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PHASED PERFORATING GUNS

Background

The invention relates to phased perforating guns.

5 Perforating guns, used in wellbores for perforating a formation, include charges mounted on a base structure. The charges are often phased, that is, pointed in different directions for perforating around the circumference of the wellbore. The charges used may be capsule charges which are
10 each individually sealed by a capsule against corrosive fluids and elevated temperatures and pressures in the wellbore. On the other hand, if non-capsule charges are used, a carrier having a sealed housing is used to surround and protect all of the non-capsule charges from the hostile
15 environment in the wellbore.

Figs. 1-7 illustrate various types of perforating guns.

20 Referring to Figs. 6a and 6b, examples of perforating guns in which non-capsule charges are loaded in a carrier housing are shown. In Fig. 6a, a perforating gun 22 includes a base structure 22b and non-capsule charges 22a mounted on the base structure. The base structure 22b
25 consists of a tube having holes 22b1 to receive the non-capsule charges. A carrier tube 22c encloses and protects the unsealed charges 22a. The carrier tube 22c is sealed to prevent well fluid from damaging the charges 22a. The holes 22b1 (into which non-capsule charges are mounted) are
30 created along the tubular base structure 22b in a spiral pattern. Corresponding areas of reduced wall thickness 22d

(indicated by dashed circular lines) are created in the carrier tube 22c to reduce the protrusion of burrs in the carrier tube wall created by the explosive force. The phasing of the non-capsule perforating gun is determined by
5 the position shown on the tubular base structure 22b.

Similarly, in Fig. 6b, a carrier tube 23c carries a base structure 22b having a plurality of integrally connected rings in which non-capsule charges can be mounted.
10 The rings are configured such that the non-capsule charges are arranged in a 60E-phased pattern. Corresponding areas of reduced thickness 23d are created in the carrier tube 23c. The areas of reduced thickness 23d and non-capsule charges must align to ensure a minimum amount of protruding
15 burrs are created in the outer surface of the carrier tube 22c. Once the gun is fired, the non-capsule charges 23a and base structure 22b break apart, but the debris remains in the carrier tube 22b. The carrier tube 22b can then be retrieved from the wellbore.

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Referring to Figs. 1a and 1b, a link-type expendable perforating gun is illustrated. In Figure 1a, a gun 10 includes capsule charges 10a which are phased (pointed in different directions) approximately 90E from each other to
25 perforate the formation about the circumference of the wellbore. A detonating cord 10b weaves around each charge for detonating the charges in response to a detonation stimulus. Each charge is connected to the next, adjacent charge via cotter pins 10c.

30

In Fig. 1b, a differently configured perforating gun 12 includes a plurality of capsule charges that are connected to each other via rivets 12a. In this configuration, the capsule charges are phased 180E from
5 each other.

Figs. 2a and 2b illustrate two other types of 180E-phased perforating guns, which are, respectively, wire and strip-type semi-expendable guns. In Fig. 2a, a perforating
10 gun 14 includes capsule charges connected together by mounting wires 14b. In Fig. 2b, a perforating gun 16 includes capsule charges 16a mounted on a rigid base structure 16b, which is made of sheet metal with openings to receive the capsule charges 16a. In the embodiments of
15 Figs. 2a and 2b, the capsule charges are mounted to alternately point in opposite directions along the mounting structure 14b or 16b.

Referring to Fig. 3, a perforating gun 18 includes
20 capsule charges 18a mounted on a straight, relatively rigid base rod 18b. The base rod 18b may be hollow, allowing a detonating cord to be inserted through the center thereof for connection to each of the charges 18a. The capsule charges 18a may be mounted onto the base 18b using screws.
25

Referring to Fig. 4, a perforating gun 20 includes a plurality of capsule charges 20a mounted on a base strip 20b that includes a metallic strip having a plurality of through-holes disposed for connection to the corresponding
30 capsule charges 20a. In the embodiment shown in Fig. 4, the

capsule charges 20a are mounted to point in only one general direction.

