US00RE47339E

(19) **United States**
(12) **Reissued Patent**
Sites, Jr.

(10) **Patent Number: US RE47,339 E**
(45) **Date of Reissued Patent: Apr. 9, 2019**

(54) **PERFORATION GUN WITH ANGLED SHAPED CHARGES**

(71) Applicant: **Joseph A Sites, Jr.**, Venetia, PA (US)

(72) Inventor: **Joseph A Sites, Jr.**, Venetia, PA (US)

(21) Appl. No.: **15/270,283**

(22) Filed: **Sep. 20, 2016**

Related U.S. Patent Documents

Reissue of:
(64) Patent No.: **9,145,763**
Issued: **Sep. 29, 2015**
Appl. No.: **13/471,597**
Filed: **May 15, 2012**

(51) **Int. Cl.**
E21B 43/117 (2006.01)
E21B 43/119 (2006.01)

(52) **U.S. Cl.**
CPC *E21B 43/117* (2013.01); *E21B 43/119* (2013.01)

(58) **Field of Classification Search**
CPC E21B 43/117; E21B 43/119
USPC 175/4.57, 4.6; 166/297, 55
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,011,551 A 12/1961 Young et al.
3,419,070 A 12/1968 Ernst
4,583,602 A * 4/1986 Ayers 175/4.52
4,753,301 A * 6/1988 Berry 175/4.6
5,544,711 A * 8/1996 Aitken E21B 43/117 166/55
5,598,591 A * 2/1997 Kelley A47C 17/80 254/122
5,598,891 A 2/1997 Snider et al.
5,775,426 A * 7/1998 Snider E21B 37/08 166/297
5,797,464 A * 8/1998 Pratt et al. 175/4.6
5,894,888 A 4/1999 Wiemers et al.
6,286,598 B1 9/2001 van Petegem et al.
6,758,124 B2 * 7/2004 Barker E21B 43/117 102/310
6,851,471 B2 * 2/2005 Barlow et al. 166/55.2
7,303,017 B2 * 12/2007 Barker et al. 166/297
7,409,992 B2 * 8/2008 Zazovsky et al. 166/297
7,762,351 B2 * 7/2010 Vidal E21B 43/117 175/4.6
7,913,758 B2 3/2011 Wheller et al.
8,033,333 B2 10/2011 Frazier et al.
8,127,848 B2 * 3/2012 Myers et al. E21B 43/119 166/297
8,327,746 B2 * 12/2012 Behrmann et al. 89/1.15
8,684,083 B2 * 4/2014 Torres et al. 166/297
8,769,795 B2 * 7/2014 Kash et al. 29/458

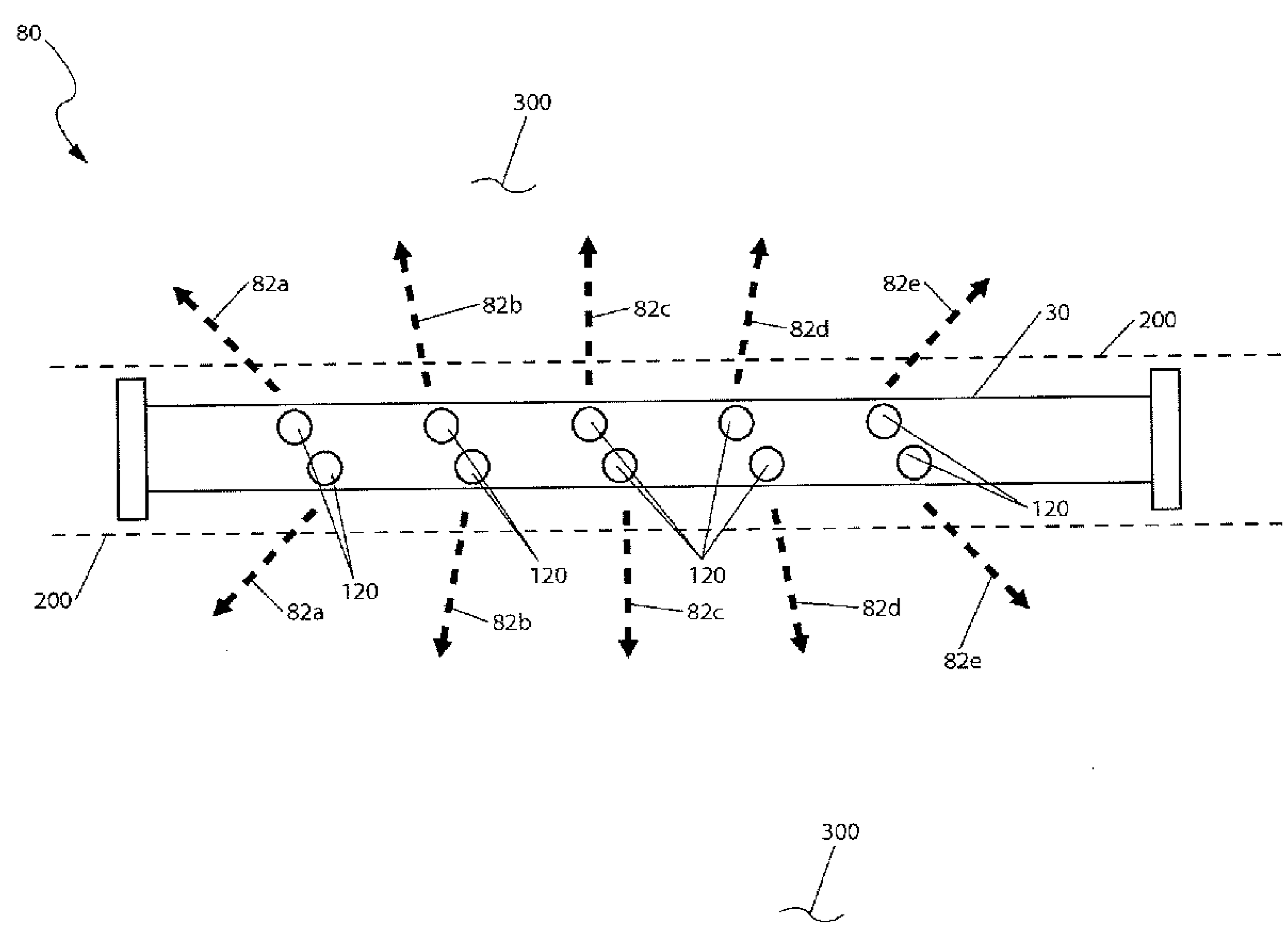
(Continued)

Primary Examiner — Jeffrey R Jastrzab
(74) *Attorney, Agent, or Firm* — Metz Lewis Brodman Must O'Keefe LLC

(57) **ABSTRACT**

A perforation gun which provides a means to create perforations required for the hydraulic fracturing of rock formations for the production of natural gas, oil, and other oil well fluids and further comprises a gun body assembly having an inserted carrier tube to nest shaped charge canisters with built in primers, conical liner, and explosive material. The charges are positioned in various angular patterns along various phase angles to create specifically directed perforation tunnels which puncture scalloped areas of the aforementioned gun body and subsequently penetrate through the wellbore, well casing, well cement, and into the rock formations for the release and removal of natural gas, oil, and other oil well fluids after hydraulic fracturing.

40 Claims, 9 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

2004/0118607	A1*	6/2004	Brooks	E21B 43/119 175/4.51
2005/0247447	A1	11/2005	Spring et al.	E21B 43/117 166/55.2
2005/0263286	A1*	12/2005	Sheffield	E21B 47/122 166/297
2006/0118303	A1*	6/2006	Schultz et al.	166/297
2010/0089643	A1*	4/2010	Vidal	E21B 43/117 175/2
2010/0269676	A1	10/2010	Behrmann et al.	
2011/0209871	A1	9/2011	Le et al.	
2013/0019770	A1*	1/2013	Walker	E21B 43/117 102/322

