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(71) Applicant (for US only): **SCHLUMBERGER TECHNOLOGY CORPORATION** [US/US]; 300 Schlumberger Drive, Sugar Land, Texas 77478 (US).

(71) Applicant (for CA only): **SCHLUMBERGER CANADA LIMITED** [CA/CA]; 125 – 9 Avenue SE, Calgary, Alberta T2G 0P6 (CA).

(71) Applicant (for FR only): **SERVICES PETROLIERS SCHLUMBERGER** [FR/FR]; 42 rue Saint Dominique, 75007 Paris (FR).

(71) Applicant (for all designated States except CA, FR, US): **SCHLUMBERGER TECHNOLOGY B.V.** [NL/NL]; Parkstraat 83, 2514 JG The Hague (NL).

(72) Inventors: **LOWE, Erick**; Etudes et Productions Schlumberger, 1 rue Becquerel, 92140 Clamart (FR). **WALSE, Bhagyashri**; Office No. 701, 7th Floor, Building No. 6, Commerzone, Survey No. 144/145, Samrat Ashok Path, Off Airport Road, Yerawada, Pune Maharashtra 411006

(IN). **KALAKONDA, Hari**; Office No. 701, 7th Floor, Building No. 6, Commerzone, Survey No. 144/145, Samrat Ashok Path, Off Airport Road, Yerawada, Pune Maharashtra 411006 (IN).

(74) Agent: **SUKHAVASI, Rushi** et al.; Schlumberger, 10001 Richmond Ave., Houston, Texas 77042 (US).

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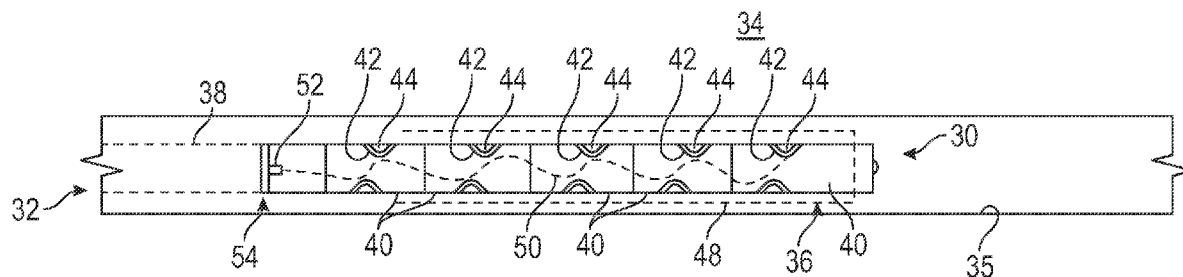


FIG. 1

(57) Abstract: A technique facilitates perforating operations. According to an embodiment, a perforating gun system utilizes a plurality of modular perforating gun sections which are readily assembled to create a perforating gun with a desired number and orientation of shaped charge holders. In some applications, the modular perforating gun sections may be formed of plastic, e.g. injection moldable plastic, to further reduce costs and provide great flexibility with respect to construction of the desired perforating gun.

## **PERFORATING GUN HAVING MODULAR CONSTRUCTION**

### **CROSS-REFERENCE TO RELATED APPLICATION**

[0001] This application claims priority to and benefit of Indian Provisional Patent Application No. 202221021701, entitled “Perforating Gun Having Modular Construction”, filed on April 12, 2022, which is incorporated herein by reference.

### **TECHNICAL FIELD**

[0002] This disclosure relates to systems and methods for assembling a perforating gun using modular sections.

### **BACKGROUND**

[0003] This section provides background information to facilitate a better understanding of the various aspects of the disclosure. It should be understood that the statements in this section of this document are to be read in this light, and not as admissions of prior art.

[0004] In many well applications, a wellbore is drilled and lined with casing. Subsequently, a perforating gun is deployed downhole to a desired location. The perforating gun has shaped charges which are ignited to create perforations through the surrounding casing and out into the formation. The perforations facilitate the flow of hydrocarbons, e.g. oil and gas, from the formation and into the wellbore for production to the surface. In fracking operations, the perforations may further be used to facilitate fracturing of the surrounding formation to enhance flow of hydrocarbons to the wellbore. Sometimes it is advantageous to create a relatively large number of perforations to enable a more thorough fracturing of the formation. However, the use of available perforating guns in creating the large number of perforations can add substantial expense to the overall operation.

**SUMMARY**

[0005] Certain embodiments commensurate in scope with the originally claimed disclosure are summarized below. These embodiments are not intended to limit the scope of the claimed disclosure, but rather these embodiments are intended only to provide a brief summary of possible forms of the disclosure. Indeed, embodiments may encompass a variety of forms that may be similar to or different from the embodiments set forth below.

[0006] In general, a system and methodology facilitate perforating operations. According to an embodiment, a perforating gun system utilizes a plurality of modular perforating gun sections which are readily assembled to create a perforating gun with desired numbers and orientations of shaped charge holders. In some applications, the modular perforating gun sections may be formed of plastic, e.g. injection moldable plastic, to further reduce costs and provide great flexibility with respect to construction of the desired perforating gun. According to an embodiment, a perforating gun includes modular perforating gun sections that may be snapped together to establish a desired length of the perforating gun. Each perforating gun section has at least one charge holder and charge retainer to receive and retain a corresponding shaped charge. According to an embodiment, a method for deploying a perforating gun in a well includes assembling the perforating gun from modular perforating gun sections. A respective section snaps together with a corresponding additional section to establish a desired length of the perforating gun. Additionally, each section has at least one charge holder and charge retainer to receive and retain a corresponding shaped charge. The method also includes deploying the perforating gun downhole in the well using a conveyance.

[0007] However, many modifications are possible without materially departing from the teachings of this disclosure. Accordingly, such modifications are intended to be included within the scope of this disclosure as defined in the claims.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0008] Certain embodiments of the disclosure will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements. It should be understood, however, that the accompanying figures illustrate the

various implementations described herein and are not meant to limit the scope of various technologies described herein, and:

**[0009]** Figure 1 is a schematic illustration of an example of a modular perforating gun system for use in a borehole, according to an embodiment of the disclosure;

**[0010]** Figure 2 is an illustration of an example of perforating gun modules which may be selectively combined, according to an embodiment of the disclosure;

**[0011]** Figure 3 is an illustration of the perforating gun modules of Figure 2 after combination, according to an embodiment of the disclosure;

**[0012]** Figure 4 is an illustration of another example of a perforating gun module which may be selectively combined with other perforating gun modules, according to an embodiment of the disclosure;

**[0013]** Figure 5 is an illustration of a perforating gun module which may be snap connected with the associated perforating gun module of Figure 4, according to an embodiment of the disclosure;

**[0014]** Figure 6 is an illustration of another example of perforating gun modules which may be selectively combined, according to an embodiment of the disclosure;

**[0015]** Figure 7 is an illustration of the perforating gun modules of Figure 6 after combination, according to an embodiment of the disclosure;

**[0016]** Figure 8 is an illustration of another example of perforating gun modules which may be selectively combined, according to an embodiment of the disclosure;

**[0017]** Figure 9 is an illustration of the perforating gun modules of Figure 8 after combination, according to an embodiment of the disclosure;

**[0018]** Figure 10 is an illustration of another example of perforating gun modules which may be selectively combined, according to an embodiment of the disclosure;

**[0019]** Figure 11 is an illustration of the perforating gun modules of Figure 10 after combination, according to an embodiment of the disclosure;

**[0020]** Figure 12 is an illustration of another example of perforating gun modules which may be selectively combined, according to an embodiment of the disclosure;

**[0021]** Figure 13 is an illustration of the perforating gun modules of Figure 12 after combination, according to an embodiment of the disclosure;

[0022] Figure 14 is an illustration of another example of a perforating gun module which may be selectively combined, according to an embodiment of the disclosure;

[0023] Figure 15 is an illustration of the perforating gun module of Figure 14 from a different angle, according to an embodiment of the disclosure;

[0024] Figure 16 is an illustration of another example of a perforating gun module which may be selectively combined, according to an embodiment of the disclosure;

[0025] Figure 17 is an illustration of the perforating gun module of Figure 16 from a different angle, according to an embodiment of the disclosure;

[0026] Figure 18 is an illustration of another example of a perforating gun module which may be selectively combined, according to an embodiment of the disclosure; and

[0027] Figure 19 is an illustration of the perforating gun module of Figure 18 from a different angle, according to an embodiment of the disclosure.

#### **DETAILED DESCRIPTION**

[0028] In the following description, numerous details are set forth to provide an understanding of some embodiments of the present disclosure. However, it will be understood by those of ordinary skill in the art that the system and/or methodology may be practiced without these details and that numerous variations or modifications from the described embodiments may be possible.

[0029] At the outset, it should be noted that in the development of any such actual embodiment, numerous implementation—specific decisions are made to achieve the developer's specific goals, such as compliance with system related and business related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time consuming but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure. In addition, the composition used/disclosed herein can also comprise some components other than those cited. In the summary of the disclosure and this detailed description, each numerical value should be read once as modified by the term "about" (unless already expressly so modified), and then read again as not so modified unless otherwise indicated in context. The term about should be understood as any amount or range within 10% of the recited amount or range (for example, a range

from about 1 to about 10 encompasses a range from 0.9 to 11). Also, in the summary and this detailed description, it should be understood that a concentration range listed or described as being useful, suitable, or the like, is intended that any concentration within the range, including the end points, is to be considered as having been stated. For example, "a range of from 1 to 10" is to be read as indicating each possible number along the continuum between about 1 and about 10. Furthermore, one or more of the data points in the present examples may be combined together, or may be combined with one of the data points in the specification to create a range, and thus include each possible value or number within this range. Thus, even if specific data points within the range, or even no data points within the range, are explicitly identified or refer to a few specific, it is to be understood that inventors appreciate and understand that any data points within the range are to be considered to have been specified, and that inventors possessed knowledge of the entire range and the points within the range.

**[0030]** Unless expressly stated to the contrary, "or" refers to an inclusive or and not to an exclusive or. For example, a condition A or B is satisfied by anyone of the following: A is true (or present) and B is false (or not present), A is false (or not present) and B is true (or present), and both A and B are true (or present).

**[0031]** In addition, use of the "a" or "an" are employed to describe elements and components of the embodiments herein. This is done merely for convenience and to give a general sense of concepts according to the disclosure. This description should be read to include one or at least one and the singular also includes the plural unless otherwise stated.

**[0032]** The terminology and phraseology used herein is for descriptive purposes and should not be construed as limiting in scope. Language such as "including," "comprising," "having," "containing," or "involving," and variations thereof, is intended to be broad and encompass the subject matter listed thereafter, equivalents, and additional subject matter not recited.

