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Scheid et al.

(54) **STRUCTURE FOR SHAPING AND APPLYING A PROPAGATING SHOCK WAVE TO AN AREA OF AN EXPLOSIVE LOAD TO INCREASE AN ENERGETIC SHOCK IMPACT EFFECT ON A TARGET**

(71) Applicant: **The United State of America as represented by the Secretary of the Navy**, Crane, IN (US)

(72) Inventors: **Eric Scheid**, Bloomington, IN (US); **Jaime Villamil**, Fayetteville, NC (US)

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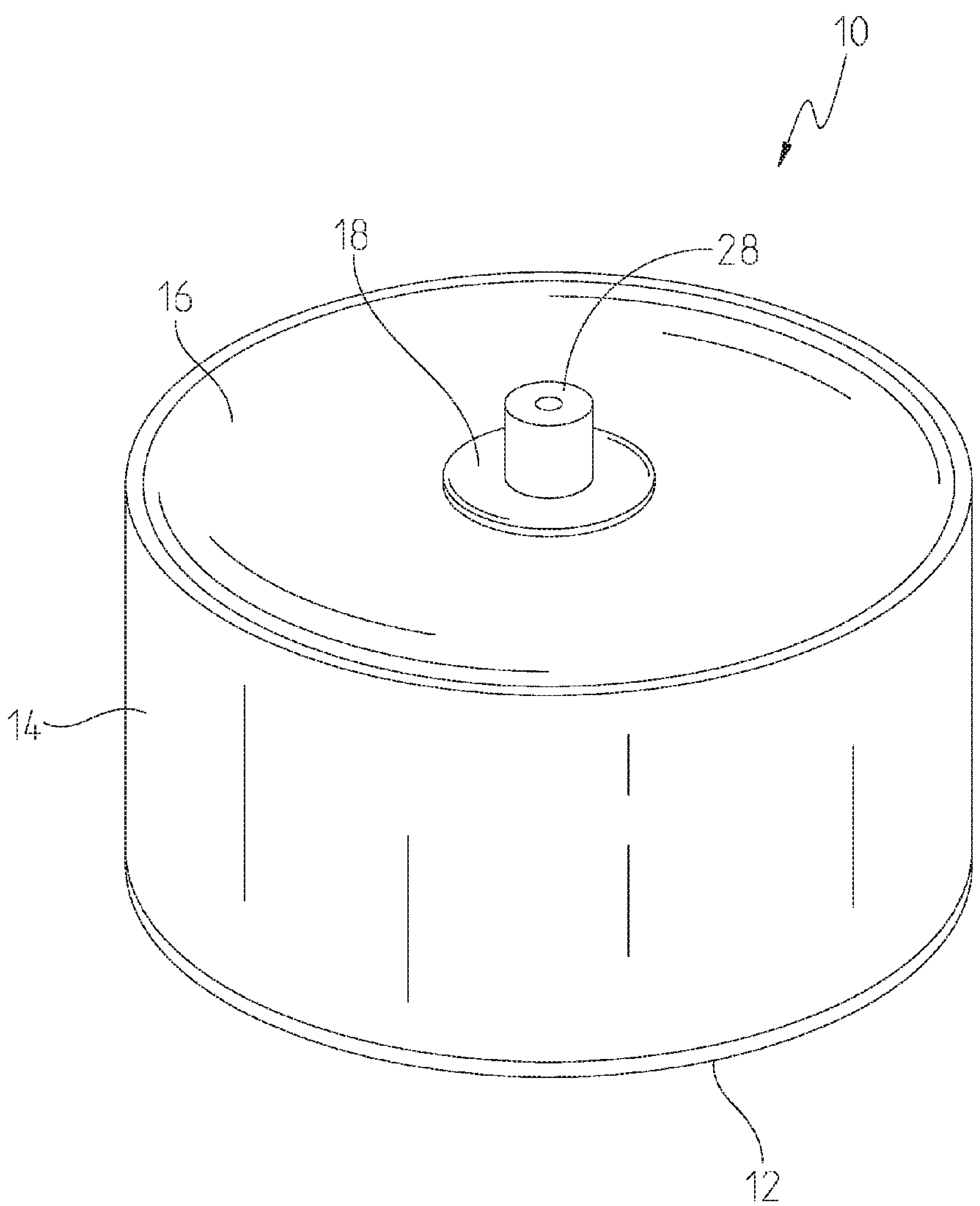
(57) **ABSTRACT**

Various embodiments including an improved shaped demolition charge apparatus and methods associated with the invention are provided in a cylindrical dynamic access structure ("CDAS"), which can include a wave shaper, a main charge, and a booster disk. An exemplary embodiment comprises a waver shaper, and a main charge, which can be plastic, bonded explosive. A wave shaper can comprise of two-layered structure in which a void is formed. A wave shaper can be disposed between a booster disk and a main charge such that the booster disk is only in contact with the main charge along an outer edge of the booster disk. A wave shaper directs or channels a shock wave from the booster disk to an outer portion of the main charge. A container can be formed or adapted around a cover, booster disk, main charge, and wave shaper.