* cited by examiner

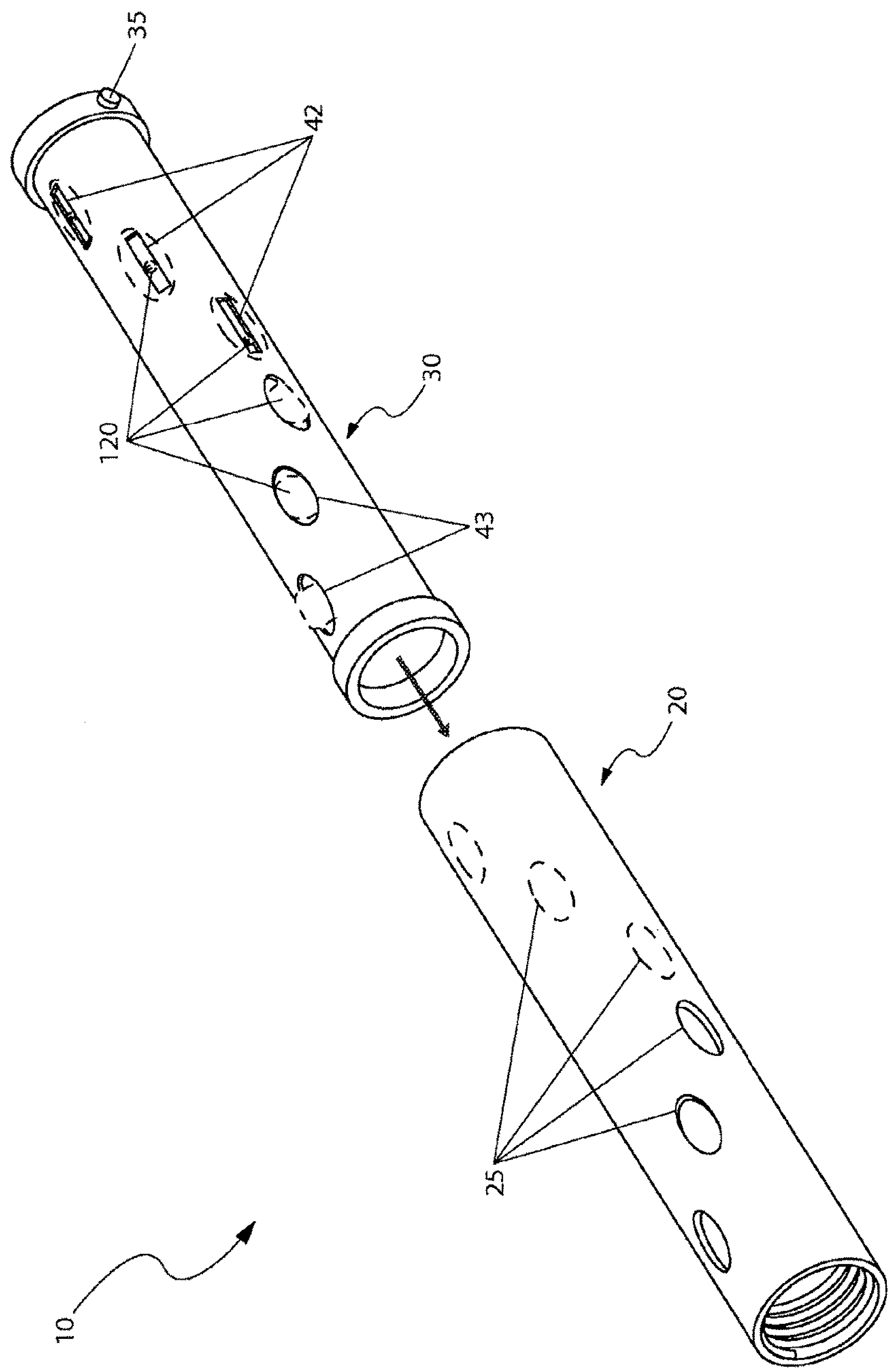


Fig. 1

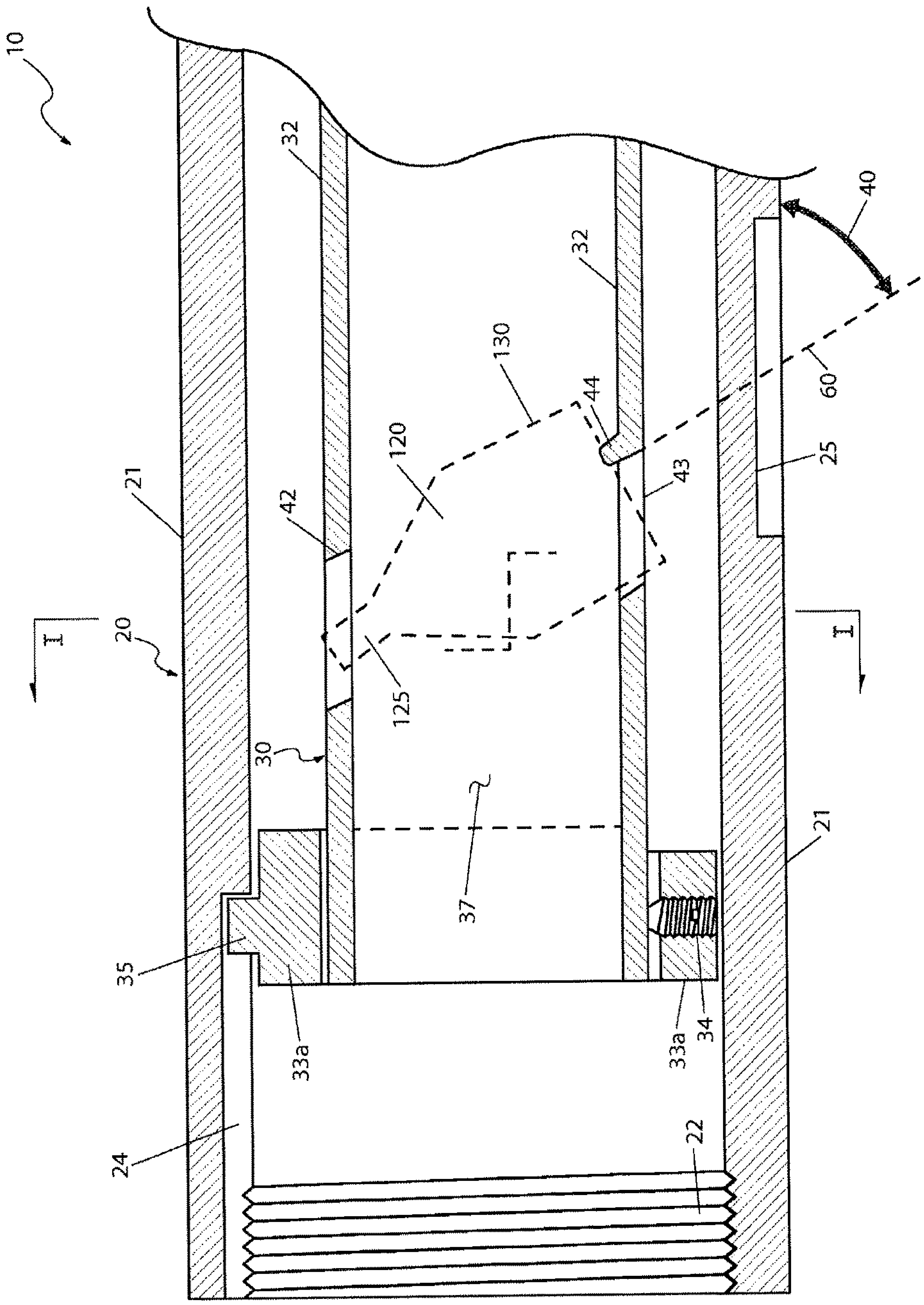

10
32
32
40
130
44
60
120
25
21
42
43
I
20
I
125
30
21
37
35
33a
33a
34
24
22

Fig. 2a