Referring to Figs. 5a and 5b, a spiral strip perforating gun 21 manufactured by Owen Oil Tubes, Inc. of Ft. Worth, Texas, is illustrated. The spiral strip perforating gun 21 includes a plurality of capsule charges 21a mounted along a spiraling base strip 21b. The direction of the capsule charges 21a are determined by the spiral shape of the base strip 21b and the amount of twist between capsule charges.

Referring to Figs. 7a and 7b, a perforating gun 24 includes capsule charges 24b mounted on a base strip 24a. The base strip 24a is a unitary structure that is bent generally along its center axis to form a first planar portion 24a2 lying in a first plane and a second planar portion 24a3 connected to and substantially coextensive with the first portion and lying in a second portion at an angle to the first plane. The unitary structure formed by the first and second surfaces 24a2 and 24a3 provide structural support and resistance to bending of the unit. The capsule charges 24b are alternately connected to the first and second portions 24a2 and 24a3 of the base strip 24a, as shown in Fig. 7b.

The base strip 24a includes recesses 24a1 alternately carved into the first and second surfaces 24a2 and 24a3, each recess 24a1 being shaped to receive the circumferential shape of a capsule charge 24b. The capsule charge 24b is held in place on a corresponding surface of the base strip by a mounting bracket 24c. A detonating cord 26 is connected to each charge 24b.

The base strip 24a is made of hardened steel, and the mounting brackets 24c are each made of mild steel, e.g., plain carbon steel. The mounting brackets 24c may be physically connected to base strip 24a by a pair of screws. When a charge detonates, the associated mounting bracket breaks to allow the spent charge casing to fall to the bottom of the wellbore. However, the base strip 24a

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portion 24a3 connected to and substantially coextensive with the first portion and lying in a second portion at an angle to the first plane. The unitary structure formed by the first and second surfaces 24a2 and 24a3 provide structural support and resistance to bending of the unit. The capsule charges 24b are alternately connected to the first and second portions

5 24a2 and 24a3 of the base strip 24a, as shown in Fig. 7b.

The base strip 24a includes recesses 24a1 alternately carved into the first and second surfaces 24a2 and 24a3, each recess 24a1 being shaped to receive the circumferential shape of a capsule charge 24b. The capsule charge 24b is held in place on a corresponding surface of the base strip by a mounting bracket 24c. A detonating cord 26

10 is connected to each charge 24b.

The base strip 24a is made of hardened steel, and the mounting brackets 24c are each made of mild steel, e.g., plain carbon steel. The mounting brackets 24c may be physically connected to base strip 24a by a pair of screws. When a charge detonates, the associated mounting bracket breaks to allow the spent charge casing to fall to the bottom of the wellbore. However, the base strip 24a itself can withstand detonation of the charges

15 24b and will not shatter when the charges 24b detonate and may be retrieved from the wellbore. The perforating gun 24 is further described in U.S. Patent No. 5,095,999, entitled "Through Tubing Perforating Gun Including a Plurality of Phased Capsule Charges Mounted on a Retrievable Base Strip Via a Plurality of Shatterable Support

20 Rings," assigned to the Assignee of the present application.

Summary

In accordance with the invention, there is provided a expendable perforating gun, comprising:

a base structure made of a deformable material, the base structure including capsule

25 charge support rings integral with the base structure, each support ring substantially circular in shape to reduce an amount of material forming the support ring so that debris is reduced upon firing of the perforating gun, and

capsule charges mounted in corresponding support rings, each support ring being adjustable by selective deformation of the base structure to face in one of a plurality of

itself can withstand detonation of the charges 24b and will not shatter when the charges 24b detonate and may be retrieved from the wellbore. The perforating gun 24 is further described in U.S. Patent No. 5,095,999, entitled "Through Tubing Perforating Gun Including a Plurality of Phased Capsule Charges Mounted on a Retrievable Base Strip Via a Plurality of Shatterable Support 20 Rings," assigned to the Assignee of the present application.