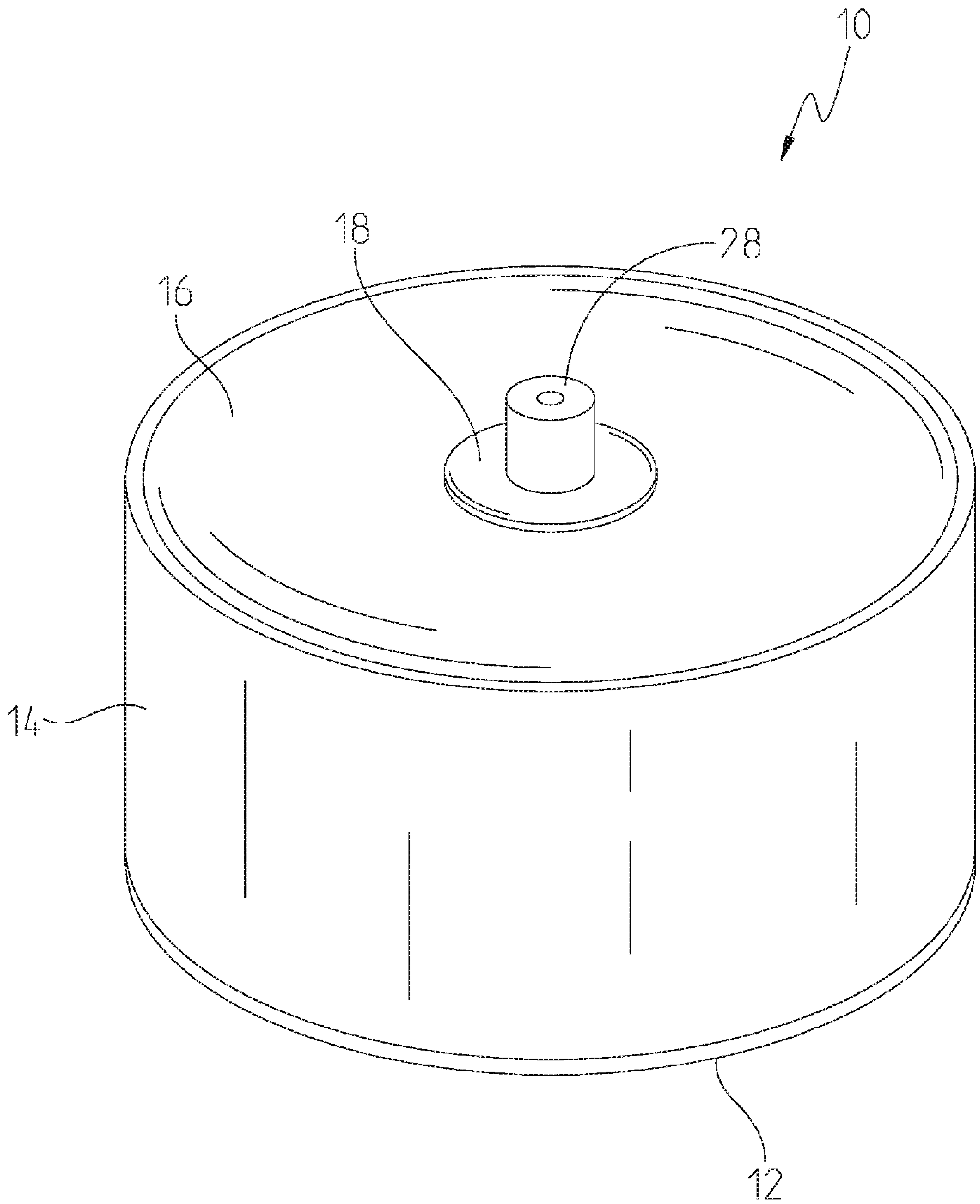


Fig. 1

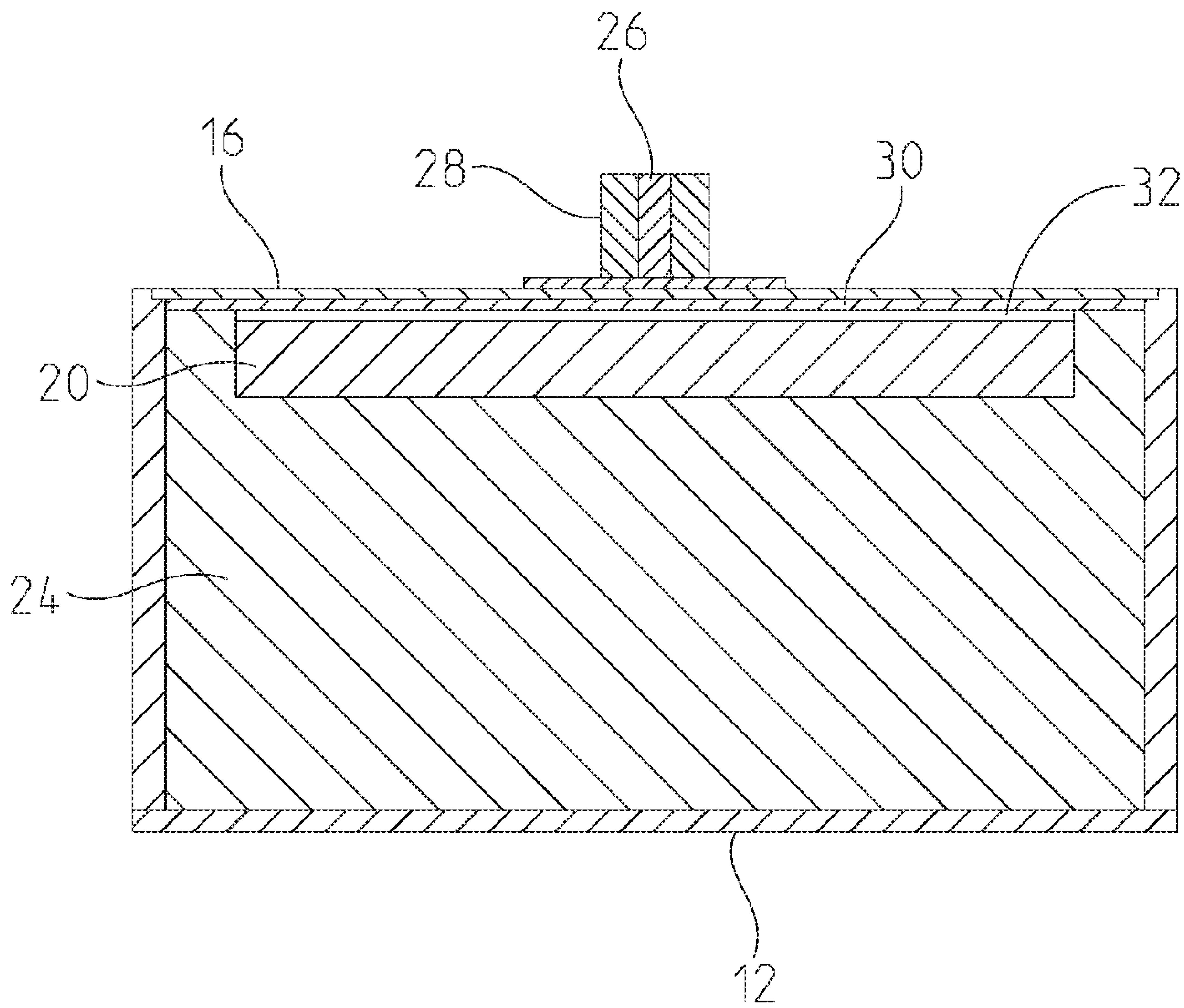


Fig. 2

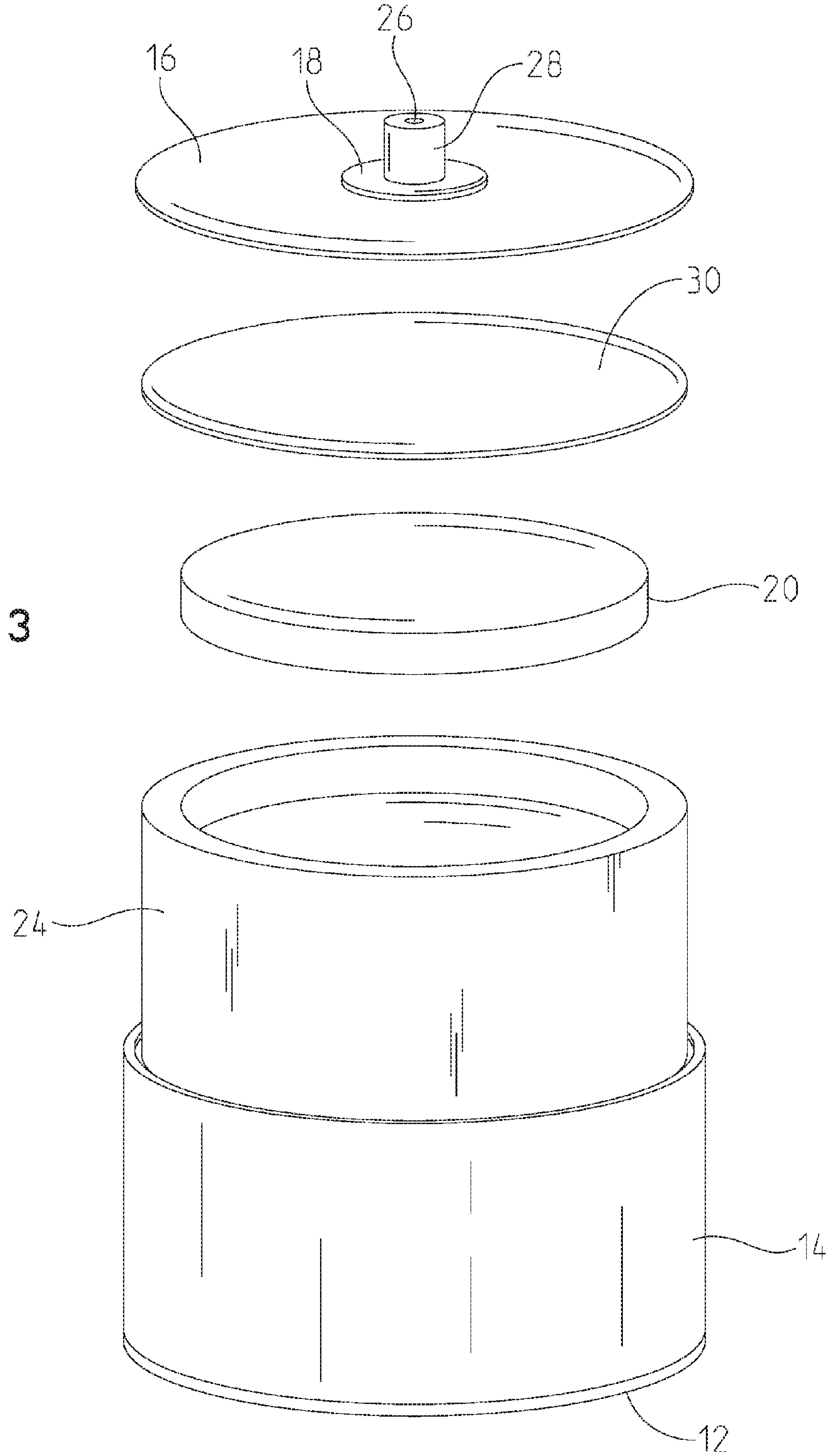


Fig. 3

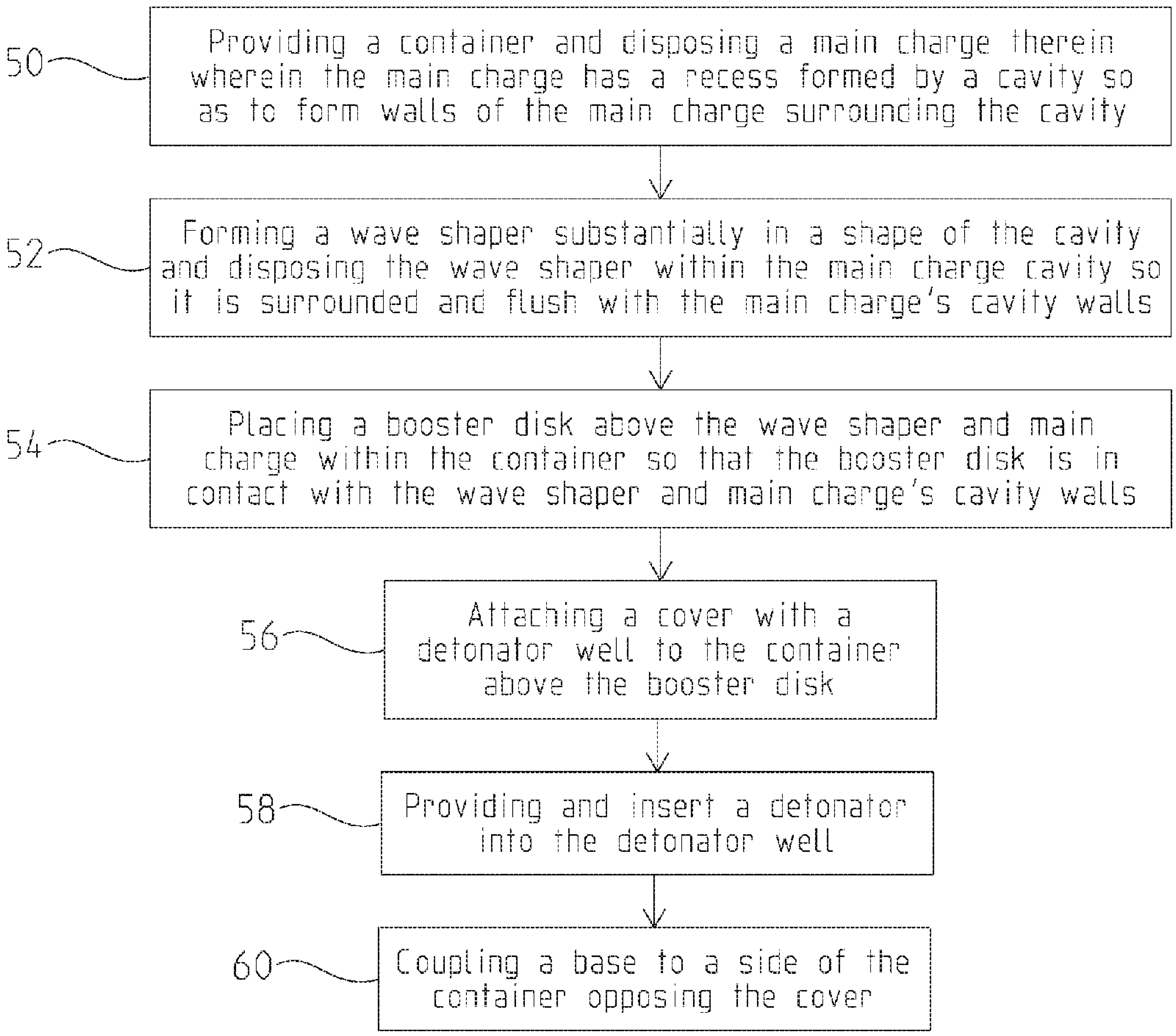

50
Providing a container and disposing a main charge therein wherein the main charge has a recess formed by a cavity so as to form walls of the main charge surrounding the cavity
52
Forming a wave shaper substantially in a shape of the cavity and disposing the wave shaper within the main charge cavity so it is surrounded and flush with the main charge's cavity walls
54
Placing a booster disk above the wave shaper and main charge within the container so that the booster disk is in contact with the wave shaper and main charge's cavity walls
56
Attaching a cover with a detonator well to the container above the booster disk
58
Providing and insert a detonator into the detonator well
60
Coupling a base to a side of the container opposing the cover

Fig. 4

STRUCTURE FOR SHAPING AND APPLYING A PROPAGATING SHOCK WAVE TO AN AREA OF AN EXPLOSIVE LOAD TO INCREASE AN ENERGETIC SHOCK IMPACT EFFECT ON A TARGET