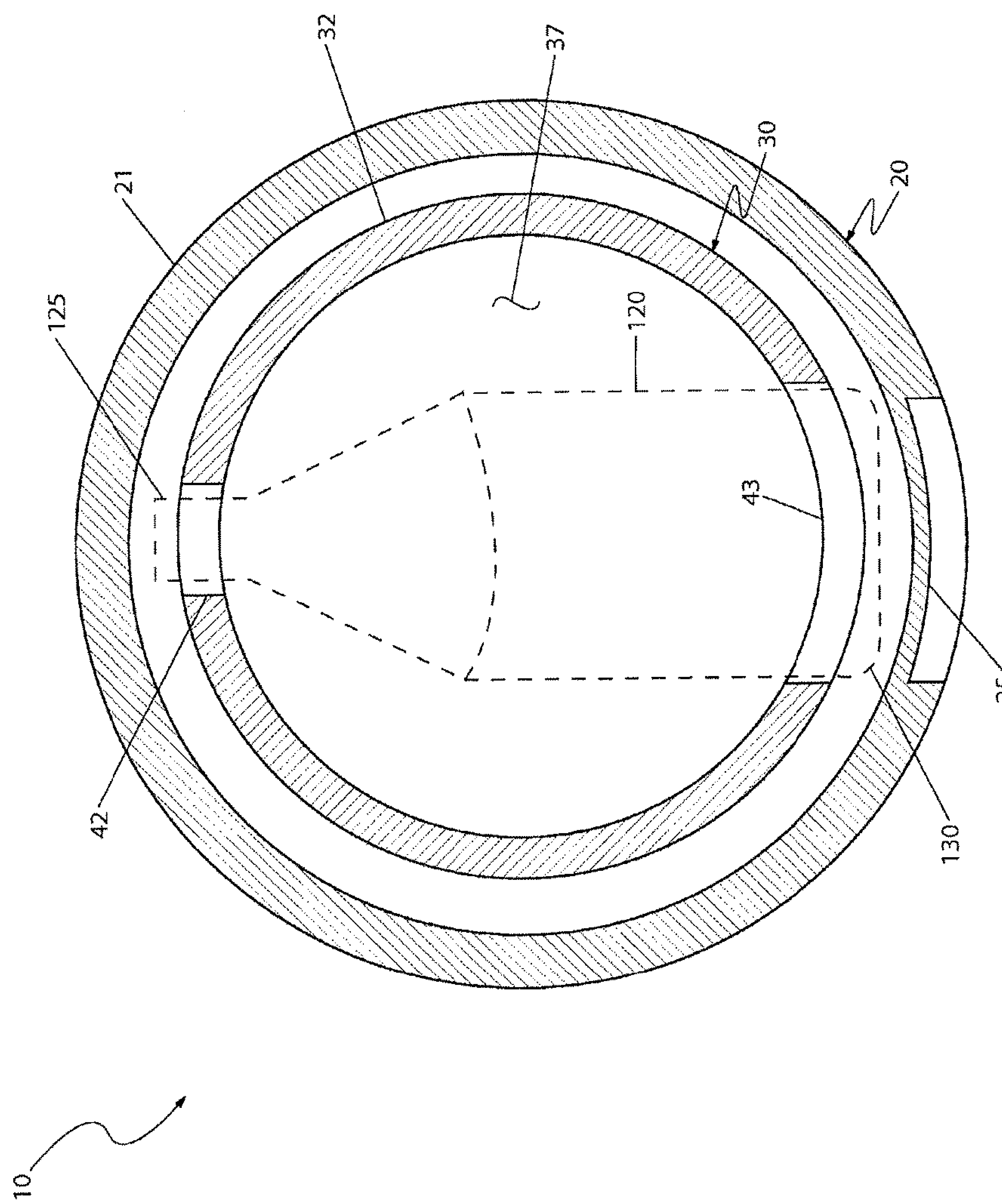


Fig. 2b

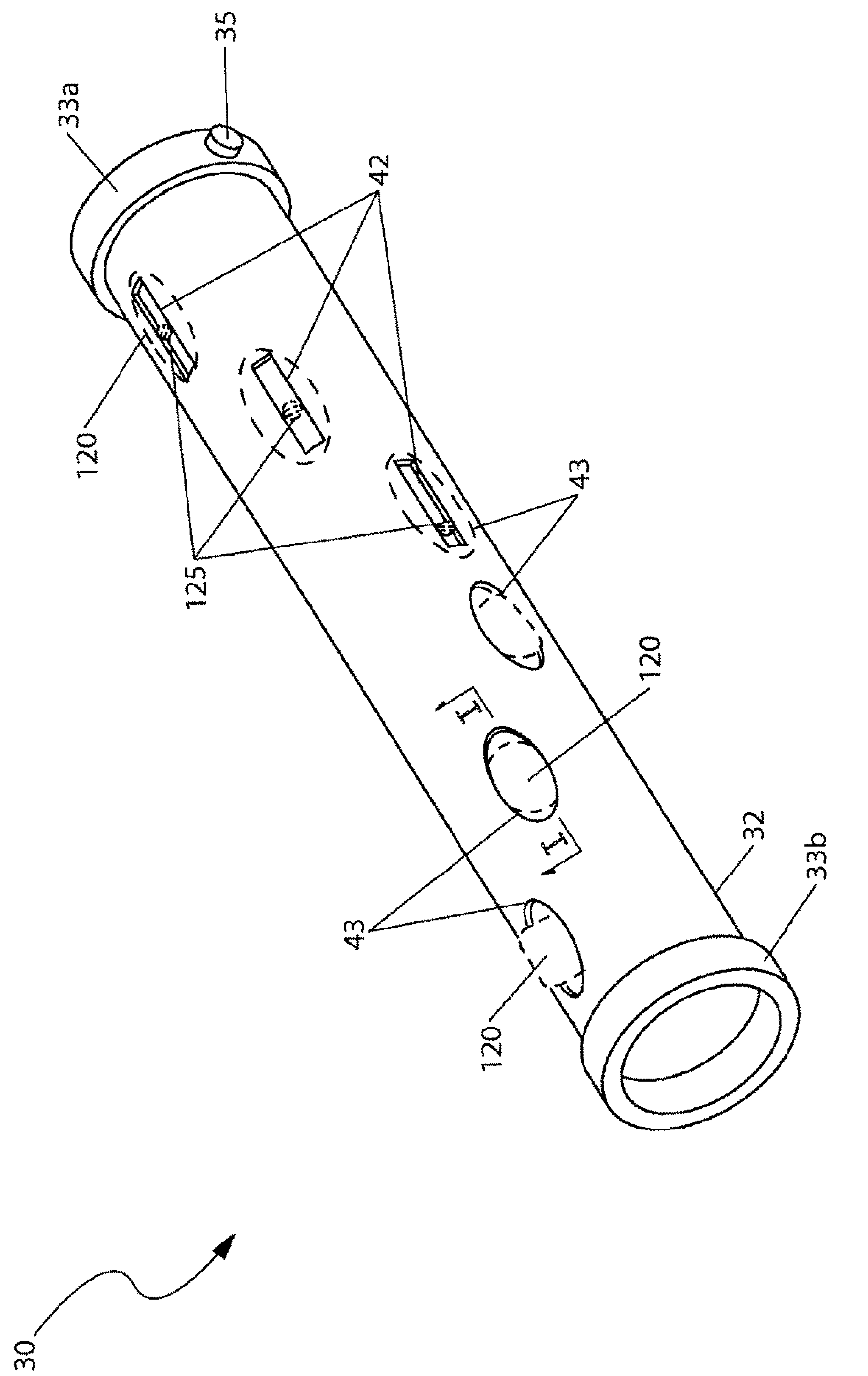
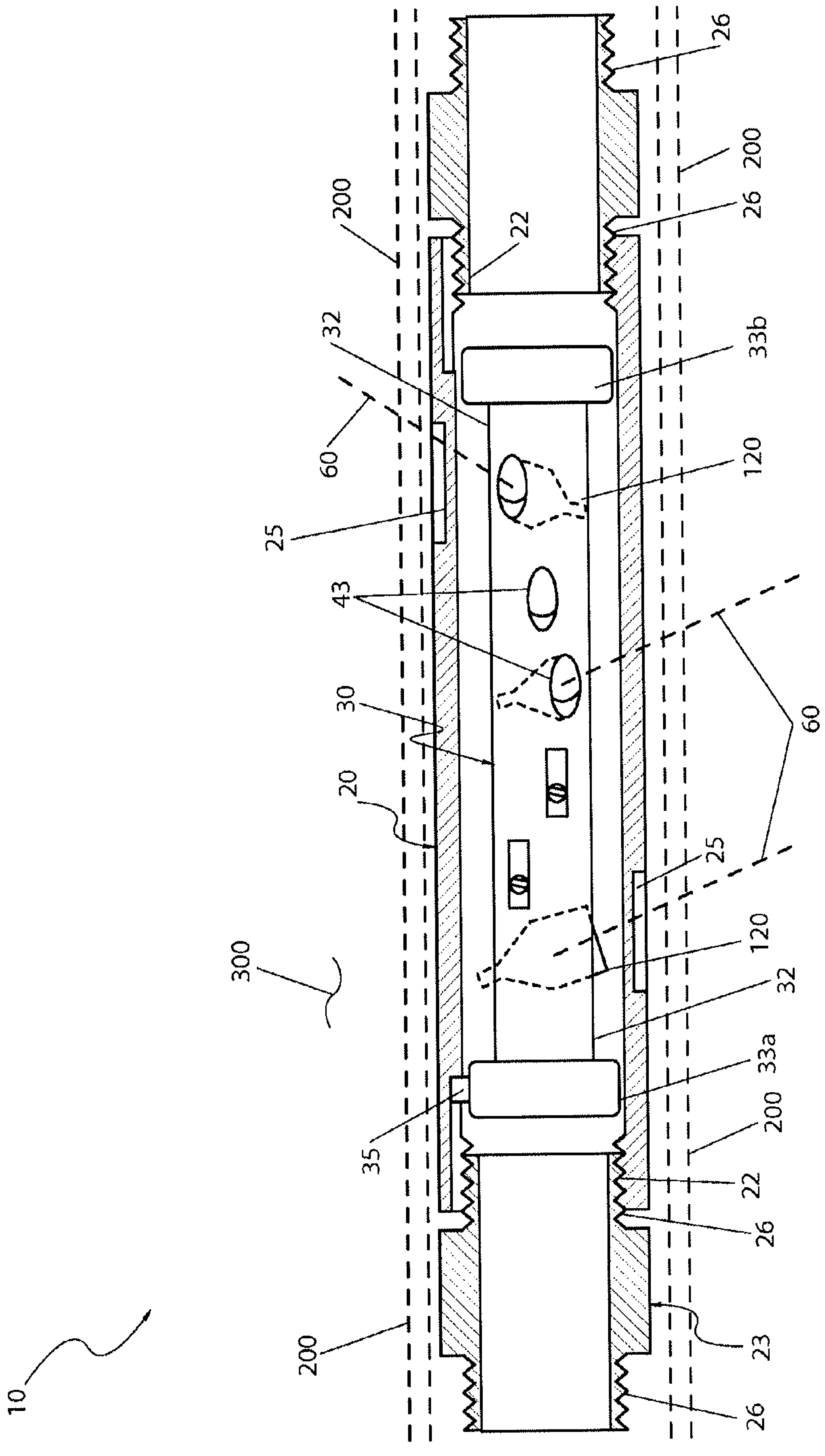


Fig. 3



26
200
26
22
200
32
33b
60
120
25
43
30
60
20
25
300
120
32
300
33a
35
200
22
26
23
200
26
10