Summary

In accordance with the invention, there is provided a expendable perforating gun, comprising:

- a base structure made of a deformable material, the base structure including capsule charge support rings integral with the base structure, each support ring substantially circular in shape to reduce an amount of material forming the support ring so that debris is reduced upon firing of the perforating gun; and

- capsule charges mounted in corresponding support rings, each support ring being adjustable by selective deformation of the base structure to face in one of a plurality of directions to provide a plurality of combinations of phasing patterns,

- wherein the base structure is deformable to allow for adjustment of the distance between successive rings, in order to vary shot density of the charges.

In another aspect, there is provided a perforating gun, comprising:

- a support member having support portions each having an opening disposed therethrough, each opening adjustable to face in any one of a plurality of directions;

- capsule charges mounted in the openings; and

- connectors integrally connecting adjacent support portions, each connector

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directions to provide a plurality of combinations of phasing patterns,

wherein the base structure is deformable to allow for adjustment of the distance between successive rings, in order to vary shot density of the charges.

In another aspect, there is provided a perforating gun, comprising:

5 a support member having support portions each having an opening disposed therethrough, each opening adjustable to face in any one of a plurality of directions; capsule charges mounted in the openings; and

connectors integrally connecting adjacent support portions, each connector having bent portions to align a center of each capsule charge generally with a longitudinal center
10 axis of the gun, the bent portions enabling the support portions to be adjustable to different positions to align centers of different sizes of capsule charges generally with the longitudinal center axis of the gun.

In another aspect, there is provided a method of arranging an expendable perforating gun to shoot in one of a plurality of combinations of phasing patterns, the
15 method comprising:

providing a perforating gun having a base structure made of a deformable material and including capsule charge support rings integral with the base structure;

forming each support ring to be substantially circular in shape to reduce an amount of material used to form the support rings so that debris is reduced after detonation;

20 twisting each support ring to face in any one of a plurality of directions;

mounting capsule charges in the support ring; and

adjusting the distance between successive rings by deforming the base structure, in order to vary shot density of the charges.

having bent portions to align a center of each capsule charge generally with a longitudinal center axis of the gun, the bent portions enabling the support portions to be adjustable to different positions to align centers of different sizes of capsule charges generally with the longitudinal center axis of the gun.

In another aspect, there is provided a method of arranging an expendable perforating gun to shoot in one of a plurality of combinations of phasing patterns, the method comprising:

- providing a perforating gun having a base structure made of a deformable material and including capsule charge support rings integral with the base structure;

- forming each support ring to be substantially circular in shape to reduce an amount of material used to form the support rings so that debris is reduced after detonation;

- twisting each support ring to face in any one of a plurality of directions;

- mounting capsule charges in the support ring; and

- adjusting the distance between successive rings by deforming the base structure, in order to vary shot density of the charges.

Brief Description of the Drawings

Figs. 1a and 1b are diagrams of link-type expendable perforating guns.

Figs. 2a and 2b are diagrams of wire and strip-type semi-expendable guns.

Fig. 3 is a diagram of a capsule charge, phased perforating gun.

Fig. 4 is a diagram of a capsule charge, non-phased perforating gun.

Fig. 5 is a diagram of a spiral-type capsule charge perforating gun.

Figs. 6a and 6b are diagrams of a phased, non-capsule charge perforating gun. Figs. 7a and 7b are diagrams of a differently configured phased, capsule charge perforating gun.

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Brief Description of the Drawings

Figs. 1a and 1b are diagrams of link-type expendable perforating guns

Figs. 2a and 2b are diagrams of wire and strip-type semi-expendable guns.

Fig. 3 is a diagram of a capsule charge, phased perforating gun.

5 Fig. 4 is a diagram of a capsule charge, non-phased perforating gun.

Fig. 5 is a diagram of a spiral-type capsule charge perforating gun.

Figs. 6a and 6b are diagrams of a phased, non-capsule charge perforating gun.