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0001] The invention described herein includes contributions by one or more employees of the Department of the Navy made in performance of official duties and may be manufactured, used and licensed by or for the United States Government for any governmental purpose without payment of any royalties thereon. This invention (Navy Case 101,477) is assigned to the United States Government and is available for licensing for commercial purposes. Licensing and technical inquiries may be directed to the Technology Transfer Office, Naval Surface Warfare Center Crane, email: Cran_CTO@navy.mil.

BACKGROUND AND SUMMARY OF THE INVENTION

[0002] Aspects disclosed herein relate to the field of explosive devices. In particular, one embodiment can include a cylindrical dynamic access structure with a plastic bonded explosive material.

[0003] Typical bulk explosive charge includes generic containers or other simple configurations consisting primarily of packaged or hand packed explosive, e.g., C4 or TNT. The performance of these devices is inefficient both in how they are initiated and how the shock wave progresses through the explosive in such a device. Therefore, more explosive materials are required by these devices than would otherwise be necessary with a more optimal design. Furthermore, some of these bulk explosive designs have safety issues that can be improved.

[0004] An apparatus in accordance with an embodiment of the invention provides a demolition charge with enhanced capabilities beyond those of traditional bulk charges. A cylindrical dynamic access structure ("CDAS") with plastic bonded explosive combines an optimized shock wave of the CDAS design with a high performance precision explosive. A charge that combines a CDAS design and plastic bonded explosive according to an embodiment of the invention can perform, for example, twenty percent to thirty percent more effectively than traditional C4 bulk charges.

[0005] One advantage of an exemplary embodiment is an ability to produce increased output from a charge mass than a bulk charge could produce with a similar charge mass and a detonator without an embodiment of the invention. Additionally, increased effectiveness of an exemplary embodiment allows a bulk charge having less mass than bulk charges without an embodiment of the invention.

[0006] Another advantage of an embodiment of the invention is an ability to produce a more energetic shock impact on the target than provided by traditional bulk charges. Traditionally charges have less optimal shock front impacts in the form of point contact or shock fronts directed parallel to the charge. For example, an exemplary embodiment provides an impact that is cylindrical. This cylindrical loading has at least two advantages. First, the cylindrical loading provided by the CDAS results in an intense load applied simultaneously over a greater area. Second, cylindrical loading provided by the exemplary CDAS results in further amplification of energy in a form of colliding shocks developed as a shock wave expands towards the center of the cylinder.