Fig. 4

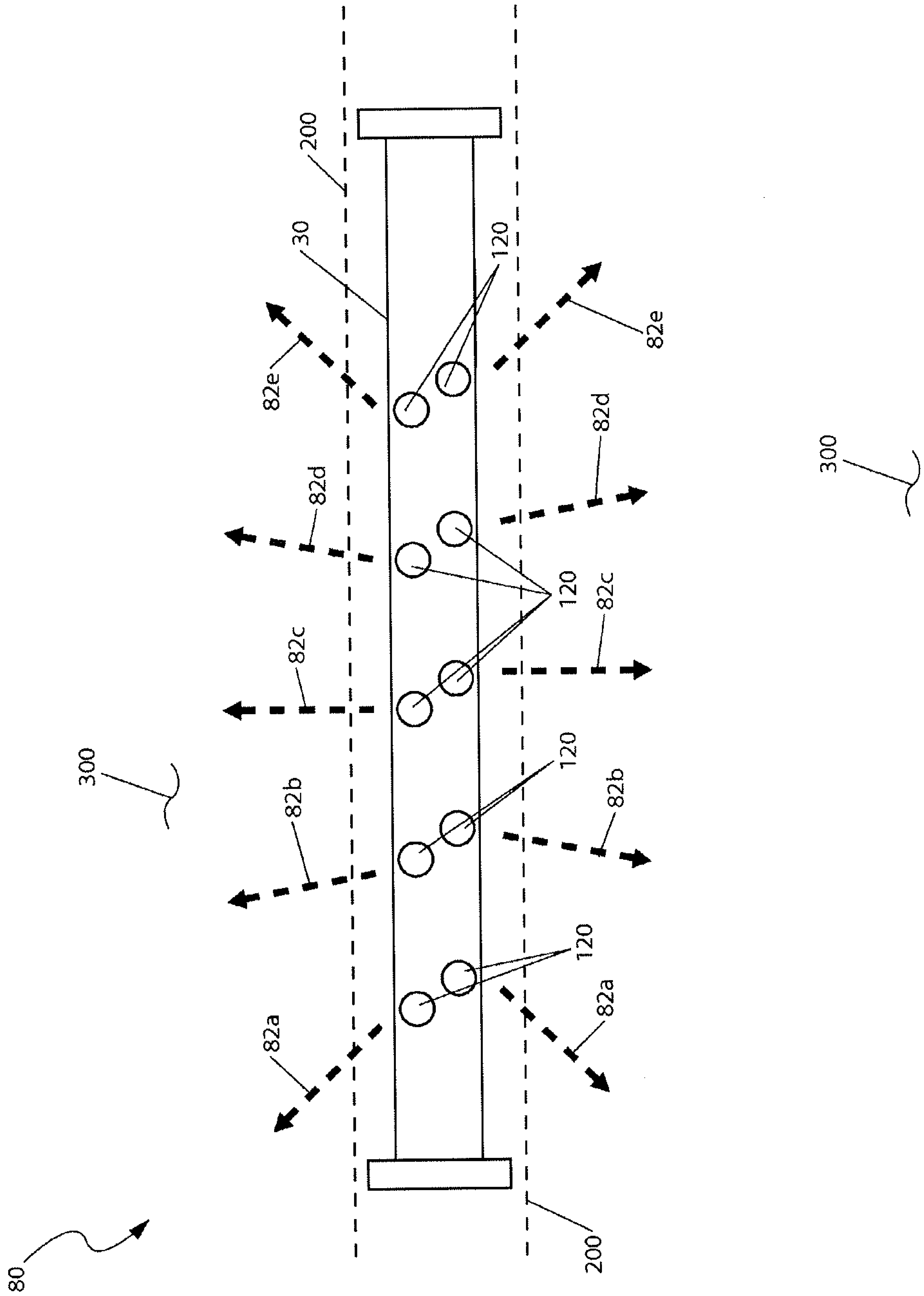

200
30
120
82e
82e
82d
82d
300
120
82c
82c
300
120
82b
82b
120
82a
82a
200
80

Fig. 5

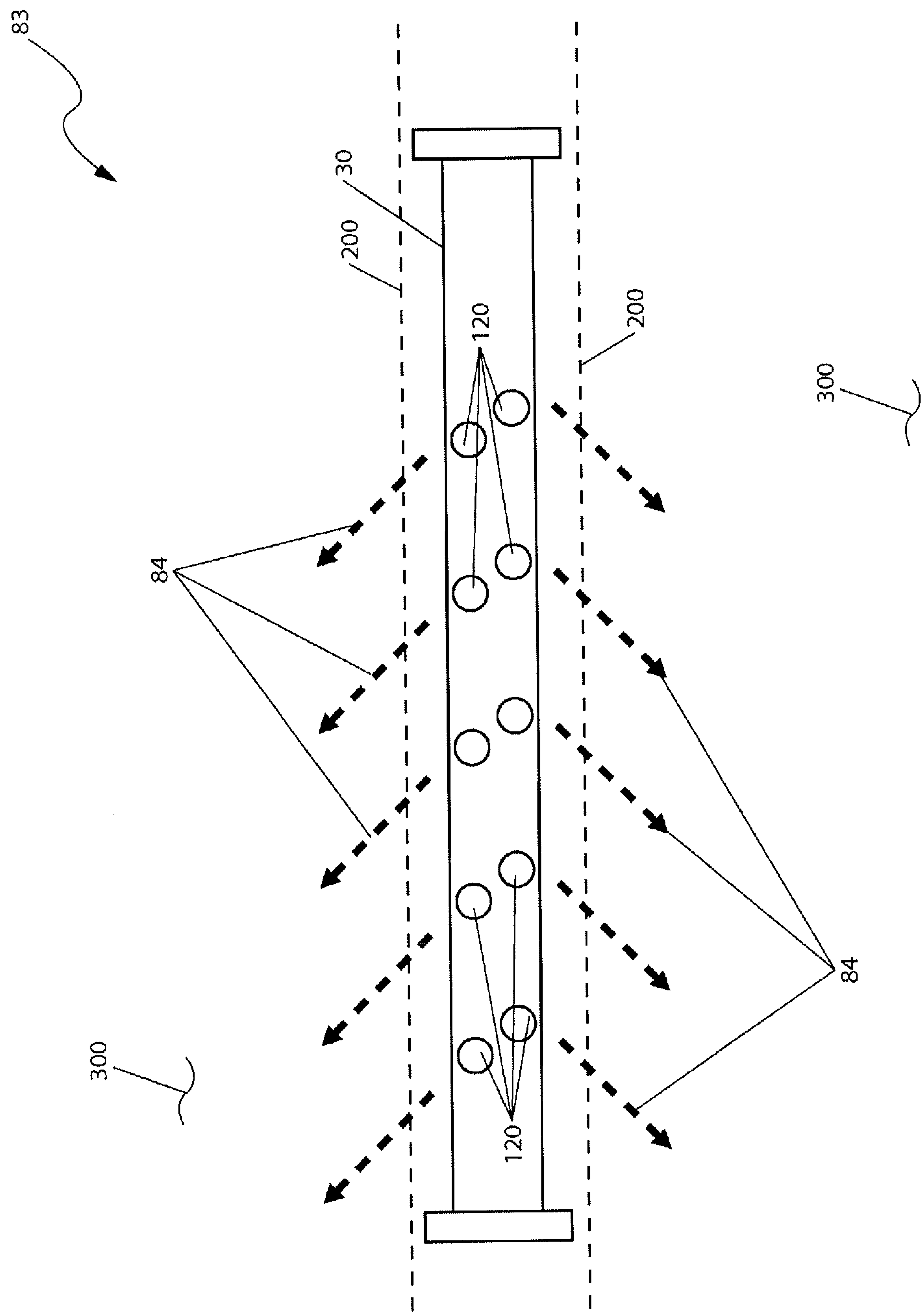


Fig. 6a

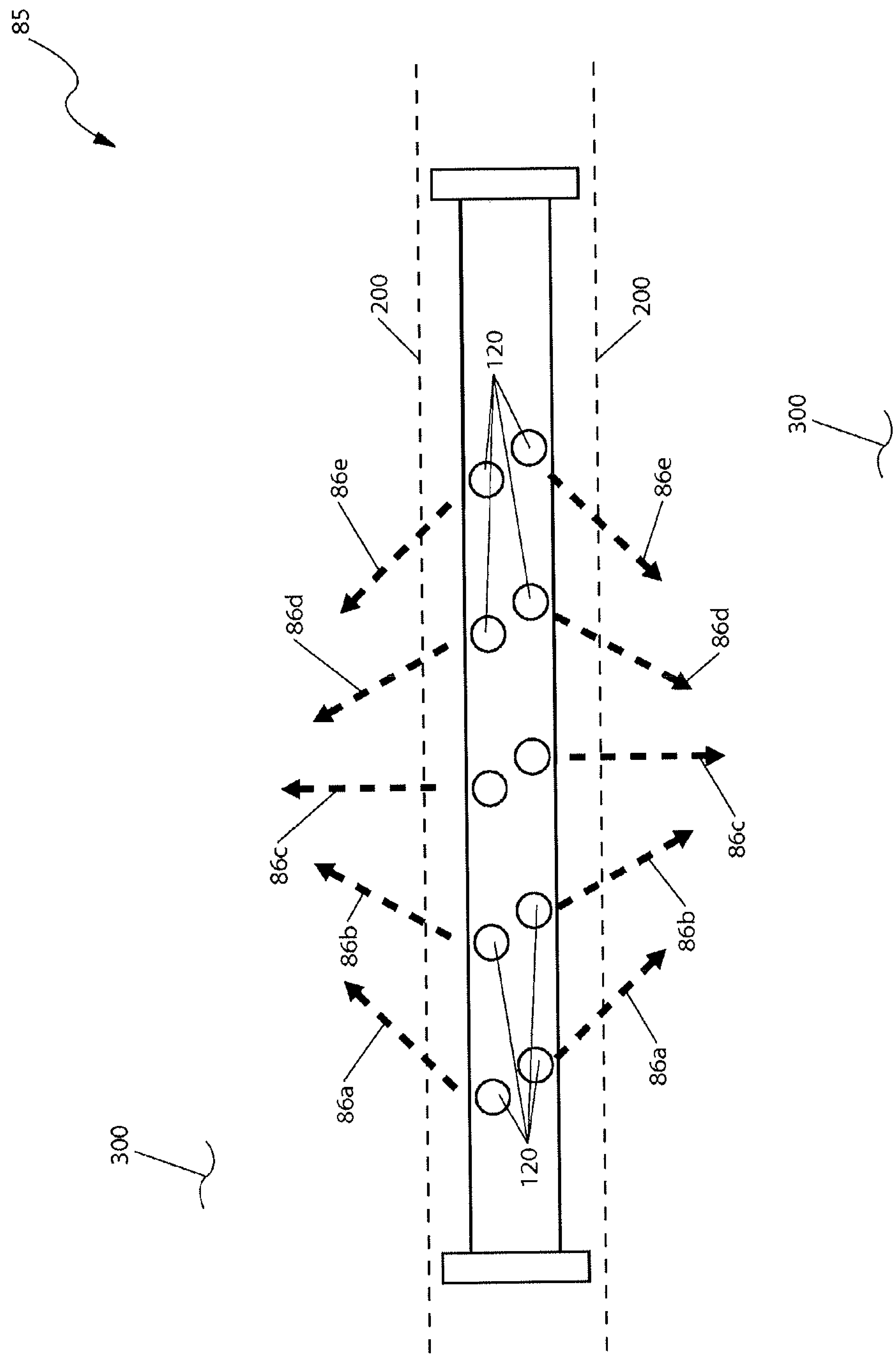

85
200
200
120
300
86e
86e
86d
86d
86c
86c
86b
86b
86a
86a
120
300

Fig. 6b

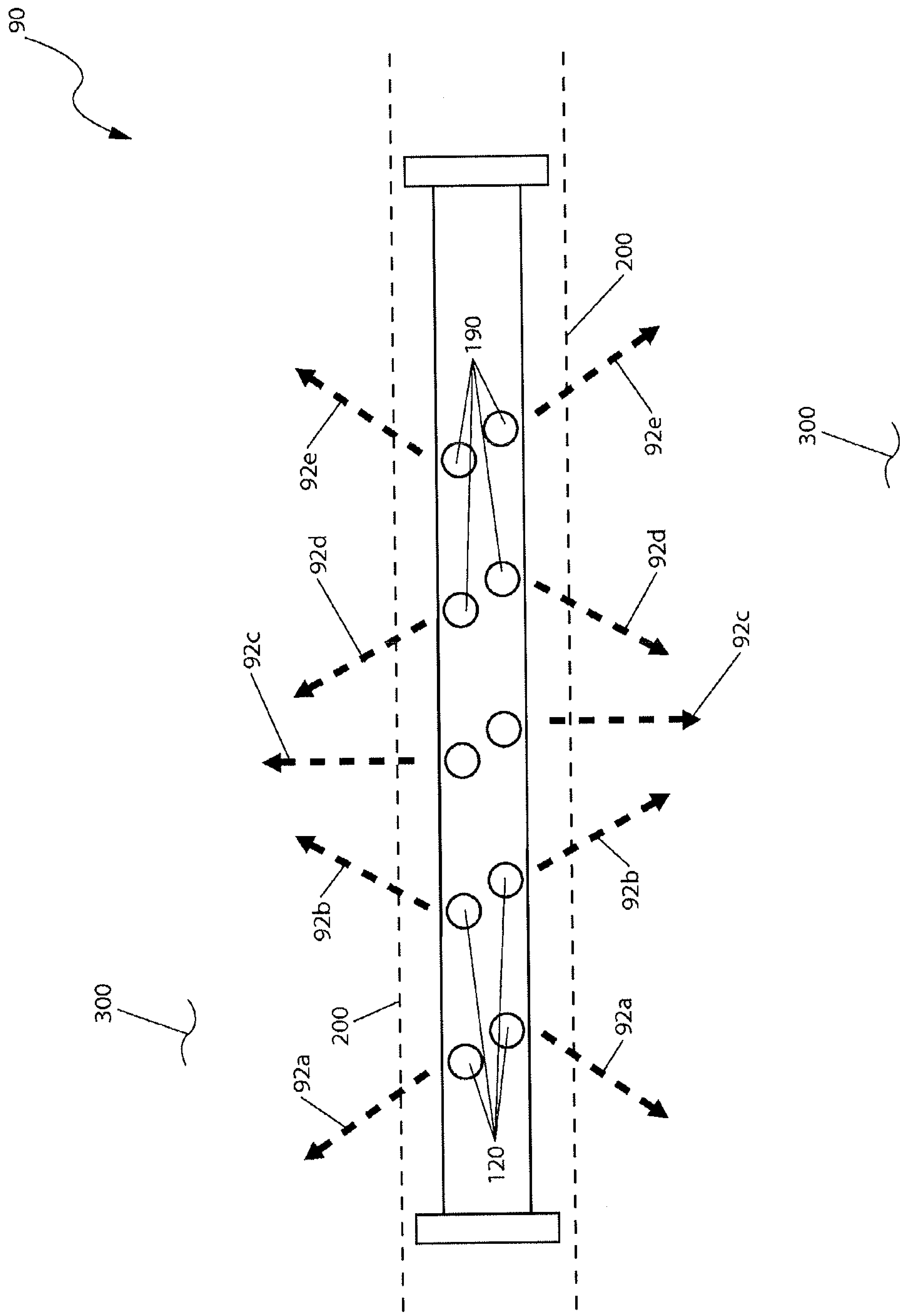

90
200
190
92e
92e
300
92d
92d
92c
92c
92b
92b
300
200
92a
92a
120

Fig. 6c

PERFORATION GUN WITH ANGLED SHAPED CHARGES

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.

RELATED APPLICATIONS

There are currently no applications co-pending with the present application.

FIELD OF THE INVENTION

The presently disclosed subject matter is directed to hydraulic fracturing of rock formations for the production of natural gas, oil, and other well fluids. More particularly this invention relates to well perforation guns that use shaped charges to create directed hydraulic fracturing perforation tunnels.

BACKGROUND OF THE INVENTION

One (1) of the largest and more important industries in the world is energy production. A simple basic fact is that the world in general and America in particular needs energy.

There are many different types of energy: coal, hydro, solar, nuclear, wind and fossil fuels (non-coal fossil fuels). Coal has a reputation for being dirty and shares with nuclear a reputation as being a source of dangerous pollution. Hydro power has been almost fully developed in the United States. Wind and solar power while attractive are unproven as reliable large scale sources of power. However, fossil fuels are well known and widely used sources of power, particularly for vehicle and heating fuels.

Fossil fuels have been widely used for well over a hundred years. The main problems with fossil fuels include price, which is a function of availability. Recovering fossil fuels is become increasingly more difficult as new fields are seldom encountered. However, newer recovery methods have increased the amount of fossil fuels that can be obtained from known fields.