Figs. 7a and 7b are diagrams of a differently configured phased, capsule charge perforating gun.

Fig. 8a is a diagram of a perforating gun having support rings integrally connected for receiving capsule charges.

Fig. 8b is a diagram of a capsule charge for mounting to the perforating gun of Fig. 8a.

Figs. 9a and 9b are top- and side-view diagrams of a perforating gun arranged in a 45E right-hand clockwise helix pattern.

Figs. 10a and 10b are top- and side-view diagrams of a perforating gun arranged in a twisted -45E/0E/45E pattern.

Figs. 11a and 11b are top- and side-view diagrams of a perforating gun arranged in a 0E-phased pattern.

Fig. 12 is a diagram of a perforating gun having widely spaced apart support rings to achieve a reduced shot density.

Detailed Description

Referring to Fig. 8a, an expendable perforating gun 100 includes a base strip 108 that forms support rings 114a-114e to receive capsule charges 110a-110e, respectively. Each of the capsule charges 110 is secured to a corresponding support ring 114 by a retaining ring 118. Other methods of retaining the capsule charge to the base strip 108 can be utilized, such as using cotter pins or bendable tabs.

Referring to Fig. 8b, each capsule charge 110 includes a capsule housing that has a lower portion 138 with a first diameter and an upper portion 140 with a second diameter, the second diameter being smaller than the first diameter. This allows the upper portion 140 to be fitted through the opening in the support ring 114. The capsule charge 110 is inserted through the support ring 114 until a shoulder 136 provided by the lower portion 138 contacts the inner surface 142 of the support ring 114. The upper portion 140 of the capsule housing has a groove 130 in which the retaining ring 118 is inserted to lock the capsule charge 110 against the support ring 114.

The base strip 108 is a single, continuous linking device that connects the capsule charges. The base strip 108 is made of a deformable material, such as malleable steel sheet metal, for example, 1075 hot rolled steel. However, other deformable materials, such as any ductile sheet metal or ductile plate metal that can include aluminum, copper, stainless steel, or nickel, may be used.

The base strip 108 is twistable so that the rings 114a-114e face in different selectable directions, thereby permitting the capsule charges to shoot in many different combinations of phasing patterns. Thus, for example, using
5 the perforating gun 100, the capsule charges can be arranged in a 0E-phased pattern (in which all the charges fire in one direction), a tri-directional pattern (e.g., -45E/0E/+45E phased firing), or a continuous 45E spiral pattern (in which adjacent charges are shot at 45E with
10 respect to a previous charge). Because the base strip may be manipulated to permit each support ring 114 to face in many directions, the possible combinations of phasing patterns are numerous, with examples shown in Figs. 9-12.

15 A further advantage of the perforating gun 100 is that the distances between the rings 114 on the base strip 108 can be selected to vary the shot density, that is, the number of shots per given length. Thus, the charges 110 can be spaced such that they barely touch each other, or they
20 can be spaced a large distance apart. In addition, the perforating gun 100 is fully expendable. Each support ring 114 on the base strip 108 receives the maximum impact of the explosion when a corresponding capsule charge is fired, and both the support ring 114 and the adjacent portions of the
25 base strip 108 surrounding the exploding capsule charge are broken into small pieces.

After the perforating gun 100 is fired, the base strip 108 shatters and drops to the bottom of the wellbore
30 along with a terminating knob 12, with the remainder of the

perforating gun 100, including mounting brackets 102, 104, and 106, being retrieved from the wellbore afterwards. Because of the small amount of material used to form the base strip 108 and the rings 114, the amount of debris that
5 falls to the bottom of the wellbore after the base strip 108 is shattered is reduced relative to many prior designs.

To manufacture, the base strip 108 can be laser cut from sheet metal. Alternatively, the base strip 108 can
10 also be machined or punched from metal, or it can be manufactured as a casting.