**[0033]** As used herein, "embodiments" refers to non-limiting examples disclosed herein, whether claimed or not, which may be employed or present alone or in any combination or permutation with one or more other embodiments. Each embodiment disclosed herein should be regarded both as an added feature to be used with one or more

other embodiments, as well as an alternative to be used separately or in lieu of one or more other embodiments. It should be understood that no limitation of the scope of the claimed subject matter is thereby intended, any alterations and further modifications in the illustrated embodiments, and any further applications of the principles of the application as illustrated therein as would normally occur to one skilled in the art to which the disclosure relates are contemplated herein.

**[0034]** Moreover, the schematic illustrations and descriptions provided herein are understood to be examples only, and components and operations may be combined or divided, and added or removed, as well as re-ordered in whole or part, unless stated explicitly to the contrary herein. Certain operations illustrated may be implemented by a computer executing a computer program product on a computer readable medium, where the computer program comprises instructions causing the computer to execute one or more of the operations, or to issue commands to other devices to execute one or more of the operations.

**[0035]** The disclosure herein generally involves a system and methodology which facilitate perforating operations. According to an embodiment, a perforating gun system utilizes a plurality of modular perforating gun sections which are readily assembled to create a perforating gun with desired numbers and orientations of shaped charge holders. For example, different numbers of modular perforating gun sections may be assembled, e.g. snap together, to create an overall modular perforating gun of a desired length with a desired number of shaped charges. In some embodiments, individual modular perforating gun sections may be selected according to the angular orientation of the shaped charge holders so as to create perforations out into the surrounding formation with desired orientations. The modular sections also may be constructed to enable selective adjustment in the angular orientation of the shaped charge holders.

**[0036]** In some applications, the modular perforating gun sections may be formed of plastic, e.g. injection moldable plastic, to further reduce costs and to provide great flexibility with respect to construction of the desired perforating gun. By way of example, the plastic modular sections may be constructed as modular sections of a perforating gun loading tube. The loading tube may be selectively assembled to quickly and inexpensively construct a perforating gun with a desired configuration. According to an

embodiment, the modular perforating gun sections are injection moldable and easily snapped together in a manner which prevents unwanted separation. The plastic, modular perforating gun sections also may be constructed to have angular adjustability, thus alleviating the need for construction of separate parts to achieve different orientations/phasings with respect to shaped charge arrangement.

**[0037]** Referring generally to Figure 1, an example of a perforating gun system 30 is illustrated as deployed in a borehole 32, e.g. a wellbore, drilled into a formation 34. The borehole/wellbore 32 may be cased with a casing 35. Additionally, the perforating gun system 30 comprises at least one perforating gun 36 deployed downhole via a suitable conveyance 38. The illustrated perforating gun 36 comprises a plurality of modular perforating gun sections 40 which may be readily assembled to construct perforating gun 36 in a desired configuration, e.g. with a desired length and desired shaped charge phasing. In this example, each perforating gun module 40 comprises at least one shaped charge holder 42, e.g. a plurality of shaped charge holders 42, sized to receive an appropriate shaped charge 44.

**[0038]** In some embodiments, the modular perforating gun sections 40 are constructed as modular sections of a loading tube 46. The perforating gun 36 may comprise loading tube 46 positioned within a surrounding tubular member 48 in some applications. However, the modular perforating gun sections 40 may be used in a variety of perforating gun types with or without the surrounding tubular member 48.

**[0039]** The perforating gun 36 also may comprise a variety of other features such as detonator cord 50 routed to each of the shaped charges 44. A detonator 52 may be used to control ignition of the detonator cord 50 and thus ignition of the shaped charges 44. Depending on the perforating operation, perforating gun 36 may comprise various other features and components, such as an electric switch or switches for activating the detonator, electrical wire for power and telemetry, and a connector 54 for coupling the perforating gun 36 with conveyance 38.

**[0040]** Referring generally to Figure 2, an example of modular perforating gun sections 40 is illustrated. In this example, two modular perforating gun sections 40 have been illustrated to facilitate description of the embodiment. However, additional modular

perforating gun sections 40 may be added to create the desired configuration/length of perforating gun 36.

**[0041]** According to the embodiment illustrated in Figure 2, each modular perforating gun section 40 has been injection molded from injection moldable plastic. Additionally, each moldable perforating gun section 40 has been formed with connection features 56 to enable easy, snap connection of adjacent sections 40 while preventing unwanted separation after connection. In this example, moldable perforating gun sections 40 may be snapped together without the use of tools.

**[0042]** As illustrated, the connection features 56 comprise a center connection feature 58 having corresponding ribs and slots to control the angular orientation of one modular perforating gun section 40 with respect to the adjacent section 40. The connection features 56 also may comprise snap connectors 60 each having a flexible hook which may be inserted into a corresponding opening and engaged to secure the adjacent sections 40 to each other, as illustrated in Figure 3. Each modular perforating gun section 40 also may comprise one or more shaped charge holders 42 combined with flexible retention members 62 arranged to secure the shaped charge 44 once inserted into a corresponding charge holder 42.

**[0043]** In some embodiments, the perforating gun sections 40 also include a central passage 64 through which a rod member 66 may be inserted. This allows the use of a weight 68 (or other type of weighted section) to orient the sections 40 and thus the shaped charges 44 via gravity. In other words, the connected, modular perforating gun sections 40 are rotated about rod member 66 under the influence of gravity on weight 68. The perforating gun sections 40 also may comprise other features to accommodate sensors, electrical wires, and other components used in a given perforating operation. For example, the perforating gun sections 40 may comprise slots/passages 70 along which detonator cord 50 may be routed to corresponding shaped charges 44.

**[0044]** Referring generally to Figures 4 and 5, another embodiment of modular perforating gun sections 40 is illustrated. This embodiment has features similar to the embodiment described above with reference to Figures 2 and 3. However, in the latter embodiment each modular perforating gun section 40 comprises a single charge holder 42 and the connection features 56 are arranged so that the shaped charges 44 alternate

180° from one perforating gun section 40 to the next. In this example, each charge holder 42 is formed with a releasable charge holder sleeve 72 which may be releasably held in place via releasable retention features 74.

**[0045]** Referring generally to Figures 6 and 7, another embodiment of modular perforating gun sections 40 is illustrated. This embodiment has features similar to the embodiment described above with reference to Figures 2 and 3. However, in the latter embodiment each modular perforating gun section 40 comprises unique connection features 56 which allow sequential perforating gun sections 40 to be snapped together while maintaining the charge holders 42, and thus the shaped charges 44, at desired angular displacements with respect to each other. For example, each successive perforating gun section 40 may provide an additional 60° (or other selected angular displacement) with respect to the adjacent perforating gun sections 40. The detonator cord 50 may be wrapped helically along the overall perforating gun 36 to ensure connection with the shaped charges 44.

**[0046]** In this example, the connection features comprise a spring hook 76 received in a corresponding slot 78 combined with orientation tabs 80 to ensure easy, secure, and properly oriented connection of sequential, modular perforating gun sections 40. As illustrated, each perforating gun section 40 also may comprise a conductive bracket 82 having a bracket tab 84 extending radially inward to a central location to ensure conductive contact with a corresponding bracket tab 84/bracket 82 of the next sequential perforating gun section 40. The contacting conductive brackets 82 provide a conductive pathway to enable transfer of signals and/or power along the overall perforating gun 36.

**[0047]** Referring generally to Figures 8 and 9, another embodiment of modular perforating gun sections 40 is illustrated. This embodiment has features similar to the embodiment described above with reference to Figures 6 and 7. However, in the latter embodiment each modular perforating gun section 40 comprises unique connection features 56 which allow adjustment of the angular orientation or phasing of each perforating gun section 40 relative to the next adjacent perforating gun section 40. For example, the connection features 56 may comprise spring tabs 86 which may be snapped into different recesses 88 located at different angular positions. As a result, the angular

orientation of sequential charge holders 42/shaped charges 44 has substantial adjustability.

**[0048]** Referring generally to Figures 10 and 11, another embodiment of modular perforating gun sections 40 is illustrated. This embodiment has features similar to the embodiment described above with reference to Figures 8 and 9. However, in the latter embodiment the unique connection features 56 allow even greater adjustment of the angular orientation or phasing of each perforating gun section 40 relative to the next adjacent perforating gun section 40. For example, the connection features 56 may again comprise spring tabs 86 which may be snapped into numerous different recesses 88 located at different angular positions about the circumference of each perforating gun section 40. As a result, the angular orientation of sequential charge holders 42/shaped charges 44 has substantial adjustability. This embodiment and various other embodiments described herein may utilize conductive brackets 82 or other types of conductors to enable transmission of signals and power along the perforating gun 36.

**[0049]** Referring generally to Figures 12 and 13, another embodiment of modular perforating gun sections 40 is illustrated. Similar to the other embodiments described herein, the modular perforating gun sections 40 may be formed of injection moldable plastic via a rapid, inexpensive injection molding process. The injection moldable sections 40 enable a quick, inexpensive technique for constructing perforating gun 36 with a desired length/configuration. In this latter example, the charge holders 42 are arranged in each perforating gun section 40 so that at least some sequential shaped charges 44 are positioned in the same plane. In this example weights 68 may again be used to pivot the modular perforating gun sections 40 about a rod member 66. Various types of connection features may be used to provide interlocking of adjacent sections 40.

**[0050]** Referring generally to Figures 14 and 15, another embodiment of modular perforating gun sections 40 is illustrated. In this example, the connection features 56 may comprise a series of pins 90 received in corresponding pin recesses 92 to control angular orientation of one perforating gun section 40 relative to the adjacent perforating gun sections 40. A central rod member 66 may be used to facilitate positioning and orientation of the charge holders 42. For example, adjacent perforating gun sections 40 may be arranged to orient multiple charge holders 42 and charges 44 in a common plane.

**[0051]** Referring generally to Figures 16 and 17, another embodiment of modular perforating gun sections 40 is illustrated. In this example flexible retention members 62 comprise laterally flexible tabs 94 which may be shifted laterally to enable insertion of a shaped charge 44 into the corresponding charge holder 42. The flexible tabs 94 then simply snap laterally back to retain the shaped charge 44. The retention features 56 may comprise a variety of concentric, circular members 96 which may be inserted into each other and held with a suitable snap hook or other type of retention feature.

**[0052]** Referring generally to Figures 18 and 19, another embodiment of modular perforating gun sections 40 is illustrated. In this example, the connection features 56 may comprise a dowel pin 98 which is received in a corresponding pin receiver recess 100 in the next adjacent perforating gun section 40. The dowel pin 98 may be used to orient the perforating gun sections 40, and thus the charge holders 42, with respect to each other along the modular perforating gun sections 40 of the overall perforating gun 36.