[0007] In one embodiment, a combination of the CDAS design and plastic bonded explosive load amplifies the effectiveness of the hardware design. Plastic bonded explosive is more energetic than hand loaded explosives such as, for example, C4. Also, a production loaded explosive, e.g., plastic bonded explosive, is more uniform and more dense, which provides a more uniform and energetic detonation.

[0008] An apparatus in accordance with an embodiment of the invention provides additional advantages as well. Such an apparatus, for example, provides the user with a factory loaded charge, thus eliminating the need to hand-build traditional demolition charges. This saves the user time and improves safety by reducing direct exposure to explosive chemicals and the risks associated with hand-forming energetic materials. Also, the CDAS can incorporate a priming or detonator well placed through a cover, e.g., a center of the cover, of the CDAS outer shell allowing for easy installation and removal of detonators or primers with various diameters without the need for additional adapters for a detonator or primer and also providing for quick installation or removal of the detonator or primer.

[0009] Additional features and advantages of the present invention will become apparent to those skilled in the art upon consideration of the following detailed description of the illustrative embodiment exemplifying the best mode of carrying out the invention as presently perceived.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The detailed description of the drawings particularly refers to the accompanying figures in which:

[0011] FIG. **1** shows a perspective external view of an exemplary embodiment of the invention;

[0012] FIG. **2** shows a cross-sectional view of an exemplary embodiment;

[0013] FIG. **3** shows an exploded view of an exemplary embodiment; and

[0014] FIG. **4** shows a block diagram illustrating one method of manufacturing an exemplary embodiment.

DETAILED DESCRIPTION OF THE DRAWINGS

[0015] The embodiments of the invention described herein are not intended to be exhaustive or to limit the invention to precise forms disclosed. Rather, the embodiments selected for description have been chosen to enable one skilled in the art to practice the invention.

[0016] Referring initially to FIG. **1**, a CDAS with plastic bonded explosives is shown generally at **10**. Embodiments comprise a base plate **12**, which supports a container **14**, and a main charge **24** (not shown). In certain embodiments a container **14** can have a plurality of containers stacked on top of each other to form varying heights. One embodiment can include, for example, a polycarbonate container **14**. A container **14** can surround a main charge **24** (not shown). A container **14** can support a cover **16**. A primer well **18** can be disposed on the center of cover **16**. A primer well **18** can support an adapter **28**, which can receive various types of detonators, such as, for example, safety fuse, shock tube detonator, electrical detonators, electronic detonators, or the like. An exemplary diameter of the CDAS can be, e.g., 12 inches across, e.g., at the top plate **16**, at the base plate **12**, or at some height of the CDAS. Height of the exemplary CDAS, e.g., from the base plate **12** to the top plate **16**, can be, e.g., 7 inches. Weight of this embodiment can be, e.g., 40 pounds. A charge design is not limited to a fixed diameter, height, or weight and can be scaled for various applications. The exemplary embodiment shown in FIG. **1** can be placed on a target structure, e.g., by hand, with the base plate **12** substantially adjacent to the target structure.

[0017] Referring to FIG. **2**, a cross-sectional view of an exemplary embodiment is shown. One exemplary embodiment of the invention includes a main charge **24** which can be formed adjacent to an entire inner surface of base plate **12** and container **14**. A main charge **24** can comprise a plastic bonded explosive, e.g., PBXN-110. PBXN-110 is a factory-loaded, precision-loaded explosive. A PBXN-110 main charge composition can be comprised of, e.g., 86 to 88 percent HMX, and 12 to 14 percent binder by weight. The exemplary embodiment of the main charge can comprise of explosives other than PBXN-110, or in any explosive combination with PBXN-110. A booster disk **30** in the embodiment shown in FIG. **2** comprises a disk of explosive booster material positioned at the top of the main charge **24** and the wave shaper **20**. One side of booster disk **30** is positioned adjacent to top plate **16**, while the other side of booster disk **30** is positioned adjacent to wave shaper **20** and main charge **24**. The wave shaper **20** prevents contact between booster disk **30** and main charge **24** except for a ring that contacts the outer diameter of booster disk **30**. In embodiments the wave shaper **20** separates the shock from the booster **30** from the main charge **24** and manipulates or shapes the shock wave from the booster hits or initiates the main charge **24**. In certain embodiments a wave shaper **20** can have a first piece and a second piece, which can be connected to form a void **32**. A wave shaper **20** can comprise one or more pieces. In the exemplary embodiment the wave shaper **20** can be plastic. In certain embodiments the waver shaper **20** can be steel, aluminum, brass, PTFE, or the like. A void **32** can be formed by and enclosed within the wave shaper **20** as shown in FIG. **2**. In certain embodiments the void **32** can be air, gases, or the like. In exemplary embodiments the wave shaper **20** forms the air void **32** within the CDAS. The wave shaper **20** is not limited to a cylindrical shape, it can be any shape that achieves effects in accordance with embodiments of the invention for example, rectangular, spherical, and the like.