The base strip 108 at its bottom end has a member 115 that connects to the terminating knob 112. At its top
15 end, the base strip 108 is attached to a first mounting bracket 106 by means of nuts and bolts fitted through openings 120. The top end of the mounting bracket 106 has openings 122 through which bolts are threaded to attach the mounting bracket 106 to a connector piece 104. The
20 connector piece 106 in turn is connected to a second mounting bracket 102 that attaches the perforating gun 100 to the rest of the perforating apparatus, including a firing head.

25 Figs. 9-12 illustrate different embodiments of the perforating gun 100.

Referring to Figs. 9a and 9b, the base strip 108a includes rings 200a-200f, twisted in a 45E (V1E) right-hand
30 clockwise helix pattern. The break 202 shown in the drawing indicates that any number of rings 200 can be inserted. The

rings 200a-200h are integrally attached to one another by means of integral connectors 204a-204h. Because the connectors 204a-204h are deformable, they can be twisted such that the rings 200a-200h face in any one of numerous
5 directions. In the embodiment of Figs. 9a and 9b, going from the top of the gun 100 down, the rings 200a-200h are arranged such that each successive ring is at a clockwise 45E angle with respect to the previous ring. Thus, if the ring 200a lies in a reference plane, then the ring 200b lies
10 in a plane B that is at a 45E angle with respect to the reference plane. The next ring 200c lies in a plane C at a 45E angle with respect to the plane B and at a 90E angle with respect to the reference plane.

15 The lengths of the connectors 204a and 204b are also selectable to vary the shot density of the perforating gun.

Using the base strip 108 with capsule charges each having a longitudinal diameter of 1-11/16", a shot density of 7 shots per foot (SPF) can be achieved. For 2-1/8" capsule charges,
20 a shot density of 6 SPF can be achieved. For 2-1/2" capsule charges, a shot density of 5 SPF can be achieved.

By varying the shot density, fluid flow profiles from perforated formations surrounding a wellbore can be
25 configured to optimize well production.

Figs. 10a and 10b illustrate a base strip 108b arranged in which the rings 210a-210g are arranged in a twisted 45E/0E/-45E (V1E) pattern. The rings 210a-210g are
30 arranged in the following sequence: 210a in a reference

plane; 210b in a plane B that is at a +45E angle with respect to the reference plane; 210c in a plane C that is at a -45E angle with respect to plane B; 210d is in a plane at a -45E angle with the respect to the plane C; 210e is in a
5 plane E that is at a +45E angle with respect to the plane D; 210f is in a plane F that is at a +45E angle with respect to the plane E; and 210g is in a plane G that is at a -45E angle with respect to the plane F.

10 Another feature of the base strip 108 of the perforating gun 100 is that the rings in the base strip can be adjusted to compensate for the different sized capsule charges such that the capsule charges all sit along generally a center axis extending along the gun 100. For
15 example, in Figs. 10a and 10b, bent portions 211 can be created in the integral connectors between rings 210a-210g such that the center of each capsule charge is mounted generally along a center axis A-A of the gun 100.

20 Figs. 11a and 11b illustrate a base strip 108c having rings 230a-230f arranged in a 0E-phased pattern, that is, all capsule charges are mounted to point generally in one direction.

25 As shown in Fig. 12, a base strip 108d includes support rings 240a-240d in which the spacing between adjacent support rings 240 is increased to reduce the shot density of the perforating gun 100. As illustrated, the integral connectors between successive support rings are
30 lengthened to decrease the number of rings per unit length.

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What is claimed is.