**[0053]** Depending on the parameters of a given environment and/or perforating gun operation, the size, configuration, and number of modular perforating gun sections 40 may vary. For example, the number and orientation of perforations into the surrounding formation may dictate the length of the perforating gun 36, the number of perforating gun sections 40, and the shaped charge orientation as well as the adjustability of the orientation. Some perforating guns 36 may be constructed with appropriate switches to enable selective firing of shaped charges 44 along different sections of the overall perforating gun 36 or of separate perforating guns 36 located downhole.

**[0054]** Similarly, various types of connection features 56, conductive features, adjustability features, and/or other features of the modular perforating gun sections 40 may be selected to facilitate the quick, easy and inexpensive assembly of a given perforating gun 36 for a given application. Various connection features 56 may be interchanged with other features of the modular perforating gun sections 40. The modular perforating gun sections 40 also may be injection molded or otherwise inexpensively created from a variety of injection moldable plastics or other suitable materials providing the desired ease of manufacture and selectively configurable structures.

**[0055]** In accordance with certain embodiments, a system for use in a well includes a perforating gun having modular perforating gun sections configured to be snapped together to establish a desired length of the perforating gun. Each modular perforating gun section has at least one charge holder and charge retainer to receive and retain a corresponding shaped charge.

**[0056]** In some embodiments, each modular perforating gun section is formed of plastic. In some embodiments, each modular perforating gun section is injection molded from plastic. In some embodiments, the modular perforating gun sections are configured to be snapped together via connection features. In some embodiments, the connection features maintain respective charge holders of adjacent modular perforating gun sections at desired phasing. In some embodiments, each modular perforating gun section comprises a conductor. The conductors are arranged to form conductive contact when the modular perforating gun sections are snapped together.

**[0057]** In some embodiments, the perforating gun includes a rod extending through the modular perforating gun sections. In some embodiments, selected modular perforating gun sections include a weight to rotate the modular perforating gun sections about the rod to a desired angular orientation. In some embodiments, the modular perforating gun sections are connected to form a loading tube of the perforating gun. In some embodiments, the perforating gun includes a tubular member surrounding the loading tube. In some embodiments, the system includes shaped charges connected via a detonator cord.

**[0058]** In accordance with certain embodiments, a perforating gun includes modular perforating gun sections configured to be snapped together to establish a desired length of the perforating gun. Each perforating gun section has at least one charge holder and charge retainer to receive and retain a corresponding shaped charge.

**[0059]** In some embodiments, each modular perforating gun section is formed of plastic. In some embodiments, each modular perforating gun section is injection molded from plastic. In some embodiments, the modular perforating gun sections are configured to be snapped together via connection features. In some embodiments, each modular perforating gun section comprises a conductor. The conductors are arranged to form conductive contact when the modular perforating gun sections are snapped together.

**[0060]** In accordance with certain embodiments, a method for deploying a perforating gun in a well includes assembling the perforating gun from modular perforating gun sections. A respective section of the modular perforating gun sections are snapped together with a corresponding additional section of the modular perforating gun sections to establish a desired length of the perforating gun. Each respective section of the modular perforating gun sections has at least one charge holder and charge retainer to receive and retain a corresponding shaped charge. The method also includes deploying the perforating gun downhole in the well using a conveyance.

**[0061]** In some embodiments, the perforating gun includes a rod extending through the plurality of modular perforating gun sections. In some embodiments, selected modular perforating gun sections include a weight to rotate the modular perforating gun sections about the rod to a desired angular orientation. In some embodiments, the modular perforating gun sections are connected to form a loading tube of the perforating gun.

**[0062]** Although a few embodiments of the disclosure have been described in detail above, those of ordinary skill in the art will readily appreciate that many modifications are possible without materially departing from the teachings of this disclosure. Accordingly, such modifications are intended to be included within the scope of this disclosure as defined in the claims.

**CLAIMS**

What is claimed is:

- 1     1.     A system for use in a well, comprising:  
2                 a perforating gun having a plurality of modular perforating gun sections  
3                 configured to be snapped together to establish a desired length of the perforating  
4                 gun, each modular perforating gun section of the plurality of modular perforating  
5                 gun sections having at least one charge holder and charge retainer to receive and  
6                 retain a corresponding shaped charge.
- 1     2.     The system as recited in claim 1, wherein each modular perforating gun section is  
2                 formed of plastic.
- 1     3.     The system as recited in claim 1, wherein each modular perforating gun section is  
2                 injection molded from plastic.
- 1     4.     The system as recited in claim 1, wherein the plurality of modular perforating gun  
2                 sections are configured to be snapped together via connection features.
- 1     5.     The system as recited in claim 4, wherein the connection features maintain  
2                 respective charge holders of adjacent modular perforating gun sections at desired  
3                 phasing.
- 1     6.     The system as recited in claim 5, wherein each modular perforating gun section  
2                 comprises a conductor, wherein the conductors being arranged to form conductive  
3                 contact when the modular perforating gun sections are snapped together.
- 1     7.     The system as recited in claim 1, wherein the perforating gun further comprises a  
2                 rod extending through the modular perforating gun sections.  
1

1 8. The system as recited in claim 7, wherein selected modular perforating gun  
2 sections of the plurality of modular perforating gun sections include a weight to  
3 rotate the plurality of modular perforating gun sections about the rod to a desired  
4 angular orientation.

1 9. The system as recited in claim 1, wherein the modular perforating gun sections  
2 are connected to form a loading tube of the perforating gun.

1 10. The system as recited in claim 9, wherein the perforating gun further comprises a  
2 tubular member surrounding the loading tube.

1 11. The system as recited in claim 1, further comprising a plurality of the shaped  
2 charges connected via a detonator cord.

1 12. A perforating gun, comprising:  
2 a plurality of modular perforating gun sections configured to be snapped together  
3 to establish a desired length of the perforating gun, each modular perforating gun section  
4 of the plurality of modular perforating gun sections having at least one charge holder and  
5 charge retainer to receive and retain a corresponding shaped charge.  
6

7 13. The perforating gun of claim 12, wherein each modular perforating gun section is  
8 formed of plastic.

9 14. The perforating gun of claim 12, wherein each modular perforating gun section is  
10 injection molded from plastic.

11 15. The perforating gun of claim 12, wherein the plurality of modular perforating gun  
12 sections are configured to be snapped together via connection features.

13

19 16. The perforating gun of claim 15, wherein each modular perforating gun section  
20 comprises a conductor, the conductors being arranged to form conductive contact when  
21 the modular perforating gun sections are snapped together.

22

23 17. A method for deploying a perforating gun in a well, comprising:  
24 assembling the perforating gun from a plurality of modular perforating gun  
25 sections, wherein a respective section of the plurality of modular perforating gun sections  
26 are snapped together with a corresponding additional section of the plurality of  
27 perforating gun sections to establish a desired length of the perforating gun, and wherein  
28 each respective section of the plurality of modular perforating gun sections has at least  
29 one charge holder and charge retainer to receive and retain a corresponding shaped  
30 charge; and

31 deploying the perforating gun downhole in the well using a conveyance.

32

33 18. The method of claim 17, wherein the perforating gun further comprises a rod  
34 extending through the plurality of modular perforating gun sections.

35

36 19. The method of claim 18, wherein selected modular perforating gun sections of the  
37 plurality of modular perforating gun sections include a weight to rotate the plurality of  
38 modular perforating gun sections about the rod to a desired angular orientation.

39

40 20. The method of claim 17, wherein the plurality of modular perforating gun  
41 sections are connected to form a loading tube of the perforating gun.