The newer recovery methods include hydraulic fracturing. Hydraulic fracturing is based on creating and propagating fractures in a geological formation by first using explosive shaped charges to create perforation tunnels and subsequently pumping liquids and propant material through the perforation tunnels into the geological formation. Hydraulic fractures enable gas and petroleum contained in the source rocks to migrate into a well where the fossil fuel can be recovered using well-known techniques.

Hydraulic fracturing is not without its problems and technical challenges. Creating effective perforation tunnels is not in itself trivial. Producing controlled explosions within a well bore to create effective perforation tunnels is even more difficult. First the explosion must be at the proper well depth. This typically requires drilling a well to the proper depth followed by the insertion of one (1) or more perforation guns containing explosive charges. Then, for maximum effect the perforation tunnels must be directed towards a desired direction. Since that location might be up, sideways, down, or at a particular angle the explosive charges should be both shaped to form a tight, effective perforation tunnel and directed towards the proper orientation. At well depth both of these desired attributes are difficult to accomplish.

Therefore, a new perforation gun that produces tight, controlled, and effective perforation tunnels in the desired direction would be beneficial. Even more beneficial would be a new perforation gun capable of producing controlled and enhanced perforation tunnels.

SUMMARY OF THE INVENTION

The principles of the present invention provide for a new explosive perforation gun that produces tight, controlled, and effective perforation tunnels in the desired direction. The perforation gun is capable of producing controlled and enhanced effect perforation tunnels.