1. An expendable perforating gun, comprising:
a base structure made of a deformable material, the base structure including capsule charge support rings integral with the base structure, each support ring substantially circular in shape to reduce an amount of material forming the support ring so that debris is reduced upon firing of the perforating gun, and
capsule charges mounted in corresponding support rings, each support ring being adjustable by selective deformation of the base structure to face in one of a plurality of directions to provide a plurality of combinations of phasing patterns.
wherein the base structure is deformable to allow for adjustment of the distance between successive rings, in order to vary shot density of the charges.
2. The perforating gun of claim 1, wherein the base structure further includes connector portions integrally connecting successive support rings.
3. The perforating gun of claim 2, wherein the base structure is preformed for a predetermined size and number of capsule charges.
4. The perforating gun of claim 2, wherein the length of each connector portion is selectable to vary the number of capsule charges mounted in the base structure.
5. The perforating gun of claim 1, wherein the plurality of combinations of phasing patterns include the following: 0°-phasing pattern, 45° clockwise helix pattern, and +45°/0°/-45° twisted pattern.
6. The perforating gun of claim 1, wherein the base structure is made of a material including sheet metal
7. The perforating gun of claim 1, wherein the base structure is made of a material selected from the group consisting of steel, aluminum, copper, and nickel
8. A perforating gun, comprising:
a support member having support portions each having an opening disposed

Since a capsule charge can be arranged at any arbitrary angle with respect to adjacent charges, any number of other combinations of phasing patterns of capsule charges can be implemented with the base strip 108.

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Thus, the perforating gun 100 offers improved flexibility by allowing different combinations of phasing patterns. In addition, a relatively small amount of material (and therefore a relatively small amount of debris
10 after perforation) is used. The distance between adjacent rings can be adjusted to vary the shot density of the gun as desired. Because the base strip 108 is narrow relative to the diameter of a cased wellbore, the base strip 108 can be positioned closer to one side to achieve better efficiency
15 for shooting charges closer to the casing wall.

Other embodiments are within the scope of the following claims.

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What is claimed is.

1. An expendable perforating gun, comprising:
a base structure made of a deformable material, the base structure including capsule charge support rings integral with the base structure, each support ring
5 substantially circular in shape to reduce an amount of material forming the support ring so that debris is reduced upon firing of the perforating gun; and
capsule charges mounted in corresponding support rings, each support ring being adjustable by selective deformation of the base structure to face in one of a plurality of directions to provide a plurality of combinations of phasing patterns,
10 wherein the base structure is deformable to allow for adjustment of the distance between successive rings, in order to vary shot density of the charges.
2. The perforating gun of claim 1, wherein the base structure further includes connector portions integrally connecting successive support rings.
3. The perforating gun of claim 2, wherein the base structure is preformed for
15 a predetermined size and number of capsule charges.
4. The perforating gun of claim 2, wherein the length of each connector portion is selectable to vary the number of capsule charges mounted in the base structure.
5. The perforating gun of claim 1, wherein the plurality of combinations of phasing patterns include the following: 0°-phasing pattern, 45° clockwise helix pattern,
20 and +45°/0°/-45° twisted pattern.
6. The perforating gun of claim 1, wherein the base structure is made of a material including sheet metal.
7. The perforating gun of claim 1, wherein the base structure is made of a material selected from the group consisting of steel, aluminum, copper, and nickel.
- 25 8. A perforating gun, comprising:
a support member having support portions each having an opening disposed

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therethrough, each opening adjustable to face in any one of a plurality of directions.

capsule charges mounted in the openings; and

connectors integrally connecting adjacent support portions, each connector having bent portions to align a center of each capsule charge generally with a longitudinal
5 center axis of the gun, the bent portions enabling the support portions to be adjustable to different positions to align centers of different sizes of capsule charges generally with the longitudinal center axis of the gun.

9. The perforating gun of claim 8, wherein the distance between successive openings is selectable to vary the number of capsule charges mounted in the support
10 member.

10. The perforating gun of claim 8, wherein the openings can be arranged to provide a plurality of phasing patterns, wherein the plurality of phasing patterns include the following: 0°-phasing pattern, 45° clockwise helix pattern, and +45°/0°/-45° twisted pattern.