[0018] The exemplary embodiment shown in FIG. **2** does not comprise a means of initiation and requires a user-installed blasting cap or similar detonator. Embodiments disclosed herein include a flexible charge primer **26**, which allows for high velocity, high-energy detonations. In embodiments a flexible charge primer **26** has a center hole for a detonator to be placed in contact with a booster **30**. A flexible charge primer **26** can comprise of, e.g., Detaprime. Detaprime is a compact, high-detonation pressure primer. Alternative embodiments can comprise a pre-installed means of initiation. In an exemplary embodiment, upon initiation of a user-installed detonator, the booster disk detonates in an expanding circular shock wave across the top of the CDAS, between a top plate **16** and a wave shaper **20**. When this expanding circular shock wave reaches the edge of booster disk **30**, it contacts and detonates a main charge **24**. This detonation of the main charge **24** occurs substantially simultaneously in a ring around the booster disk **30**, where the booster disk **30** is in contact with main charge **24**. This simultaneous ring of detonation at the top portion of main charge **24** results in a cylindrical shaped shock front progressing through the main charge toward the base plate **12**. This exemplary cylindrical shock pattern produces an intense load applied simultaneously over a great area and involves amplification of the energy in the form of colliding shocks developed as the shock wave expands towards the center of the CDAS.

[0019] Referring to FIG. **3**, an exploded diagram view of an exemplary embodiment is shown. This view shows a detonator adapter **28**, a flexible charge primer **26** (not shown), a primer well **18**, a top plate **16**, a booster disk **30**, a wave shaper **20**, and a main charge **24**, in order from top to bottom, exploded out of a container **14** and away from base plate **12**. The wave shaper **20** fits down into the depression in the top of main charge **24** and booster disk **30** fits onto the top of wave shaper **20** and main charge **24** such that booster disk **30** is in contact with main charge **24** along the outer edge of booster disk **30**, with wave shaper **20** preventing most of the bottom of booster disk **30** from being in contact with main charge **24**. When the components of this embodiment are collapsed back into position, top plate **16** seals to a container **14** to enclose (from top to bottom) booster disk **30**, wave shaper **20**, and the main charge **24** within the CDAS comprised of top plate **16**, container **14**, base plate **12**, primer well **18**, and adaptor **28**.

[0020] Referring to FIG. **4**, a block diagram illustrating an exemplary method associated with manufacturing an exemplary CDAS. As a preliminary step to one variant of the exemplary method, an exemplary process can include providing CDAS components such as described herein. At step **50**, providing a container and disposing a main charge therein wherein the main charge has a recess formed by a cavity so as to form walls of the main charge surrounding the cavity. At step **52**, forming a wave shaper substantially in a shape of the cavity and disposing the wave shaper within the main charge cavity so it is surrounded and flush with the main charge's cavity walls. At step **54**, placing a booster disk above the wave shaper and main charge within the container so that the booster disk is in contact with the wave shaper and main charge's cavity walls. At step **56**, attaching a cover with a detonator well to the container above the booster disk. At step **58**, providing and insert a detonator into the detonator well. At step **60**, coupling a base to a side of the container opposing the cover.

[0021] Note that an exemplary embodiment can omit step **58** until a time the CDAS is ready for use. An exemplary wave shaper can be formed by either, for example, one piece or multiple pieces thereby forming a void inside the wave shaper which can have for example, air, gas, or the like within it. An exemplary main charge can be adapted so that it can be inserted into the container, leaving an open area for a wave shaper and an enclosed area between the inner wall of the container, and the outer wall of the wave shaper, which allows the outer area of the main charge to be in contact with a booster disk. An exemplary main charge can be placed so that it is adjacent to and touches the outer area of a booster disk, surrounds the waver shaper, and also in lateral contact with an inner wall of a container. An exemplary base can be placed adjacent to a main charge and connected to a container.

[0022] Although the invention has been described in detail with reference to certain preferred embodiments, variations and modifications exist within the spirit and scope of the invention as described and defined in the following claims.