A perforation gun that is in accord with the present invention includes an outer gun body assembly having a straight steel pipe casing with internal female threads at each end, a plurality of external recessed areas, and an orientation slot extending inward from one (1) end of the steel pipe. The perforation gun further includes a carrier tube assembly having a linear charge tube, a first collar having an external alignment pin that is dimensioned to slide into the orientation slot and which is located at one (1) end of the charge tube, a second collar at the opposite end of the charge tube, a plurality of shaped charge saddle slots through the charge tube, and a plurality of shaped charge body apertures through the charge tube, wherein the plurality of shaped charge saddle slots and the plurality of shaped charge body apertures form a plurality of shape charge holders, and wherein the charge tube is a length of straight steel pipe that is slightly shorter than said outer gun body assembly. The perforation gun further includes a plurality of shaped charges, each having a shaped charge saddle, each having a charge base, and each of which is located in an associated shape charge holder of the plurality of shape charge holders. The carrier tube assembly is inserted into the outer gun body assembly such that the alignment pin slides into the orientation slot to control the orientation of the plurality of shape charges with respect to the external recessed areas.

BRIEF DESCRIPTION OF THE DRAWINGS

The advantages and features of the present invention will become better understood with reference to the following more detailed description and claims taken in conjunction with the accompanying drawings in which like elements are identified with like symbols and in which:

FIG. **1** is an exploded perspective view of a perforation gun **10** having angled shaped charges according to a preferred embodiment of the present invention;

FIG. **2**a is a side cut-away view of the perforation gun **10** shown in FIG. **1**;

FIG. **2**b is a section view of the perforation gun **10** taken along section line I-I of FIG. **2**a;

FIG. **3** is a perspective view of a carrier tube assembly **30** of the perforation gun **10** shown in FIG. **1**;

FIG. **4** is a side cut-away view of the perforation gun **10** shown in FIGS. **1** and **3** in use;

FIG. **5** is an exemplary perforation tunnel vector diagram for the perforation gun **10** shown in FIGS. **1**, **3**, and **4** according to a preferred fan-shot embodiment **80**;

FIG. **6**a is an exemplary perforation tunnel vector diagram for the perforation gun **10** using a down-shot embodiment **83**;

FIG. 6b is an exemplary perforation tunnel vector diagram of a limited-entry embodiment **85** of the invention; and,

FIG. 6c is an exemplary fracture perforation tunnel vector diagram of a combined-limited-entry-fan-shot embodiment **90** of the invention.

DESCRIPTIVE KEY

10 perforation gun
20 outer gun body assembly
21 steel pipe casing
22 female threaded region
23 male threaded coupling
24 orientation slot
25 recessed area
26 male threaded region
30 carrier tube assembly
32 charge tube
33a first collar
33b second collar
34 set screw
35 orientation/alignment pin
37 carrier interior space
40 perforation tunnel vector angle
42 shaped charge saddle slot
43 shaped charge body aperture
44 clip feature
60 perforation tunnel vector
80 fan-shot embodiment
82a first fan perforation tunnel vector
82b second fan perforation tunnel vector
82c third fan perforation tunnel vector
82d fourth fan perforation tunnel vector
82e fifth fan perforation tunnel vector
83 down-shot embodiment
84 down-shot perforation tunnel vector
85 limited-entry embodiment
86a first limited-entry perforation tunnel vector
86b second limited-entry perforation tunnel vector
86c third limited-entry perforation tunnel vector
86d fourth limited-entry perforation tunnel vector
86e fifth limited-entry perforation tunnel vector
90 combined limited-entry-fan-shot embodiment
92a first combined perforation tunnel vector
92b second combined perforation tunnel vector
92c third combined perforation tunnel vector
92d fourth combined perforation tunnel vector
92e fifth combined perforation tunnel vector
120 shaped charge canister
125 shaped charge saddle
130 charge base
200 well casing
300 geological formation

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The best mode for carrying out the invention is presented in terms of its preferred embodiment, herein depicted within FIGS. **1** through **6**c, and a person skilled in the art will appreciate that many other embodiments of the invention are possible without deviating from the basic concept of the invention, and that any such work around will also fall under scope of this invention. It is envisioned that other styles and configurations of the present invention can be easily incorporated into the teachings of the present invention, and only one particular configuration shall be shown and described for purposes of clarity and disclosure and not by way of limitation of scope.

The terms “a” and “an” herein do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced items.

Referring to FIGS. **1**, **2**a, and **2**b, the principles of the present invention provide for a perforation gun **10** that uses angled shaped charges **120** to explosively perforate geological formations **300**. The perforation gun **10** is first placed inside a well casing **200** (see FIG. **4**), the shaped charges **120** are directed to the desired direction, and then the shaped charges **120** are exploded to create fracture patterns that assist extraction of natural gas, oil, and other oil well fluids.

The perforation gun **10** comprises an outer gun body assembly **20** that receives and accurately positions a carrier tube assembly **30**. The outer gun body assembly **20** and the carrier tube assembly **30** are aligned and machined so as to position a plurality of internal shaped charges **120** which create interactive angled perforation tunnel vectors into geological formation **300** (see FIGS. **4** through **6**c) upon detonation. Those vectors aid hydraulic fracturing of the geological formation **300** and the release and capture of natural gas, oil, and other oil well fluids.

Each outer gun body assembly **20** includes a variable length of a specially machined straight steel pipe casing **21** that has internal female threaded regions **22** machined at each end, and a plurality of external machined recessed areas **25**. The female threaded regions **22** enable any number of outer gun body assemblies **20** to be attached together in an “end-to-end” manner using interconnecting male threaded couplings **23** (see FIG. **4**). The recessed areas **25** of the outer gun body assembly **20**, which are preferably circular, oval, or rectangular shaped to a depth of approximately one-half (½) of the thickness of the steel pipe casing **21** are arranged to align with corresponding shaped charges **120** that are positioned within the carrier tube assembly **30**. Upon detonation, the recessed areas **25** provide weak sections of steel pipe casing **21** that are readily punctured by the perforation jets produced by the exploding shaped charges **120**.

The outer gun body assembly **20** includes an orientation slot **24** along an inside surface at one (1) end of the steel pipe casing **21**. The orientation slot **24** accurately orientates the carrier tube assembly **30** within the outer gun body assembly **20**. The orientation slot **24** works in conjunction with a corresponding orientation/alignment pin **35** of the carrier tube assembly **30**. The orientation/alignment pin **35** is a cylindrically-shaped feature having a diameter sized to provide a sliding fit in the orientation slot **24**.

During loading of the carrier tube assembly **30** into the outer gun body assembly **20** the orientation/alignment pin **35** is positioned at a trailing end of the carrier tube assembly **30** during insertion. To completely insert the carrier tube assembly **30** into the outer gun body assembly **20** the orientation/alignment pin **35** slides into the orientation slot **24** to properly establish the correct theta (rotational) position of the carrier tube assembly **30** within the outer gun body assembly **20**. Complete insertion happens when the orientation/alignment pin **35** abuts the inward end of the orientation slot **24**. This longitudinally and rotationally positions the carrier tube assembly **30** within the outer gun body assembly **20** which is then held in place with a recessed snap ring.

Referring now primarily to FIGS. **2**a and **3**, the carrier tube assembly **30** includes a linear charge tube **32**, a first collar **33**a, a second collar **33**b, a plurality of shaped charge saddle slots **42**, and a plurality of shaped charge body apertures **43**. The charge tube **32** is a length of specially prepared straight steel pipe slightly shorter than the outer gun body assembly **20** into which it is installed. The charge tube **32** enables attachments to the collars **33**a, **33**b via respective threaded set screws **34** (only one shown in FIG. **2**a). The first collar **33**a includes the aforementioned integral orientation/alignment pin **35** which protrudes perpendicularly to engage the corresponding orientation slot portion **24** as previously described.

The shaped charge saddle slots **42** comprise circular, rectangular, or oval-shaped features that are machined through the charge tube **32** to allow insertion of a shaped charge saddle **125** of a shaped charge **120** placed inside the carrier tube assembly **30**. Each shaped charge saddle slot **42** has a corresponding shaped charge body aperture **43** that is machined through an opposing surface of the charge tube **32**. Each shaped charge body aperture **43** comprises a circular or cylindrical-shaped machined feature having a diameter dimensioned to receive a charge base **130** of a shaped charge **120**.

Referring now primarily to FIG. **2**b, the system **10** uses a plurality of commercially-available shaped charges **120** such as those available from OWEN OIL TOOLS™, TITAN SPECIALTIES, LTD™, and others. Each shaped charge **120** has a cylindrical shaped charge base **130** having a single protruding conical-shaped end that forms the shaped charge saddle **125**. Each shaped charge **120** also has a contained explosive, a conical metal liner, a shaped charge body, and built in primers. The direction of a shape charge **120** can be variably directed via the joint angular and positional characteristics of a shaped charge saddle slot **42** and a shaped charge body aperture **43** that directs an explosion toward a recessed area **25**. Selective pairings of shaped charge saddle slots **42** and shaped charge body apertures **43** can angle a shaped charge **120** **[**toward an**]** *generally in the direction of one* end of the carrier tube assembly **30** along a plane which **[**is parallel to and**]** horizontally **[**extending**]** *extends* along the center of the carrier tube assembly **30** (see FIGS. **5** through **6**c).

Referring now primarily to FIG. **2**a, located along the perimeter of each shaped charge body aperture **43** is at least one (1) machined clip feature **44** which comprises a malleable, finger-shaped appendage that can be bent and positioned using a hand tool against the charge base portion **130** of a shaped charge canister **120** to secure the shaped charge canister **120** in position.