11. A method of arranging an expendable perforating gun to shoot in one of a plurality of combinations of phasing patterns, the method comprising.

providing a perforating gun having a base structure made of a deformable material and including capsule charge support rings integral with the base structure.

forming each support ring to be substantially circular in shape to reduce an
20 amount of material used to form the support rings so that debris is reduced after detonation;

twisting each support ring to face in any one of a plurality of directions;

mounting capsule charges in the support ring; and

adjusting the distance between successive rings by deforming the base
25 structure, in order to vary shot density of the charges

12. The perforating gun of claim 11, wherein the plurality of phasing patterns include the following 0°-phased pattern, 45° clockwise helix pattern, and +45°/0°/-45° twisted pattern

therethrough, each opening adjustable to face in any one of a plurality of directions,

capsule charges mounted in the openings; and

connectors integrally connecting adjacent support portions, each connector having bent portions to align a center of each capsule charge generally with a longitudinal center axis of the gun, the bent portions enabling the support portions to be adjustable to
5 different positions to align centers of different sizes of capsule charges generally with the longitudinal center axis of the gun.

9. The perforating gun of claim 8, wherein the distance between successive openings is selectable to vary the number of capsule charges mounted in the support
10 member.

10. The perforating gun of claim 8, wherein the openings can be arranged to provide a plurality of phasing patterns, wherein the plurality of phasing patterns include the following: 0°-phasing pattern, 45° clockwise helix pattern, and +45°/0°/-45° twisted pattern.

15 11. A method of arranging an expendable perforating gun to shoot in one of a plurality of combinations of phasing patterns, the method comprising:

providing a perforating gun having a base structure made of a deformable material and including capsule charge support rings integral with the base structure;

forming each support ring to be substantially circular in shape to reduce an
20 amount of material used to form the support rings so that debris is reduced after detonation;

twisting each support ring to face in any one of a plurality of directions;

mounting capsule charges in the support ring; and

adjusting the distance between successive rings by deforming the base
25 structure, in order to vary shot density of the charges.

12 The perforating gun of claim 11, wherein the plurality of phasing patterns include the following: 0°-phased pattern, 45° clockwise helix pattern, and +45°/0°/-45° twisted pattern.

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- 13 The method of claim 11, further comprising:
 preforming the base structure for a predetermined size and number of
capsule charges

What is claimed is:

1. An expendable perforating gun, comprising:
a base structure made of a deformable material, the base structure including capsule charge support rings integral with the base structure, each support ring substantially circular in shape to reduce an amount of material forming the support ring so that debris is reduced upon firing of the perforating gun; and
capsule charges mounted in corresponding support rings, each support ring being adjustable by selective deformation of the base structure to face in one of a plurality of directions to provide a plurality of combinations of phasing patterns,
2. The perforating gun of claim 1, wherein the base structure further includes connector portions integrally connecting successive support rings.
3. The perforating gun of claim 2, wherein the base structure is preformed for a predetermined size and number of capsule charges.
4. The perforating gun of claim 2, wherein the length of each connector portion is selectable to vary the number of capsule charges mounted in the base structure.
5. The perforating gun of claim 1, wherein the plurality of combinations of phasing patterns include the following: 0°-phasing pattern, 45° clockwise helix pattern, and +45°/0°/-45° twisted pattern.
6. The perforating gun of claim 1, wherein the base structure is made of a material including sheet metal.
7. The perforating gun of claim 1, wherein the base structure is made of a material selected from the group consisting of steel, aluminum, copper, and nickel.

What is claimed is:

1. (Amended) An expendable perforating gun, comprising:
a base structure made of a deformable material, the base structure including capsule charge support rings integral with the base structure, each support ring substantially circular in shape to reduce an amount of material forming the support ring so that debris is reduced upon firing of the perforating gun; and
capsule charges mounted in corresponding support rings, each support ring being adjustable by selective deformation of the base structure to face in one of a plurality of directions to provide a plurality of combinations of phasing patterns.
2. (Amended) The perforating gun of claim 1, wherein the base structure further includes connector portions integrally connecting successive support rings.
3. The perforating gun of claim 2, wherein the base structure is preformed for a predetermined size and number of capsule charges.
4. The perforating gun of claim 2, wherein the length of each connector portion is selectable to vary the number of capsule charges mounted in the base structure.
5. The perforating gun of claim 1, wherein the plurality of combinations of phasing patterns include the following: 0°-phasing pattern, 45° clockwise helix pattern, and +45°/0°/-45° twisted pattern.
6. The perforating gun of claim 1, wherein the base structure is made of a material including sheet metal.
7. The perforating gun of claim 1, wherein the base structure is made of a material selected from the group consisting of steel, aluminum, copper, and nickel.