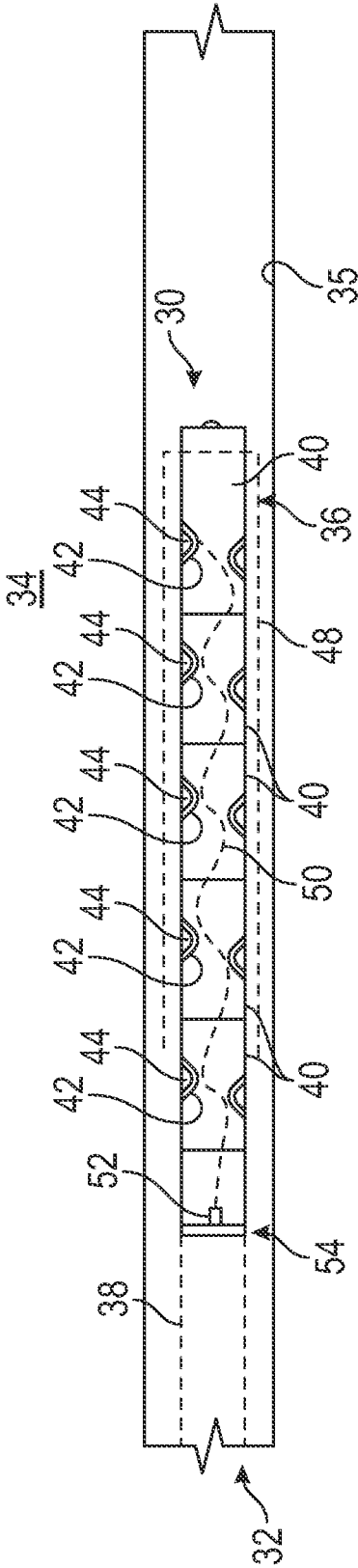


FIG. 1

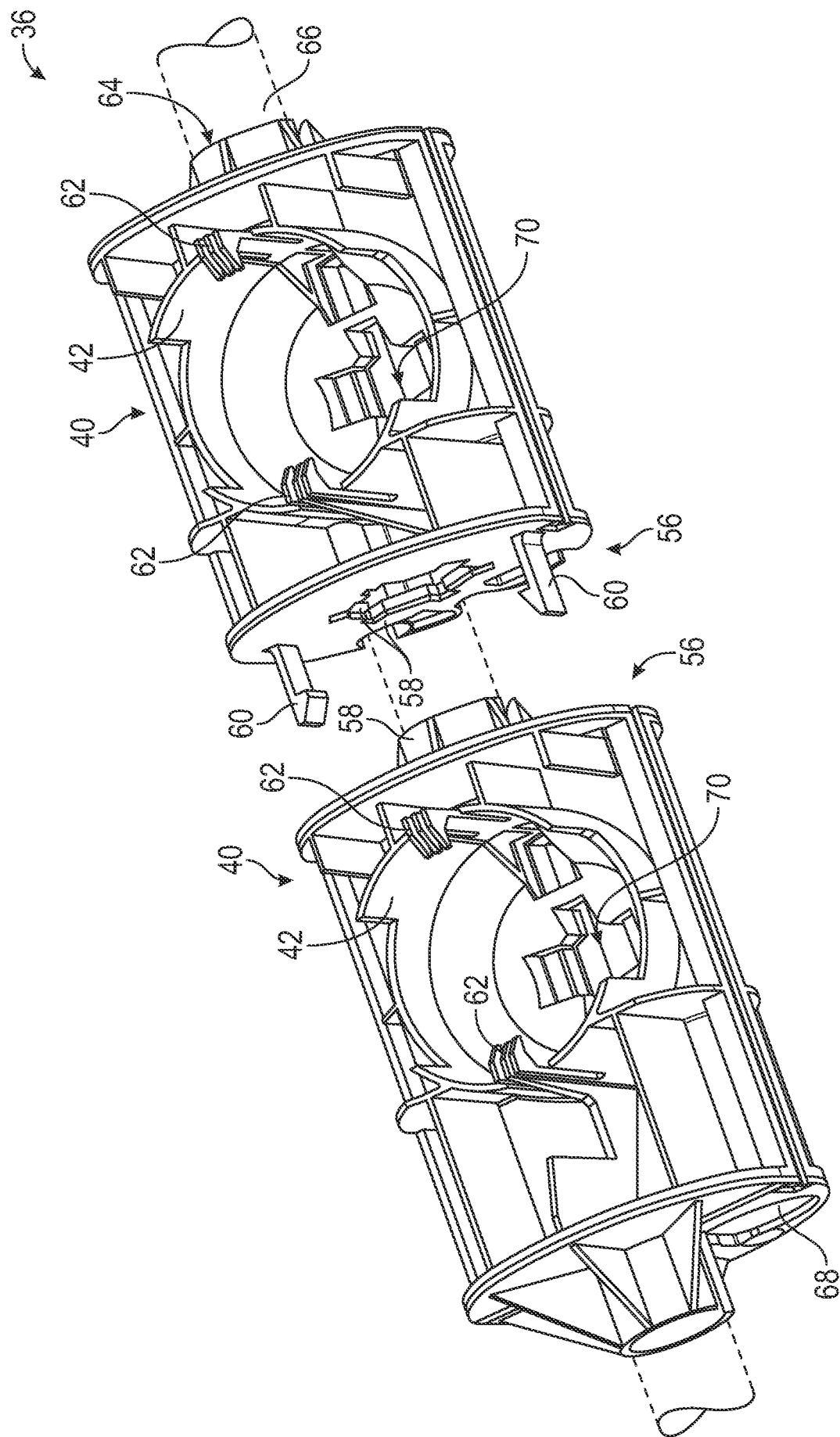


FIG. 2

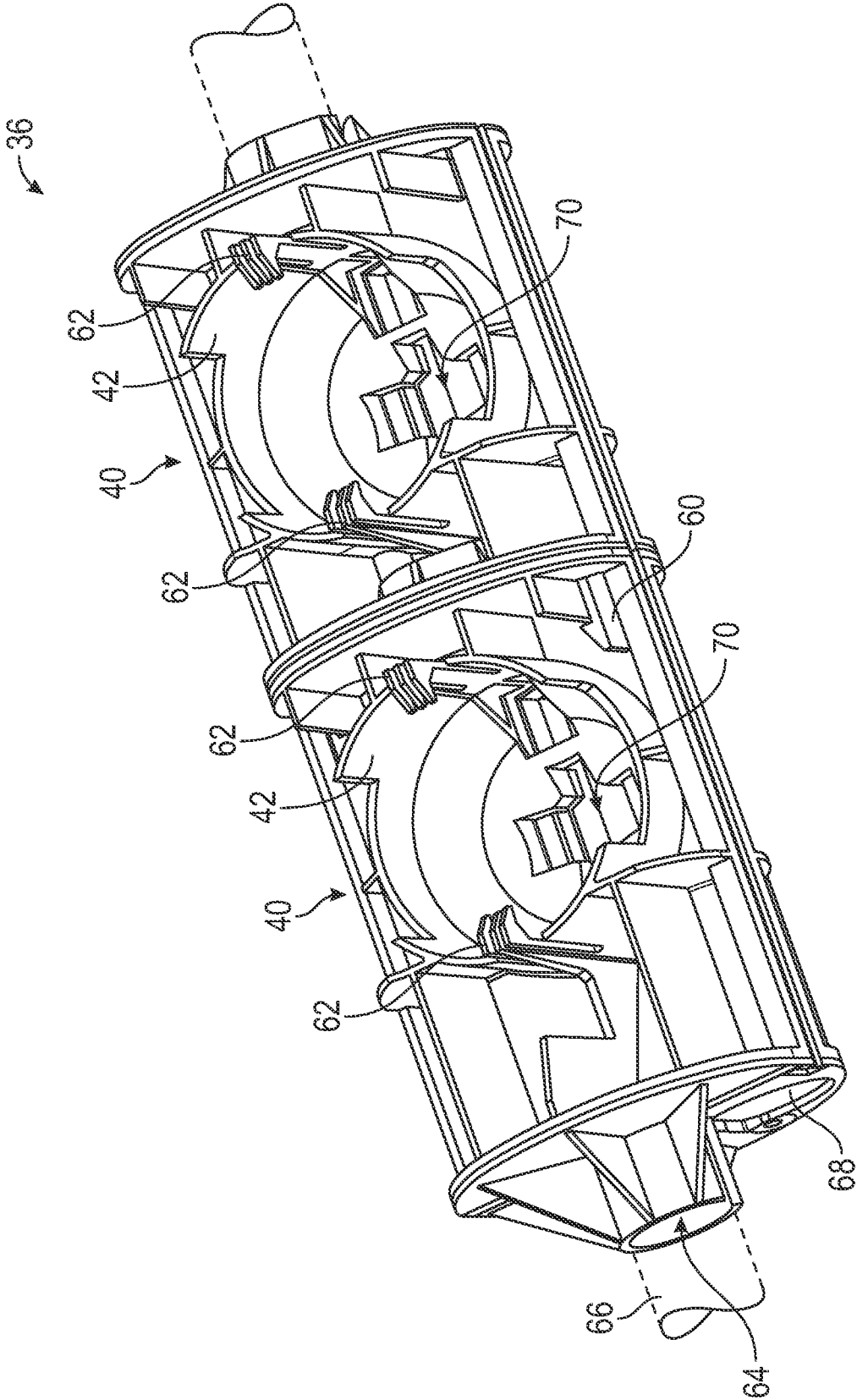


FIG. 3

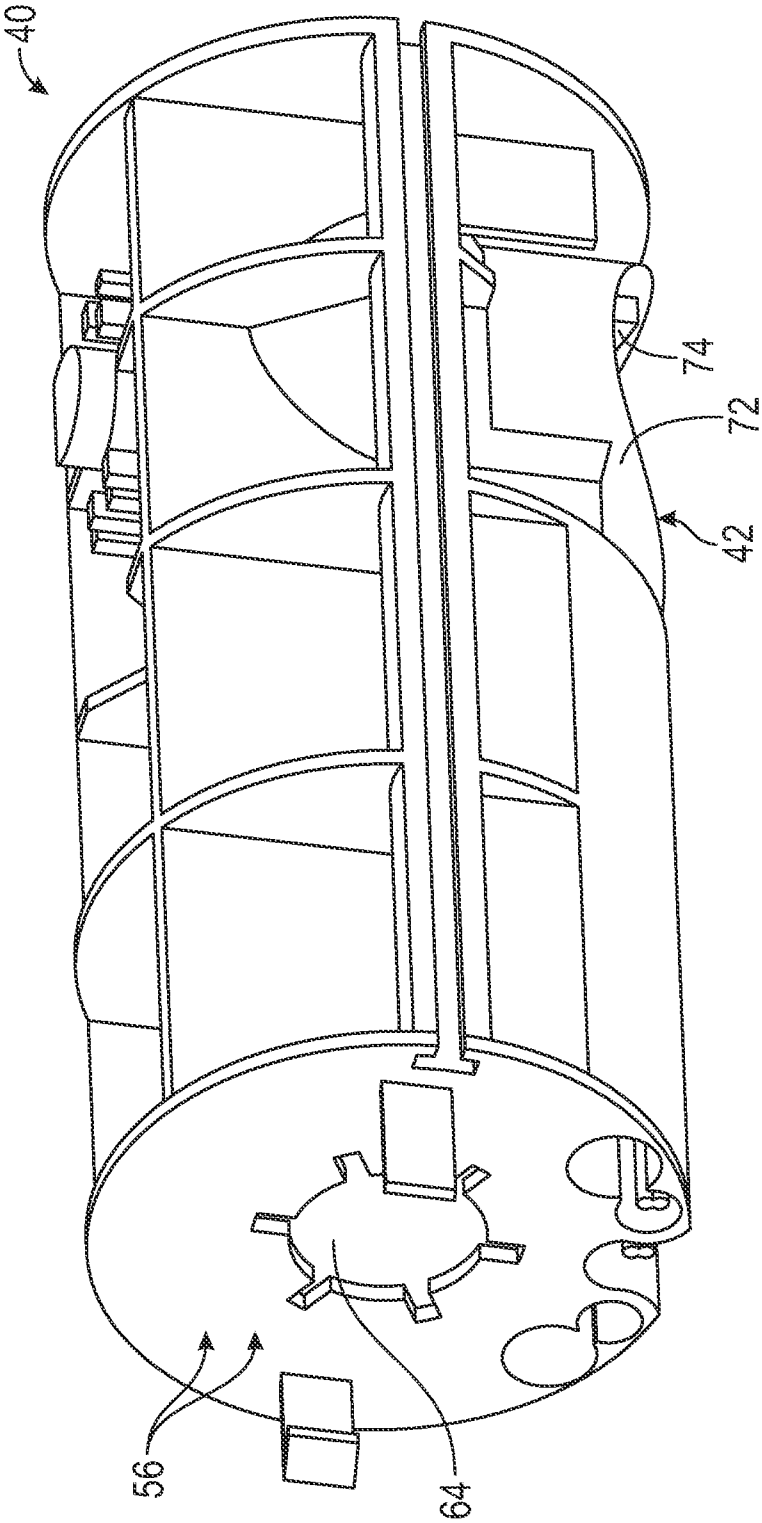


FIG. 4