1. An explosive device comprising:
- a detonator;
- a primer;
- a cover comprising a priming well at a center section of said cover adapted to removably receive said detonator, and said primer;
- a booster disk adapted to generate a first shock wave based on firing said detonator;
- a main charge adapted to generate an explosive force based on said first shock wave;
- a wave shaper structure comprising a first and second layer structure operable for channeling said first shock wave, said wave shaper is disposed between said booster disk and said main charge, wherein said wave shaper structure is operable to direct or channel said first shock wave from the booster disk to an outer portion of said main charge; and
- a container formed or adapted for enclosing or coupling with said cover, said booster disk, said wave shaper, and said main charge.

2. An explosive device as set forth in claim **1**, wherein said main charge comprises a plastic bonded explosive.

3. An explosive device as set forth in claim **1**, wherein said booster disk comprises a booster explosive.

4. An explosive device as set forth in claim **1**, wherein said cover removably receives a detonator or initiator at a first location in a center section.

5. An explosive device as set forth in claim **1**, wherein said priming well is formed to accept a flexible charge primer.

6. An explosive device as set forth in claim **2**, wherein said plastic bonded explosive comprises PBXN-110.

7. An explosive device as set forth in claim **1**, wherein said container comprises a polycarbonate material.

8. An explosive device as set forth in claim **1**, wherein said container is 6 to 18 inches in diameter and 5 to 20 inches in height.

9. An explosive device as set forth in claim **1**, wherein said first shock wave simultaneously or near simultaneously detonates said main charge at said outer portion of said main charge.

10. An explosive device comprising a charge and a means operable for enabling detonation of a booster disk that results in the subsequent detonation of the charge simultaneously along a ring at an outer edge of said booster disk.

11. A method for making an explosive device comprising the steps of:
- placing a primer into a center portion of a priming well, wherein said priming well is adapted to removably receive a detonator;
- aligning and connecting said priming well at a center section of a cover;
- connecting a container to said cover, wherein said container can be a plurality of containers placed on each other;
- placing a booster disk adjacent to said priming well and said cover;
- forming a wave shaper, wherein said wave shaper comprises a first and second structure wherein a void is formed;
- placing said wave shaper adjacent to said booster disk;
- adapting a main charge wherein said main charge is placed within the container adjacent to said booster disk, and disposed around said wave shaper; and
- connecting a base to said container and adjacent to said main charge.

12. A method of manufacturing an improved explosive comprising
- providing a container and disposing a main charge therein wherein the main charge has a recess formed by a cavity so as to form walls of the main charge surrounding the cavity;
- providing an explosive booster disk operable to generate a first shock wave operable to detonate said main charge;
- forming a shock wave shaper substantially in a shape of the cavity and formed with an air gap within said shock wave shaper, said shock wave shaper formed to channel said first shock wave along a surface of said wave shaper towards said walls of the main charge surrounding the cavity;
- disposing the wave shaper within the main charge cavity so it is surrounded and flush with the main charge's cavity walls;
- placing said booster disk above the wave shaper and main charge within the container so that the booster disk is in contact with the wave shaper and main charge's cavity walls;
- attaching a cover with a detonator well to the container above the booster disk; and
- coupling a base to a side of the container opposing the cover.

13. A method as in claim **12**, further comprising providing and inserting a detonator into the detonator well.

14. A method of manufacturing an explosive device comprising:
- providing a detonator;
- providing a primer;
- providing a cover comprising a priming well at a center section of said cover adapted to removably receive said detonator, and said primer;
- providing a booster disk adapted to generate a first shock wave based on firing said detonator;
- providing a main charge adapted to generate an explosive force based on said first shock wave;
- providing a wave shaper structure comprising a first and second layer structure operable for channeling said first shock wave, said wave shaper is disposed between said booster disk and said main charge, wherein said wave shaper structure is operable to direct or channel said first shock wave from the booster disk to an outer portion of said main charge; and
- providing a container formed or adapted for enclosing or coupling with said cover, said booster disk, said wave shaper, and said main charge.

15. A method as set forth in claim **14**, wherein said main charge comprises a plastic bonded explosive.

16. A method as set forth in claim **14**, wherein said booster disk comprises a booster explosive.

17. A method as set forth in claim **14**, wherein said cover removably receives a detonator or initiator at a first location in a center section.

18. A method as set forth in claim **14**, wherein said priming well is formed to accept a flexible charge primer.

19. A method as set forth in claim **15**, wherein said plastic bonded explosive comprises PBXN-110.

20. A method as set forth in claim **14**, wherein said container comprises a polycarbonate material.

21. A method as set forth in claim **14**, wherein said first shock wave simultaneously or near simultaneously detonates said main charge at said outer portion of said main charge.

22. An explosive device comprising a container and an explosive means operable for channeling of a booster disk detonation shock wave so as to detonate a main charge within the explosive means simultaneously along a ring or an outer edge of said booster disk in contact or proximity to outer sections of the main charge so as to result in reflection or direction of detonation of the main charge from an outer ring area of the main charge inwards towards a center of the main charge.

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