13. The method of claim 11, further comprising:
preforming the base structure for a predetermined size and number of
capsule charges.

8. A perforating gun, comprising:
a support member having support portions each having an opening disposed therethrough, each opening adjustable to face in any one of a plurality of directions;
capsule charges mounted in the openings; and
connectors integrally connecting adjacent support portions, each connector having bent portions to align a center of each capsule charge generally with a longitudinal center axis of the gun, the bent portions adjustable to different positions for different sizes of capsule charges.

9. The perforating gun of claim 8, wherein the distance between successive openings is selectable to vary the number of capsule charges mounted in the support member ~~base structure~~.

10. The perforating gun of claim ~~10~~ 8, wherein the openings can be arranged to provide a plurality of phasing patterns, wherein the plurality of phasing patterns include the following: 0°-phasing pattern, 45° clockwise helix pattern, and +45°/0°/-45° twisted pattern.

11. A method of arranging an expendable perforating gun to shoot in one of a plurality of combinations of phasing patterns, the method comprising:
providing a perforating gun having a base structure made of a deformable material and including capsule charge support rings integral with the base structure;
forming each support ring to be substantially circular in shape to reduce an amount of material used to form the support rings so that debris is reduced after detonation;
twisting each support ring to face in any one of a plurality of directions;
and

8. A perforating gun, comprising:
a support member having support portions each having an opening
disposed therethrough, each opening adjustable to face in any one of a plurality of
directions;
capsule charges mounted in the openings; and
connectors integrally connecting adjacent support portions, each connector
having bent portions to align a center of each capsule charge generally with a longitudinal
center axis of the gun.

9. The perforating gun of claim 8, wherein the distance between successive
openings is selectable to vary the number of capsule charges mounted in the base
structure.

~~10.——(Cancelled)——~~

11. The perforating gun of claim 10, wherein the plurality of phasing patterns
include the following: 0°-phasing pattern, 45° clockwise helix pattern, and +45°/0°/-45°
twisted pattern.

12. A method of arranging an expendable perforating gun to shoot in one of a
plurality of combinations of phasing patterns, the method comprising:
providing a perforating gun having a base structure made of a deformable
material and including capsule charge support rings integral with the base structure;
forming each support ring to be substantially circular in shape to reduce an
amount of material used to form the support rings so that debris is reduced after
detonation;
twisting each support ring to face in any one of a plurality of directions;
and

mounting capsule charges in the support rings.

12. The method of claim 12, further comprising:
adjusting the distance between successive rings to vary shot density.

13. The perforating gun of claim 12, wherein the plurality of phasing patterns include the following: 0°-phased pattern, 45° clockwise helix pattern, and +45°/0°/-45° twisted pattern.

14. The method of claim 12, further comprising:
preforming the base structure for a predetermined size and number of capsule charges.

mounting capsule charges in the support rings.

13. The method of claim 12, further comprising:
adjusting the distance between successive rings to vary shot density.

14. The perforating gun of claim 12, wherein the plurality of phasing patterns include the following: 0° -phased pattern, 45° clockwise helix pattern, and $+45^\circ/0^\circ/-45^\circ$ twisted pattern.

15. The method of claim 12, further comprising:
preforming the base structure for a predetermined size and number of capsule charges.

~~16. (Cancelled)~~

~~17. (Cancelled)~~

~~18. (Cancelled)~~