Referring again to FIG. **3**, the carrier tube assembly **30** can be incrementally positioned such that the shaped charge saddle slots **42** and shaped charge body apertures **43** align the shaped charge canisters **120** at selective phase angles along a spiral or straight pattern from one (1) end of the carrier tube assembly **30** to the other. It is understood that various phase angles such as one-hundred-eighty (180°) degrees, ninety (90°) degrees, sixty (60°) degrees, and the like may be used based upon a user's preference to produce a desired geological perforation formation **300** and hydraulic fracturing effect.

Referring now to FIG. **4**, which is a side cut-away view of the system **10** in use, the system **10** includes the outer gun body assembly **20** with threaded couplings **22** at each end. Male couplings **23** provide male threaded regions **26** that mate with female threaded region **22**. This enables any number of desired outer gun body assemblies **20**, each containing a carrier tube assembly **30** to be coupled together to create a selective length system **10**.

Upon detonation, the angular positioning of the shaped charges **120** with respect to corresponding shaped charge saddle slots **42** and shaped charge apertures **43** produce directed perforation tunnel vectors **60** that penetrate the well casing structure **200**, any surrounding well casing cement, and the surrounding geological formation **300**. The outer gun body assemblies **20** and the carrier tube assemblies **30** may be specifically machined with the aforementioned features **42**, **43** to enable positioning of the shaped charges **120** at various phase angles and angular orientations to create desired geological formation perforations and subsequent fracturing.

Possible perforation tunnel vectors **60** are illustrated in FIGS. **5** through **6**c. FIG. **5** shows a preferred fan-shot pattern **80**. The carrier tube assembly **30** is configured with shaped charge **120** oriented and arranged at a selected phase angle to form a fan-shot pattern **80** upon detonation. The fan shot pattern **80** is produced by arranging groups of shaped charges **120** at phase angles that progressively increase along the length of the carrier tube assembly **30**. The shaped charges **120** produce monotonically decreasing (measured in an X-Y plane with 0° toward the right) perforation tunnel vectors **60** comprising first fan perforation tunnel vectors **82**a (such as 135°) near the left hand side of the carrier tube assembly **30**, smaller angled second fan perforation tunnel vectors **82**b (such as 120°) further way from the left hand side, substantially perpendicular third fan perforation tunnel vectors **82**c at the middle of the carrier tube assembly **30**, smaller angled fourth fan perforation tunnel vectors **82**d (such as 60°) past the middle of the carrier tube assembly **30**, and still smaller angled fifth fan perforation tunnel vectors **82**e (such as 45°) near the right hand side of the carrier tube assembly **30**. The actual number and angle of the shaped charge canisters **120** and resulting fan perforation tunnel vectors **82**a, **82**b, **82**c, **82**d, **82**e, may be selectively varied to produce a desired fracturing effect.

FIG. **6**a shows another set of preferred perforation tunnel vectors **60** arranged to produce a down-shot pattern **83**. The down-shot pattern **83** is produced by arranging groups of shaped charges **120** at fixed angles, such as 135° along the length of the carrier tube assembly **30**. The down-shot pattern **83** is directed downward. However, by inverting the carrier tube assembly **30** an up-shot pattern that is directed upward can be produced. The actual angle of the shaped charge **120** and resulting down-shot pattern **83** (or up-shot pattern) can be varied to produce a desired geological formation **300** perforation tunnels and subsequent hydraulic fracturing effect.

FIG. **6**b shows another set of preferred perforation tunnel vectors **60** arranged in a limited-entry pattern **85**. The limited-entry pattern **85** is produced by arranging groups of shaped charges **120** to produce perforation tunnel vectors **60** having angles that monotonically vary from the nearest end of the carrier tube assembly **30** toward 90° at the middle of the carrier tube assembly **30**. For example, first limited-entry perforation tunnel vectors **86**a near the left hand side of the carrier tube assembly **30** at an angle of 45°, second limited-entry perforation tunnel vectors **86**b further toward the middle of the carrier tube assembly **30** at an angle of 60°, third limited-entry perforation tunnel vectors **86**c at the middle of the carrier tube assembly **30** that are perpendicular to the carrier tube assembly **30**, fourth limited-entry perforation tunnel vectors **86**d located to the right of the middle of the carrier tube assembly **30** having an angle of 120°, and fifth limited-entry perforation tunnel vectors **86**e nearest the right hand side of the carrier tube assembly **30** at an angle of 135°.

The limited-entry pattern **85** shown in FIG. **6**b produces limited-entry perforation tunnels **86**a, **86**b, **86**c, **86**d, **86**e that collectively concentrate the explosive forces from the shaped charges **120** to produce a desired geological formation **300** perforation tunnel and subsequent hydraulic fracturing effect. Again, it should be noted that the angles can be selectively varied to produce a desired perforation tunnel geometry and subsequently hydraulic fracturing effect.

FIG. **6**c shows another set of preferred perforation tunnel vectors **60**, but this time arranged in a limited-entry-fan-shot embodiment **90**. The limited-entry-fan-shot embodiment **90** is produced by arranging groups of shaped charges **120** to produce perforation tunnel vectors **60** having angles that spread out in a wide angle across the carrier tube assembly **30** from each end to the middle, with the middle perforation tunnel vectors **60** being perpendicular to the carrier tube assembly **30**. The shaped charges **120** are arranged along selected phase angles to produce the combined limited-entry-fan-shot embodiment **90**.

The combined limited-entry-fan-shot embodiment **90** is envisioned as producing a plurality of first combined perforation tunnel vectors **90**a (say at 135°) near the left hand side, second combined perforation tunnel vectors **90**b (say at 45°) left of the center of the carrier tube assembly **30**, third combined perforation tunnel vectors **90**c at the center of the carrier tube assembly **30** and at 90°, fourth combined perforation tunnel vectors **90**d right of the center of the carrier tube assembly **30** (say at 135°), and fifth combined perforation tunnel vectors **90**e near the right hand side of the carrier tube assembly **30** (say at 45°). Such an arrangement of combined limited-entry perforation tunnel vectors **90**a, **90**b, **90**c, **90**d, **90**e diffuse the perforation jets from the system **10** at some locations while concentrating them at the middle of the carrier tube assembly **30** so as to produce a desired geological formation **300** perforation geometry and subsequently hydraulic fracturing effect. The combined limited-entry-fan-shot perforation tunnel vectors **90**a, **90**b, **90**c, **90**d, **90**e are described as emanating at suggested angles; however, the actual number and angles of the shaped charges **120** and resulting perforation tunnel vectors **90**a, **90**b, **90**c, **90**d, **90**e may be selectively varied to produce a desired fracturing effect.

It is envisioned that other styles and configurations of the present invention can be easily incorporated into the teachings of the present invention; only one (1) particular configuration is shown and described for purposes of clarity and disclosure and not by way of limitation of scope.

The preferred embodiment of the present invention can be utilized by technicians skilled in the art after having received appropriate instructions in the configuring and assembly of the system **10**. After initial purchase or acquisition of the system **10**, it would be installed as indicated in FIGS. **1** through **4**.

The method of using the system **10** may be achieved by performing the following steps: procuring a number of matched outer gun body assemblies **20** and carrier tube assemblies **30** having desired overall lengths, phase angles, and being machined with properly aligned recessed areas **25**, shaped charge saddle slots **42**, and shaped charge body apertures **43** so as to produce a desired geological formation perforation effect with subsequent hydraulic fracturing upon detonation; inserting an initial carrier tube assembly **30** into a matching outer gun body assembly **20** until obtaining full engagement of the orientation/alignment pin **35** within the corresponding orientation slot **24** and securing in place with a snap ring; inserting the system **10** within a horizontal well casing structure in a conventional manner; detonating the system **10** remotely in a normal manner to produce perforation tunnel vectors **60** being projected into surrounding geological formation(s) at desired angles and directions, thereby producing a desired geological formation **300** perforation effect with subsequent fracturing effect using the present invention **10**.

The method of utilizing additional units of the system **10** may be achieved by performing the following steps: inserting any additional carrier tube assemblies **30**, as desired, into respective outer gun body assemblies **20**; arranging the outer gun body assemblies **20** in a desired sequential order in a linear manner; joining adjacent outer gun body assemblies **20** by threading the male threaded regions **26** of the connecting couplings **23** to the female threaded regions **22** of the adjacent outer gun body assemblies **20**; and, performing detonation, perforation, and subsequent hydraulic fracturing as described above.

It is further understood that during preparation and assembly of the system **10**, as described above, any number or sequence of patterns from the system **10** can be produced; including the fan shot pattern **80**, the down-shot pattern **83**, the limited-entry pattern **85**, and the alternate combined limited-entry-fan-shot pattern **90**. The various patterns can also be mixed to produce a desired geological formation **300** perforation jet geometry and subsequent hydraulic fracturing effect.

The foregoing descriptions of specific embodiments of the present invention have been presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the invention and method of use to the precise forms disclosed. Obviously many modifications and variations are possible in light of the above teaching. The embodiment was chosen and described in order to best explain the principles of the invention and its practical application, and to thereby enable others skilled in the art to best utilize the invention and various embodiments with various modifications as are suited to the particular use contemplated. It is understood that various omissions or substitutions of equivalents are contemplated as circumstance may suggest or render expedient, but is intended to cover the application or implementation without departing from the spirit or scope of the claims of the present invention.

