TCP End Cap, denoted by Ref. No. 33, is significantly smaller than the opening in the Standard End Cap.

[0017] Because both Standard End Cap assemblies and TCP End Cap assemblies are used in the industry, it is advantageous to be able to adapt a Standard End Cap to function as a TCP End Cap if hydrostatic circumstances so require. A design currently exists that allows this type of adaptation: it is known as a "Snap Ring" assembly and is shown in FIG. 13. The Snap Ring assembly works as follows:

[0018] By inserting an "inner end cap" 23 into the opening in a Standard End Cap 21, one can adapt the Standard End Cap 21 to function as a TCP End Cap.

[0019] However, the inner end cap 23 must fit snugly within the Standard End Cap 21, because if the inner end cap 23 comes out of place the Standard End Cap will no longer function as a TCP End Cap.

[0020] To ensure the inner end cap 23 fits snugly within the Standard End Cap's opening, the industry employs snap rings 22, which are rings of metal.

[0021] Snap rings 22 are intended to surround the exterior circumference of the inner end cap 23. By surrounding the outer circumference of the inner end cap 23, the snap ring 22 occupies any void that exists between the inner ring of a Standard End Cap's open-

ing and the outer circumference of an inner end cap 23. An example of such a void can be seen at Ref. No. 26 in FIG. 13.

[0022] By eliminating any void 26 between the Standard End Cap 21 and the inner end cap 23, the snap ring 22 creates a snug fit that holds the inner end cap 23 in place and allows the assembly to function as a TCP End Cap.

[0023] Similar uses of end caps and snap rings in the manner described above are known in the prior art (see, e.g., U.S. Pat. No. 5,632,348; U.S. Pat. No. 6,009,947; U.S. Pat. No. 9,284,824). But problem with the use of snap rings 22 is that they require persons in the industry to maintain a stock of three parts: the Standard End Caps 21, the inner end caps 23, and the snap rings 22. The invention disclosed herein, which Applicant was unable to locate in any prior art, permits a Standard End Cap to be adapted to function as a TCP End Cap utilizing only a Standard End Cap and an inner end cap.

SUMMARY OF THE INVENTION

[0024] The present invention provides a method for adapting a Standard End Cap assembly into a TCP end cap assembly by employing an inner end cap that includes "anchors" and a Standard End Cap that includes "receivers." The inner end cap with anchors is placed into the opening of the Standard End Cap with receivers, then the inner end cap is rotated until the anchors on the inner end cap interlock with the receivers on the Standard End Cap, resulting in a snug fit that functions as a TCP end cap. The present invention also provides an alternative assembly, wherein the inner end cap includes receivers and the Standard End Cap includes anchors.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The drawings included herewith are not intended to in any way limit the scope of the invention disclosed herein. The drawings are merely included to clarify and exemplify the invention as disclosed and claimed herein.

[0026] FIG. 1 shows a standard perforating gun with standard circular-shaped scallops and a cross-sectional view of the same.

[0027] FIG. 2 shows a cross-sectional and standard view of a perforating gun with charges loaded below circular scallops.

[0028] FIG. 3 shows a standard charge that may be loaded beneath a scallop in a perforating gun.

[0029] FIG. 4 shows a comparative view of a perforating gun with elliptical shaped scallops and a perforating gun with circular shaped scallops.

[0030] FIG. 5 shows the milling of a scallop in a perforating gun using the industry's current method, which does not create scallops of substantially uniform thickness.

[0031] FIG. 6 shows a scallop created using the industry's current method.

[0032] FIG. 7 shows an example of the method of creating scallops of substantially uniform thickness.

[0033] FIG. 8 shows a scallop created of substantially uniform thickness.

[0034] FIG. 9 shows a perforating gun that includes pliable arms to hold charges in place and pliable tabs to hold primer cord in place.

[0035] FIG. 10 shows a string of perforating guns.

[0036] FIG. 11 shows a Standard End Cap assembly.

[0037] FIG. 12 shows a TCP end cap assembly.

[0038] FIG. 13 shows a snap ring assembly used to adapt a Standard End Cap into a TCP end cap assembly.

[0039] FIG. 14 shows the present invention for adapting a Standard End Cap into a TCP end cap assembly using an inner end cap with anchors and a Standard End Cap with receivers.

[0040] FIG. 15 shows an alternative version of the present invention for adapting a Standard End Cap into a TCP end cap assembly where the inner end cap includes receivers and the Standard End Cap includes anchors.

[0041] FIG. 16 shows generally how perforating guns are used to create subterranean fissures that facilitate the extraction of energy resources.

[0042] FIG. 17 shows generally how perforating guns are used to create subterranean fissures that facilitate the extraction of energy resources.

DETAILED DESCRIPTION OF THE INVENTION

[0043] The present invention comprises a two-piece assembly that allows a user to adapt a Standard End Cap into a TCP End Cap. Referring to FIG. 14, one embodiment of the present invention includes an inner end cap 15 that includes anchors 14. As can be seen in FIG. 14, the anchors 14 are discrete raised surfaces (such as a “bumps,” “wedges,” “arms,” etc.) that are included on the inner end cap. In the embodiment shown in FIG. 14, the anchors 14 are included on the outer circumference 15 of the inner end cap. As also can be seen in FIG. 14, the inner ring of the Standard End Cap 3 includes “receivers” 20, which are indentations in the Standard End Cap that correspond in shape and size to the anchors 14 on the inner end cap. In the embodiment shown in FIG. 14, the receivers 20 are included on the inner ring of the Standard End Cap 3.