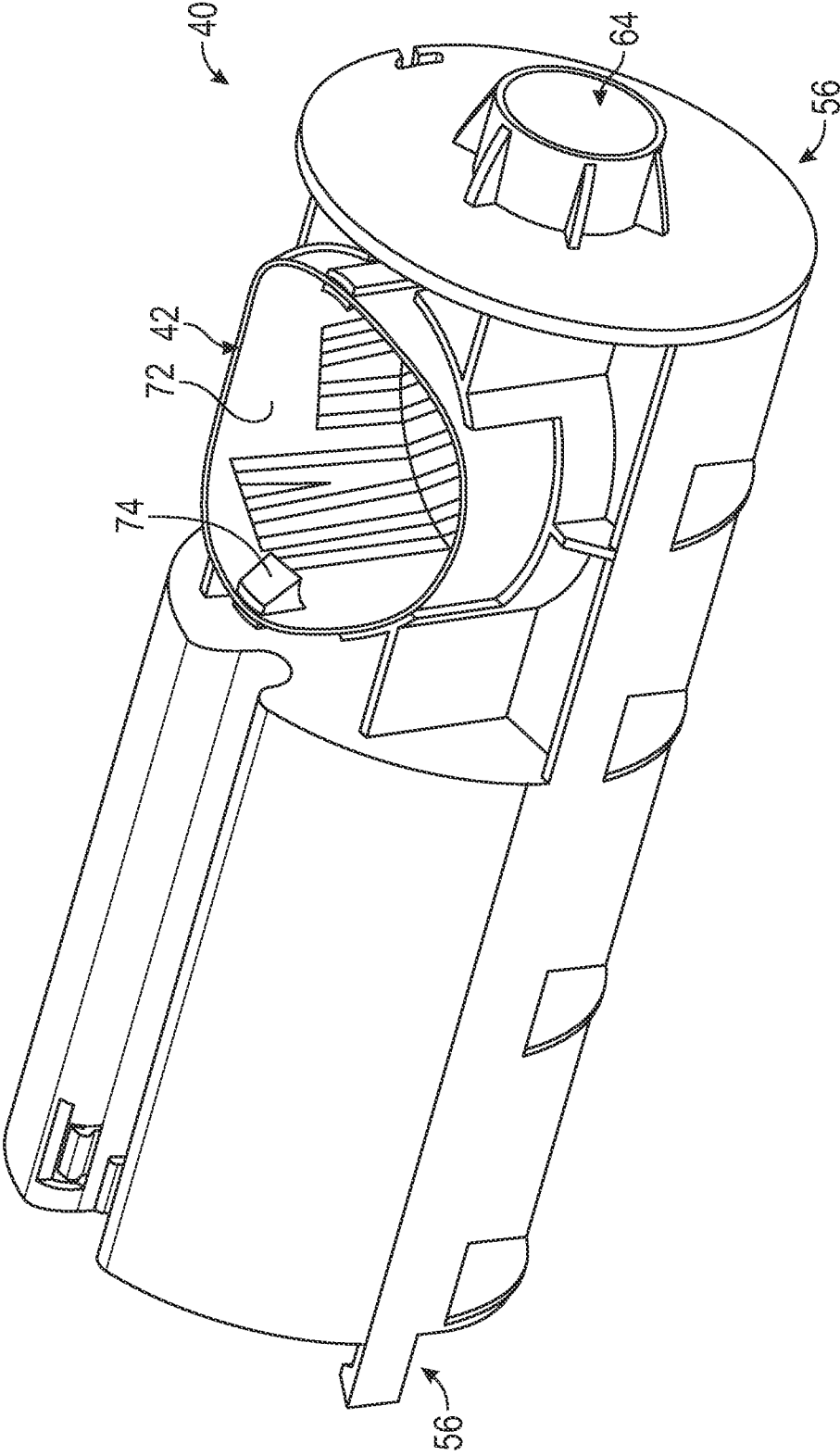


FIG. 5

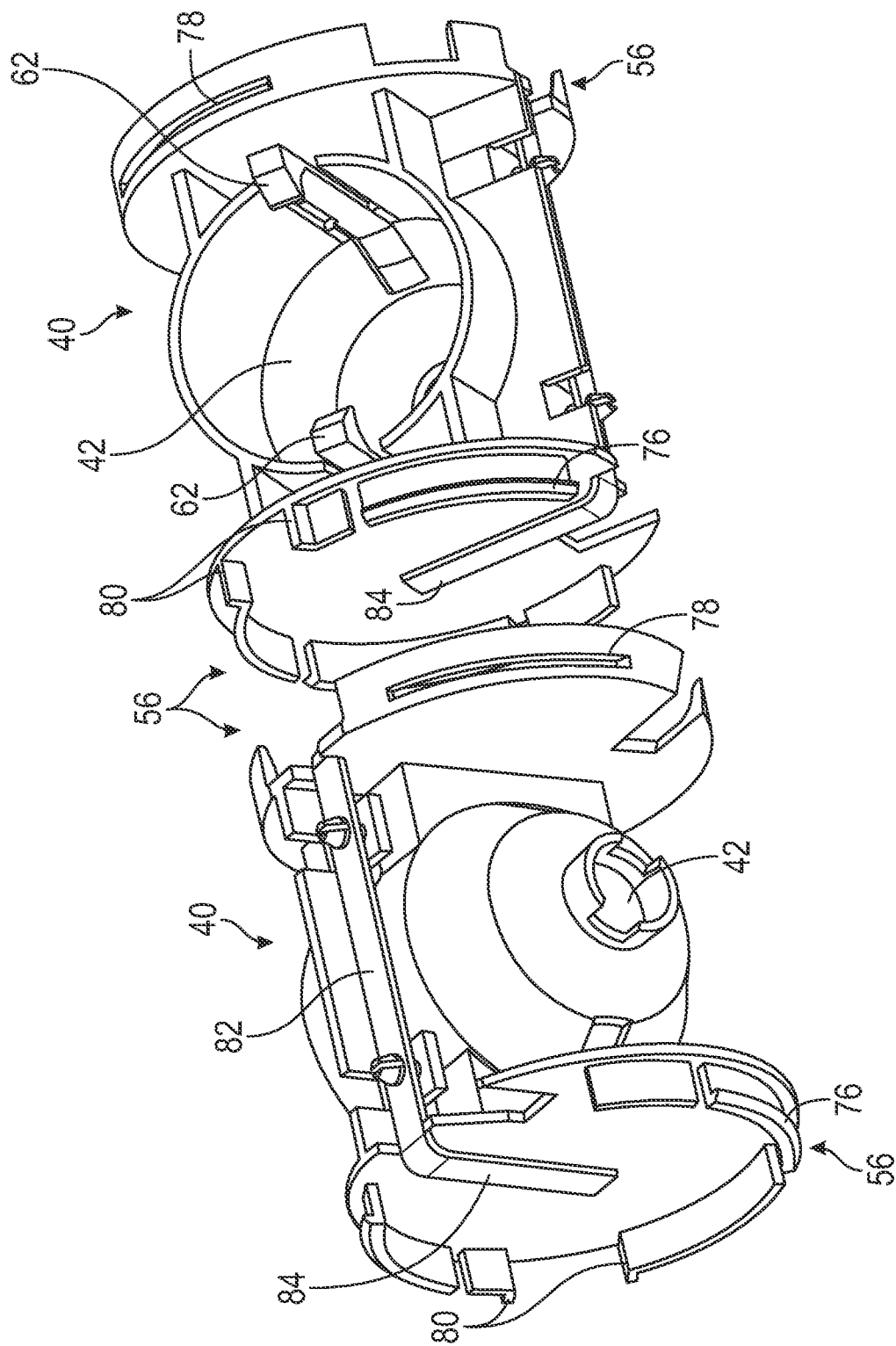


FIG. 6

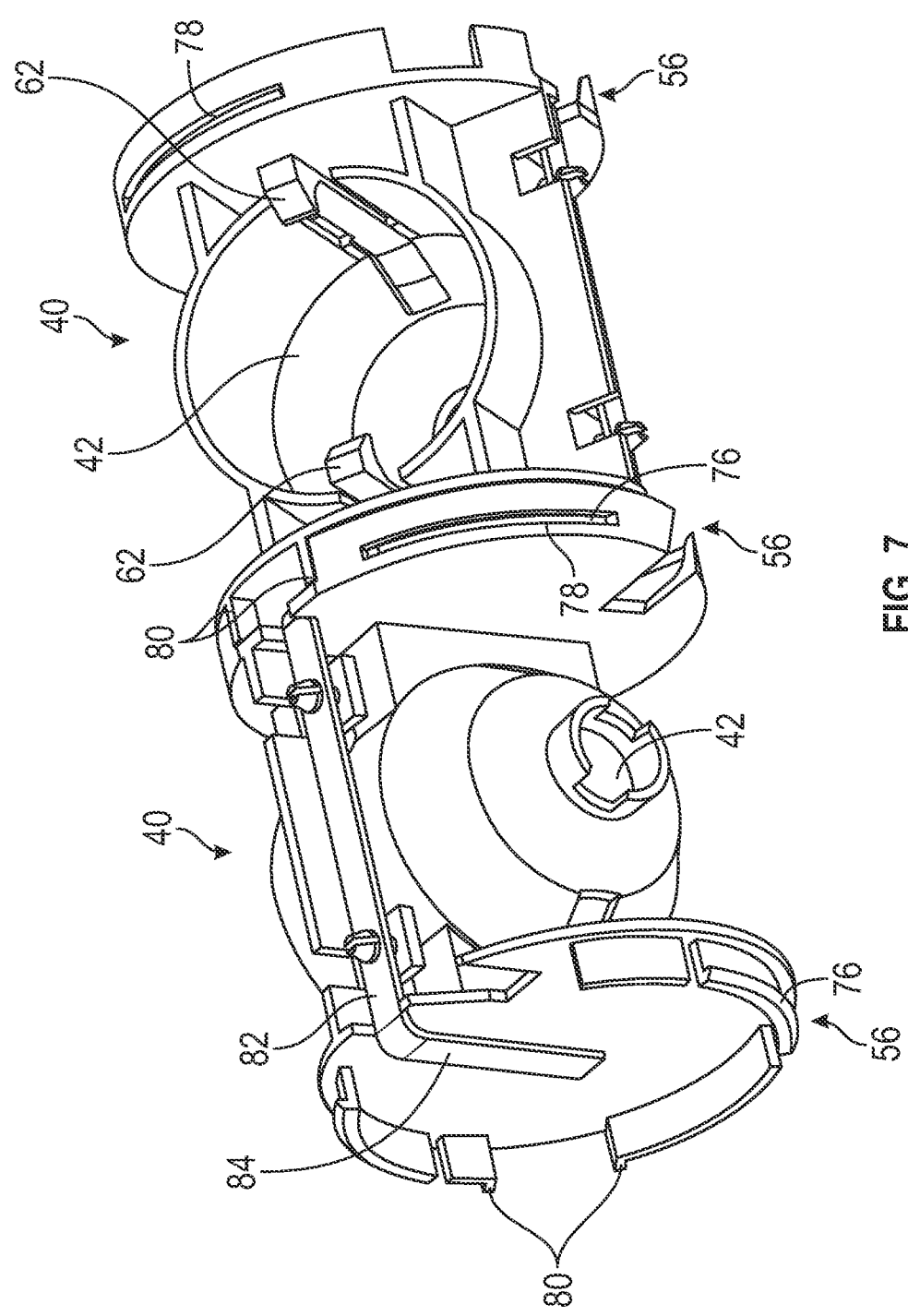
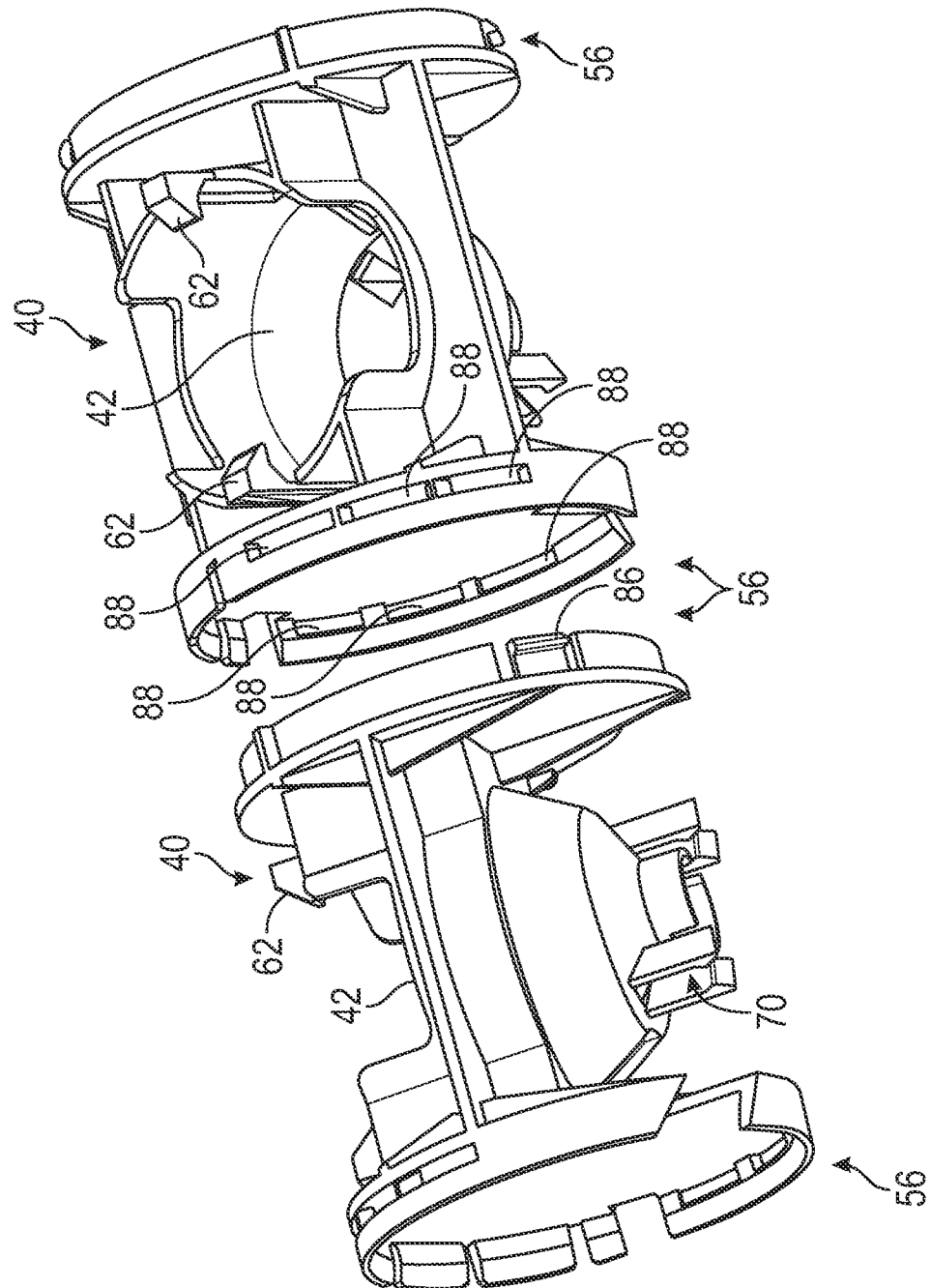


FIG. 7