What is claimed is:

1. A perforation gun, comprising:

an outer gun body assembly having a first straight steel pipe with internal female threads at each end, a plurality of external recessed areas, and an orientation slot extending inward from one end of said first straight steel pipe;

a carrier tube assembly having a linear charge tube which has an external surface, a first collar having an external alignment pin dimensioned to slide into said orientation slot, said first collar fits over one end of said charge tube into an installed position radially outward of said external surface, a second collar that fits over the opposite end of said charge tube, a plurality of shaped charge saddle slots through said charge tube, and a plurality of *corresponding* shaped charge body apertures through said charge tube, wherein said *each of said* plurality of shaped charge saddle slots and *corresponding ones of* said plurality of shaped charge body apertures form a plurality of shaped charge holders, and wherein said charge tube is a length of a second straight steel pipe slightly shorter than said outer gun body assembly; and

a plurality of shaped charges, each*:* having a shaped charge saddle, **[**each having**]** a charge base**[**,**]** and **[**each of which is located**]** *received and restrained* in **[**an associated shaped charge holder] *one* of said plurality of shaped charge holders *by its respective shaped charge saddle inserted in a corresponding shaped charge saddle slot and being angularly adjustable therein*;

wherein said carrier tube assembly is inserted into said outer gun body assembly such that said alignment pin slides into said orientation slot so as to control the orientation of said plurality of shaped charges with respect to said external recessed areas; and

wherein said first collar is locked into position relative to said charge tube *by insertion of said alignment pin in said orientation slot*.

2. The perforation gun according to claim **1**, wherein said internal female threads [are] *further comprise a* machined *surface*.

3. The perforation gun according to claim **1**, wherein said external recessed areas are machined approximately half way through said first straight steel pipe.

4. The perforation gun according to claim **1**, further including a male coupling having threaded male members on each end, wherein said male coupling is attached to one end of said first straight steel pipe by threading into said internal female threads, and wherein said male coupling enables attachment of a second perforation gun.

5. The perforation gun according to claim **4**, comprising two individual perforation guns joined together by male coupling.

6. The perforation gun according to claim **1**, wherein said first collar is locked to said charge tube by a set screw.

7. The perforation gun according to claim **6**, wherein said position of said first collar can be adjusted on said charge tube such that said alignment pin engages said orientation slot to controllably orientate the position of said shaped charges with respect to said recessed areas.

8. The perforation gun according to claim **1**, wherein each shaped charge saddle slot is machined through said charge tube to allow insertion of a shaped charge saddle.

9. The perforation gun according to claim **8**, wherein each shaped charge body aperture is machined through said charge tube to allow insertion of a charge base.

10. The perforation gun according to claim **9**, wherein each shaped charge is secured in position by a malleable appendage that extends from said carrier tube to contact that shaped charge's charge base.

11. The perforation gun according to claim **1**, wherein said plurality of shaped charges are orientated with respect to said recessed areas by said orientation slot so as to produce a desired geological fracturing effect.

12. The perforation gun according to claim **11**, wherein said plurality of shaped charges are orientated with respect to said recessed area to produce a fan shot pattern.

13. The perforation gun according to claim **12**, wherein said fan shot pattern is produced by arranging groups of shaped charges at phase angles that progressively increase along said carrier tube assembly so as to produce monotonically decreasing perforation tunnel vectors.

14. The perforation gun according to claim **11**, wherein said plurality of shaped charges are orientated with respect to said recessed area to produce a down-shot pattern.

15. The perforation gun according to claim **14**, wherein said down-shot pattern is produced by arranging groups of shaped charges at fixed angles along said carrier tube assembly.

16. The perforation gun according to claim **11**, wherein said plurality of shaped charges are orientated with respect to said recessed area to produce a limited-entry pattern.

17. The perforation gun according to claim **16**, wherein said limited-entry pattern is produced by arranging groups of shaped charges to produce perforation tunnel vectors having angles that monotonically vary from each end of said carrier tube assembly toward 90° at the middle of said carrier tube assembly.

18. The perforation gun according to claim **11**, wherein said plurality of shaped charges are orientated with respect to said recessed area to produce a limited-entry-fan-shot pattern.

19. The perforation gun according to claim **18**, wherein said limited-entry-fan-shot pattern is produced by arranging groups of shaped charges to produce perforation tunnel vectors having angles that spread out in a wide angle across said carrier tube assembly from each end to the middle of said carrier tube, with the middle perforation tunnel vector perpendicular to said carrier tube assembly.

20. The perforation gun according to claim 1, wherein said plurality of shaped charge saddle slots further comprise circular, rectangular or oval shaped features through said charge tube to allow insertion of a shaped charge saddle.

21. The perforation gun according to claim 1, wherein a shaped charge is secured in position within at least one of said plurality of shaped charge holders by a clip.

22. The perforation gun according to claim 21, wherein said clip is selectively engaged with said shaped charge to permit insertion and retention of said shaped charge in said at least one of said plurality of shaped charge holders.

23. The perforation gun according to claim 1, wherein at least a portion of said plurality of shaped charge holders are orientated to receive a shaped charge at a non-perpendicular angle with respect to said external surface of said charge tube.

24. A perforation gun according to claim 23, wherein said at least a portion of said plurality of shaped charge holders are orientated to receive said shaped charge at varying angles with respect to said external surface of said charge tube.

25. A perforation gun according to claim 24, wherein said charge tube has a midpoint along its axial length and said varying angles of said shaped charge holders decrease along said axial length of said carrier assembly from said midpoint to each end, creating a limited entry explosive pattern.

26. A perforation gun according to claim 25, wherein said at least a portion of said plurality of shaped charge holders are additionally orientated in a spiral pattern along the axial length of said charge tube.

27. A perforation gun according to claim 25, wherein said shaped charge is secured in position within at least one of said plurality of shaped charge holders by a clip.

28. The perforation gun according to claim 27, wherein said clip is selectively engaged with said shaped charge to permit insertion and retention of said shaped charge in said at least one of said plurality of shaped charge holders.

29. A perforation gun for creating a pattern of perforation tunnels in at least one of a well casing and a rock formation, said perforation gun comprising:

an outer gun body having an interior space, an exterior surface and a longitudinal axis, said exterior surface having a plurality of recessed areas forming a spiral pattern along said longitudinal axis; and

a carrier selectively axially mounted in a preselected position within said interior space of said outer gun body, said carrier having:

a longitudinal axis coincident with said longitudinal axis of said outer gun body;

an axis perpendicular to and extending outwardly from said longitudinal axis at a preselected point along said longitudinal axis dividing said longitudinal axis into two portions;

a plurality of shaped charge bodies; and

a plurality of spaced apart shaped charge holders, extending along said longitudinal axis, sized and shaped to: (i) receive and restrain each of said plurality of shaped charge bodies interiorly adjacent to corresponding ones of said plurality of recessed areas of said outer gun body and form a coincident preselected spiral pattern along with longitudinal axis; and (ii) expel a focused explosive charge therefrom along a charge vector extending radially outwardly from said longitudinal axis and forming an included phase angle with said perpendicular axis; at least a plural portion of said plurality of said shaped charge holders being mounted in a preselected pattern along said longitudinal axis such that said charge vectors are non-intersecting and independently form monotonically decreasing included phase angles with respect to perpendicular axis creating a limited entry explosive pattern.

30. A perforation gun according to claim 29, wherein said carrier has two ends and said perpendicular axis is located at a midpoint along said longitudinal axis.

31. A perforation gun according to claim 29, wherein said carrier has two ends and a midpoint along said longitudinal axis and a portion of said varying phase angles of said shaped charge holders monotonically increase along said longitudinal axis from said midpoint to each end, creating a fan-shaped explosive pattern and a portion of said varying angles of said shaped charge holders monotonically decrease along said longitudinal axis from said midpoint to each end, creating a limited entry explosive pattern.

32. A perforation gun according to claim 29, wherein the shape of said plurality of charge holders further comprise at least one of saddle apertures and body apertures which are selected from the group consisting of circles, ovals and rectangles.

33. A perforation gun according to claim 29, wherein said carrier further comprises at least one collar defining a spaced apart relationship between said carrier and said outer gun body.

34. A perforation gun according to claim 29, wherein at least one of said carrier and said outer gun body further comprise an alignment pin mountable in a corresponding orientation slot in at least one other of said carrier and said outer gun body to register said carrier with said outer gun body such that said plurality of charge holders are aligned with said plurality of said recessed areas of said outer gun body.

35. A perforation gun according to claim 29, further comprising at least one coupler mounted on an end of said outer gun body to affix at least one other perforation gun in a linear, axial relationship with said perforation gun.

36. A perforation gun according to claim 29, wherein at least one of said plurality of shaped charge bodies is secured in position within at least one of said plurality of shaped charge holders by a clip.

37. A perforation gun according to claim 36, wherein said clip is selectively engaged with at least one of said plurality of shaped charge bodies to permit insertion and retention of said shaped charge body in one of said plurality of shaped charge holders.

38. A perforation gun according to claim 37, wherein said clip is malleable.

39. A perforation gun according to claim 20, wherein said shaped charge saddle slot features form a perimeter which directly receives and restrains said shaped charge saddle.

40. A perforation gun according to claim 39, wherein said shaped charge saddle slot features are integral with said carrier tube.

* * * * *