[0044] The embodiment of the present invention shown in FIG. 14 works to secure the inner end cap 15 within the opening of the Standard End Cap 3 as follows:

[0045] An inner end cap 15 with an anchor 14 is placed into the opening of a Standard End Cap 3 with a receiver 20.

[0046] The inner end cap 15 is then rotated until the anchor 14 is forced into the receiver 20.

[0047] When the anchor 14 is forced into the receiver 20, the inner end cap 15 and the Standard End Cap 3 become interlocked, resulting in a snug fit without needing an additional part in the form of a snap ring.

[0048] It should be noted that, within the industry, inner end caps are manufactured to fit relatively snugly within the opening of a Standard End Cap.

[0049] It should also be noted that the invention disclosed herein can function by placing the anchor(s) on the Standard End Cap and the receiver(s) on the inner end cap. FIG. 15 depicts this type of alternative assembly, where the inner end cap 29 includes a receiver 30 and the inner ring of the Standard End Cap includes an anchor 28. Thus, any configuration by which an inner end cap is held within the opening of a Standard End Cap by creating a raised surface on one of the components that interlocks with a recessed portion on the other component, as such interlocking is described herein, should be considered within the scope of the invention disclosed herein.

[0050] It should also be noted that multiple anchors and receivers may be used in a single assembly. Thus, a single inner end cap or Standard End Cap may have one or more anchors intended to respectively interlock with one or more receivers on a corresponding Standard End Cap or inner end cap.

[0051] Those with skill in the art will recognize that the anchors can be any shape or size that can be included on the inner end cap or Standard End Cap and that can interlock with the receivers included on a corresponding Standard End Cap or inner end cap. Those with skill in the art will also recognize that receivers can be any shape or size that can be included on the Standard End Cap or inner end cap and that can interlock with the anchors included on a corresponding inner end cap or Standard End Cap. Thus, the essence of the invention is including on either an inner end cap or a Standard End Cap any raised or recessed feature that can interlock with a corresponding raised or recessed feature on a corresponding Standard End Cap or inner end cap, so as to create a substantially voidless, snug fit between the inner end cap and the Standard End Cap without needing an additional part in the form of a snap ring.

[0052] In addition, the anchors and receivers may be included, respectively, on other surfaces of the inner end cap and the Standard End Cap. The only requirement of the present invention relative to the location of anchors and receivers is that the anchors and receivers must be able to sync, such that the inner end cap and Standard End Cap form an interlocked, snug fit that results from the anchors interlocking with the receivers.

[0053] Having thus described the invention, what is desired to be protected by Letters Patent is presented in the subsequently appended claims.

What is claimed is:

1. A method of adapting a Standard End Cap assembly of a perforating gun to function as a Tubing Conveyed Perforating end cap assembly of a perforating gun, comprising:
 - a) a Standard End Cap that includes at least one receiver;
 - b) an inner end cap that includes at least one anchor;
 - c) whereby the inner end cap is inserted into an opening of the Standard End Cap; and
 - d) wherein the at least one anchor on the inner end cap interlocks with the at least one receiver on the Standard End Cap.
2. The method of adapting a Standard End Cap assembly of a perforating gun to function as a Tubing Conveyed Perforating end cap assembly of a perforating gun claimed in claim 1, wherein the at least one receiver is included on the inner ring of the Standard End Cap and the at least one anchor is included on the outer circumference of the inner end cap.
3. A method of adapting a Standard End Cap assembly of a perforating gun to function as a Tubing Conveyed Perforating end cap assembly of a perforating gun, comprising:
 - a) an inner end cap that includes at least one receiver;
 - b) a Standard End Cap that includes at least one anchor;
 - c) whereby the inner end cap is inserted into an opening of the Standard End Cap; and
 - d) wherein the at least one anchor on the Standard End Cap interlocks with the at least one receiver on the inner end cap.
4. The method of adapting a Standard End Cap assembly of a perforating gun to function as a Tubing Conveyed Perforating end cap assembly of a perforating gun claimed

in claim 3, wherein the at least one receiver is included on the outer circumference of the inner end cap and the at least one anchor is included on the inner ring of the Standard End Cap.

5. An apparatus for adapting a Standard End Cap assembly of a perforating gun to function as a Tubing Conveyed Perforating end cap assembly of a perforating gun, comprising:

- a) an inner end cap;
- b) a Standard End Cap; and
- c) whereby the inner end cap is able to interlock with the Standard End Cap when the inner end cap is inserted into an opening of the Standard End Cap.

6. The apparatus claimed in claim 5, wherein:

- a) the Standard End Cap includes at least one receiver; and

- b) the inner end cap includes at least one anchor.

7. The apparatus claimed in claim 5, wherein:

- a) the Standard End Cap includes at least one anchor; and
- b) the inner end cap includes at least one receiver.

* * * * *