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11

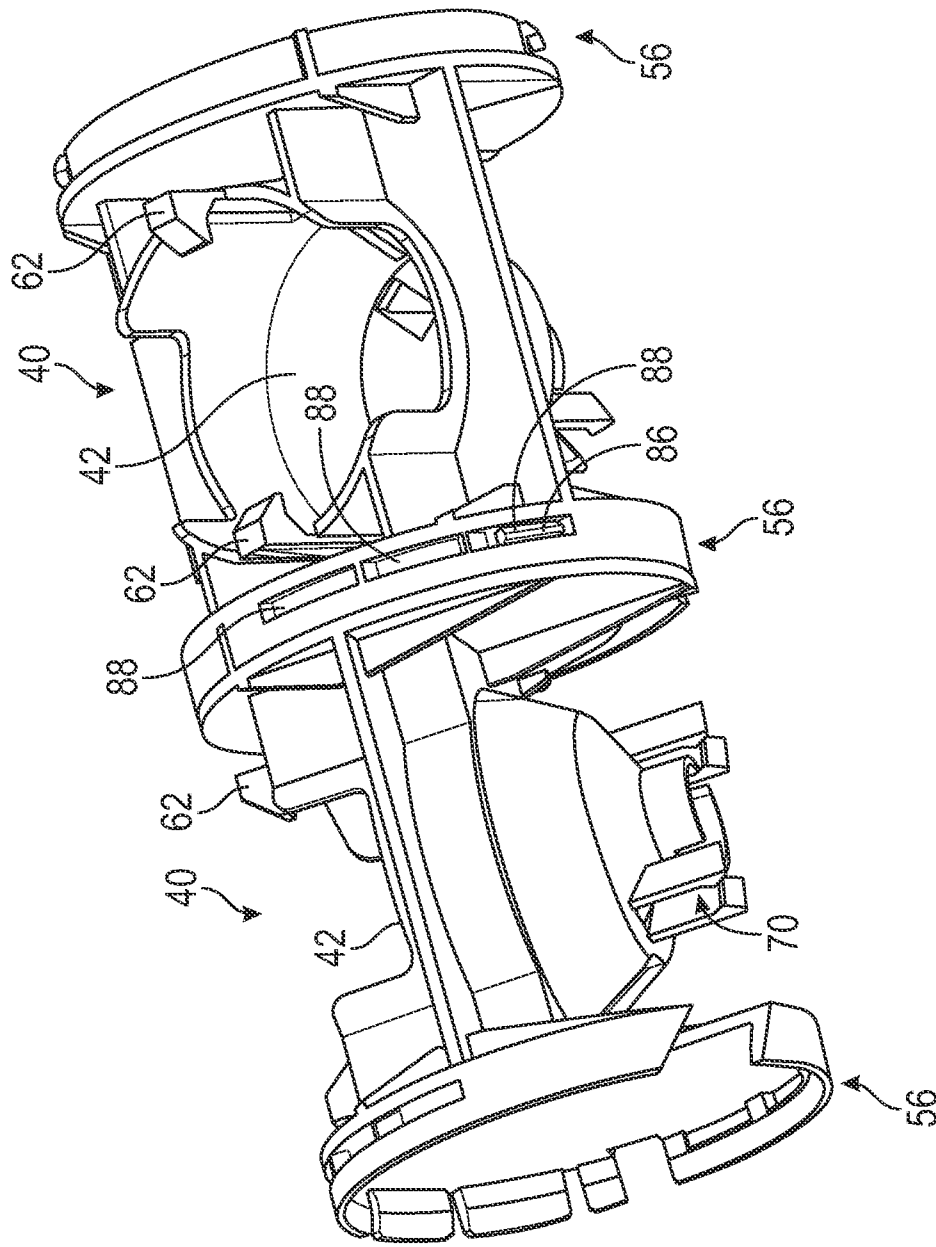


FIG. 9

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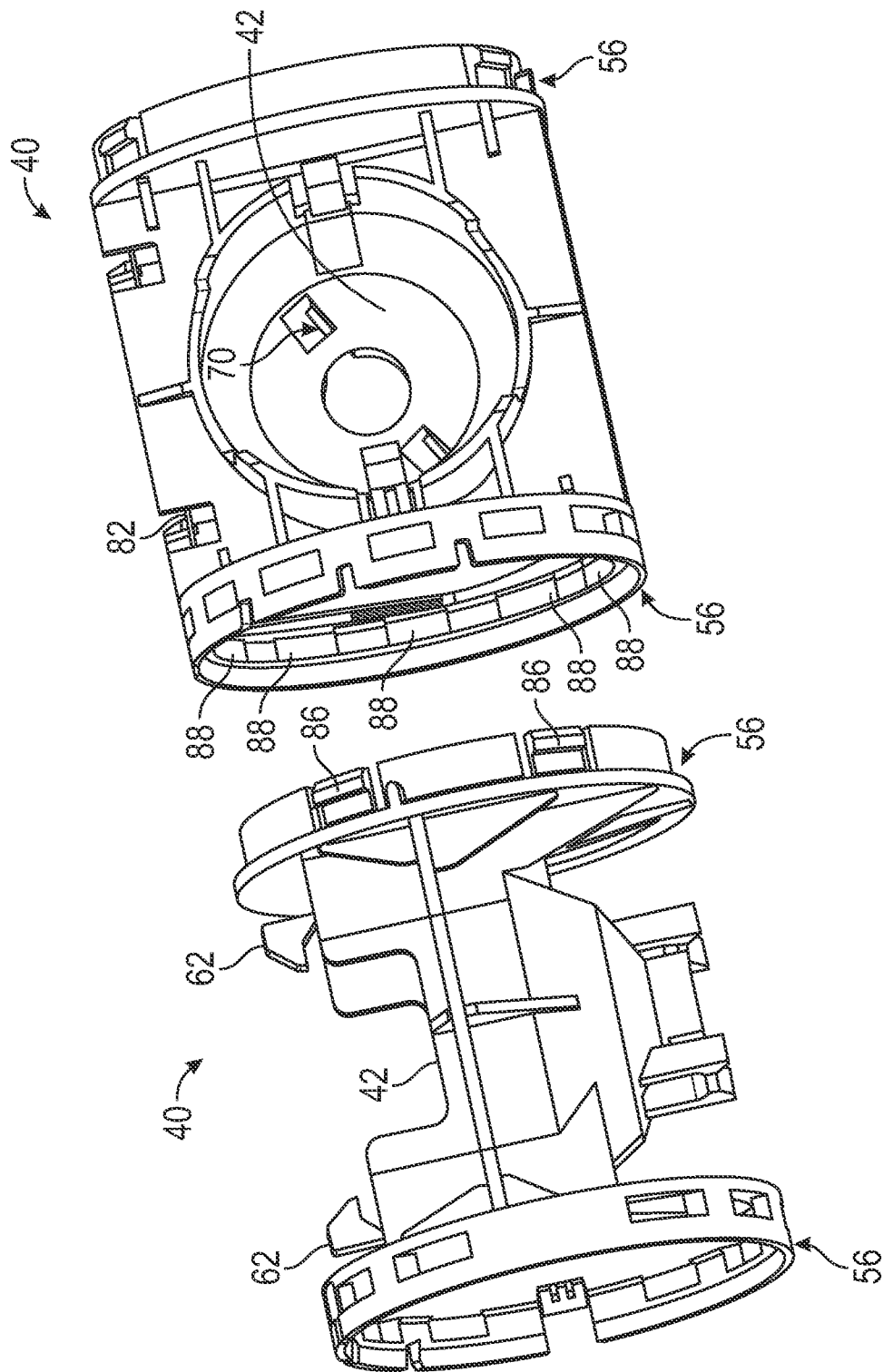


FIG. 10

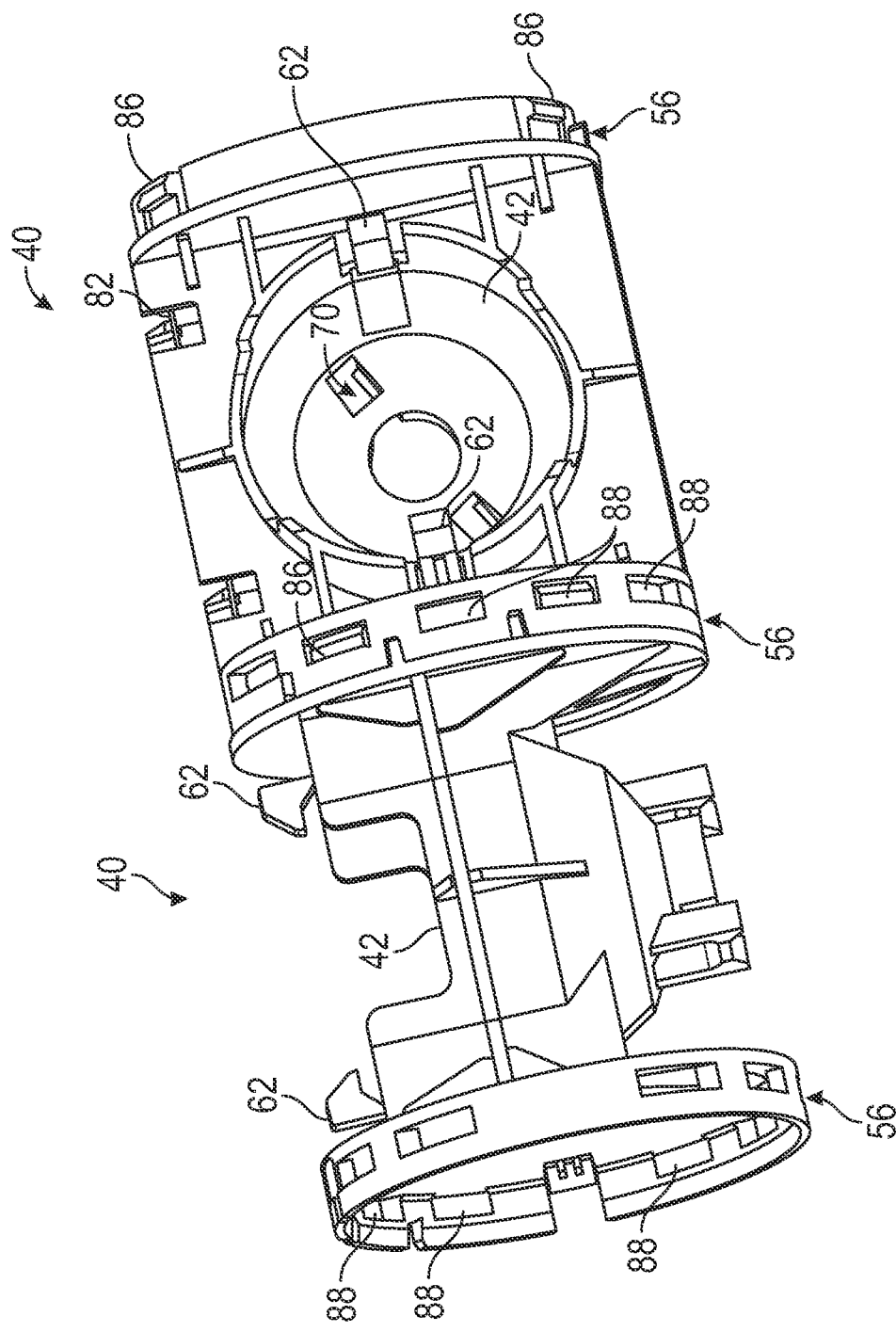


FIG. 11

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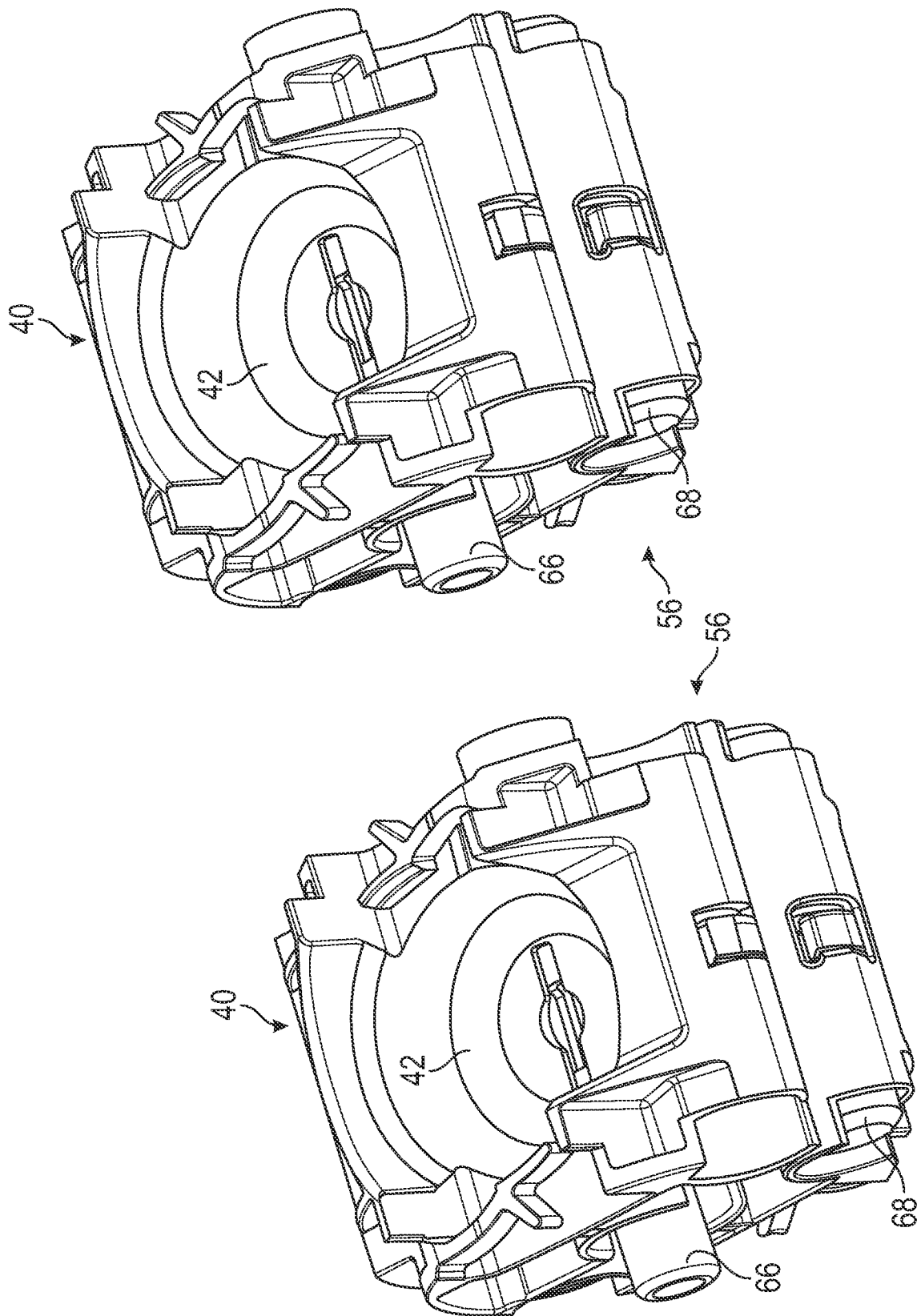


FIG. 12

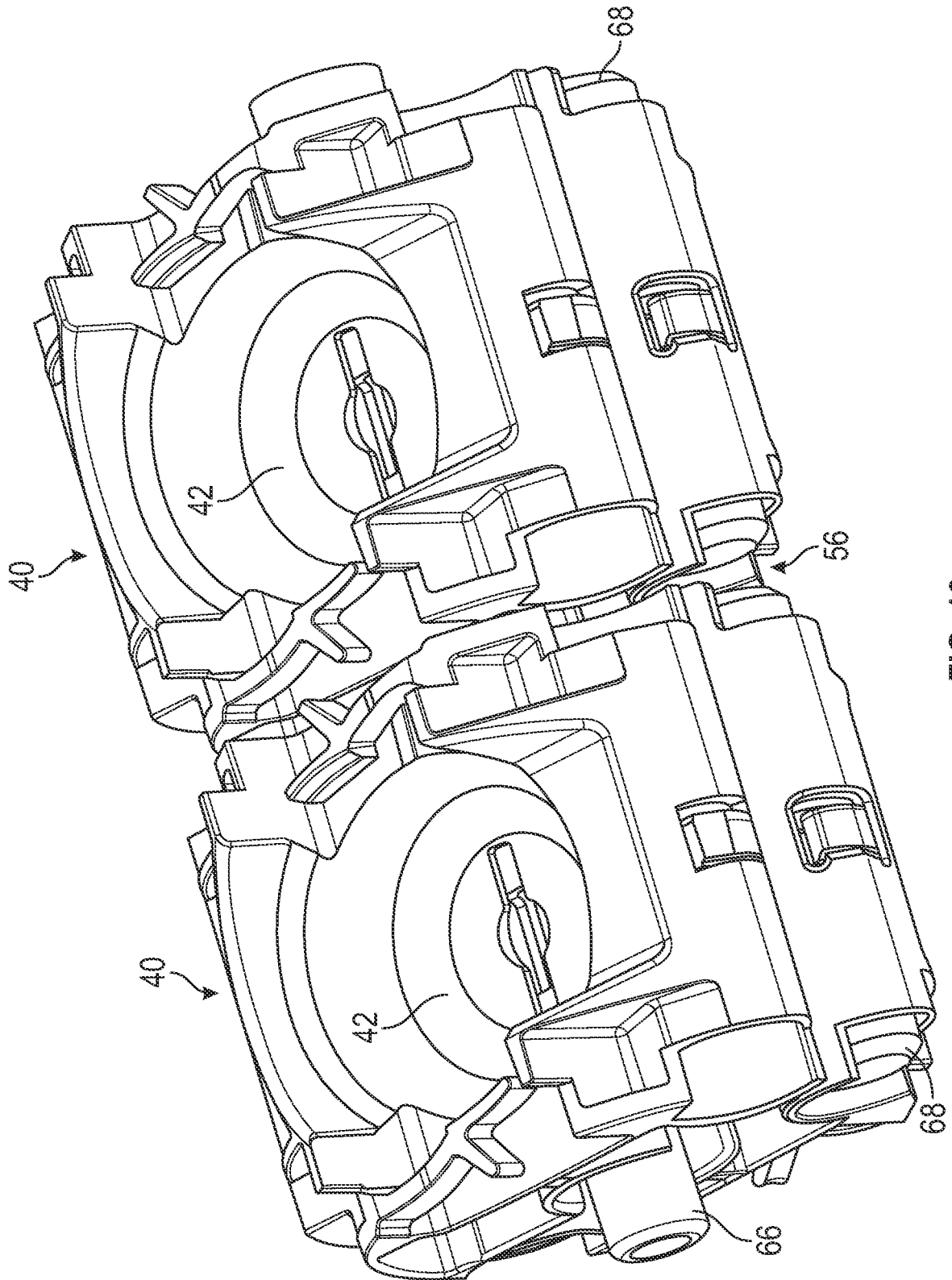


FIG. 13

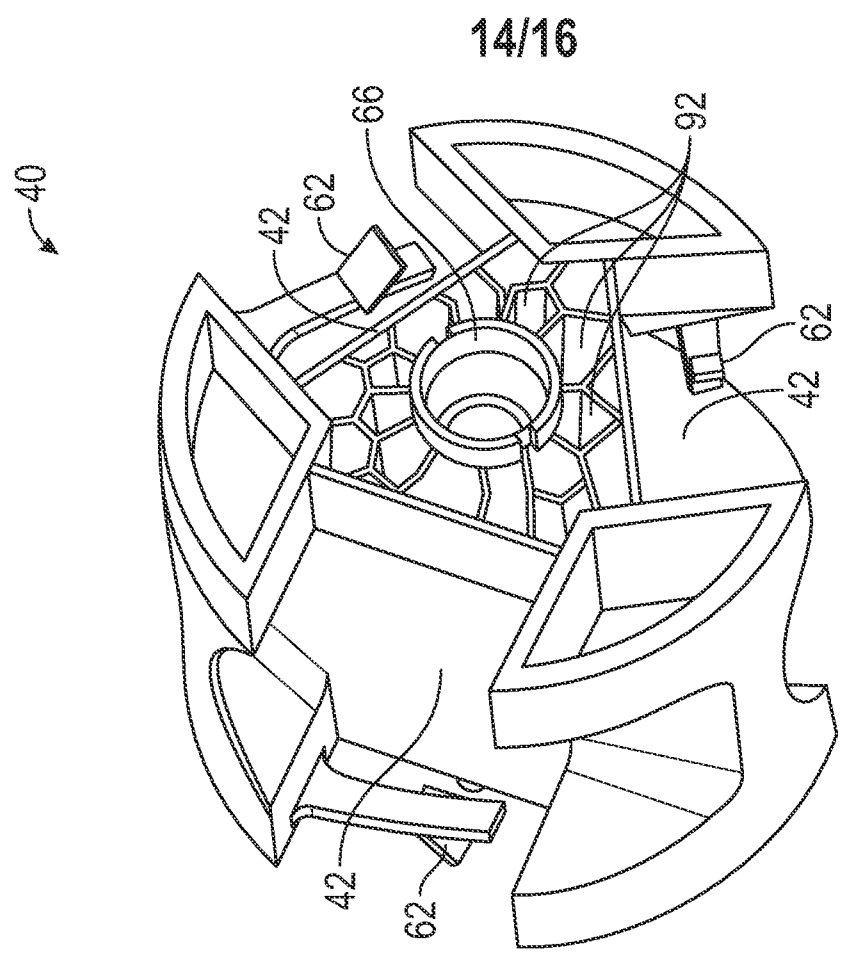


FIG. 15

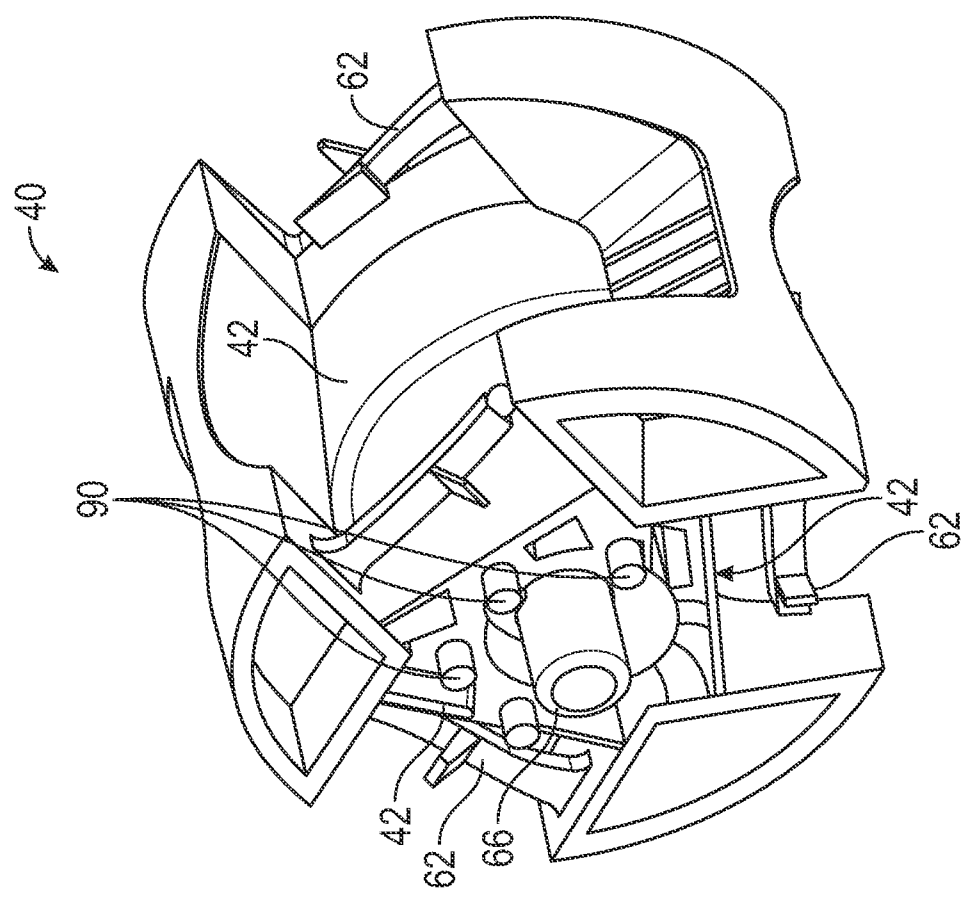


FIG. 14

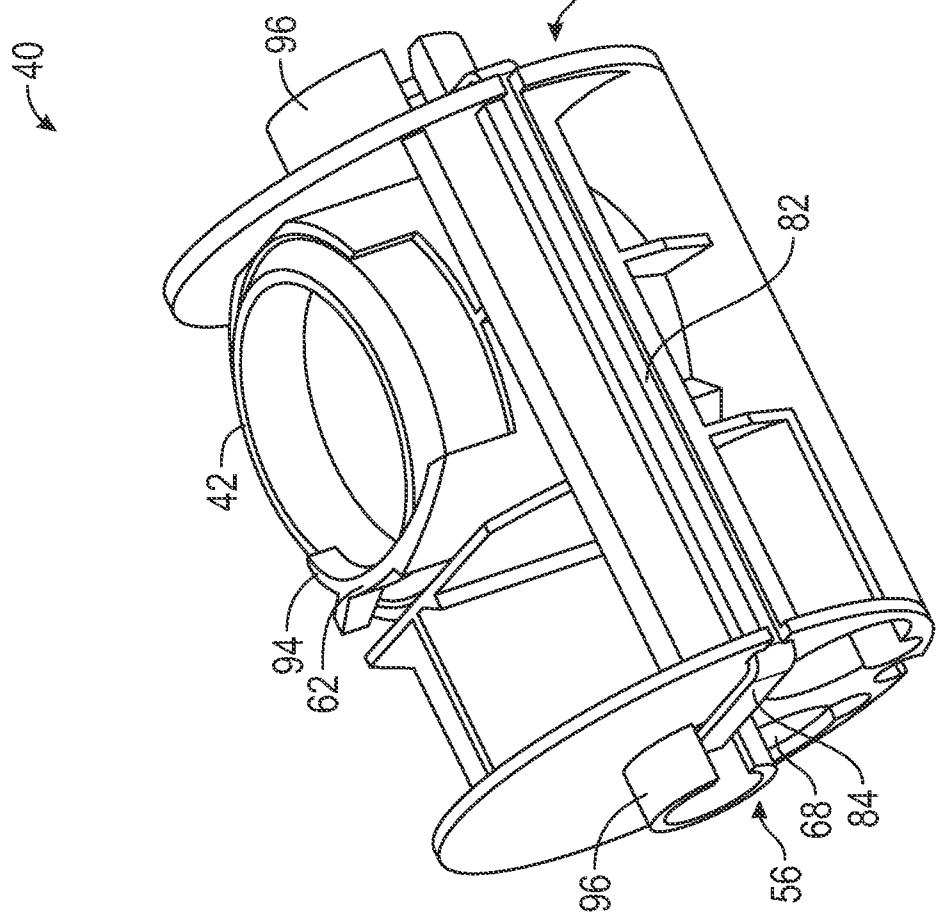


FIG. 16

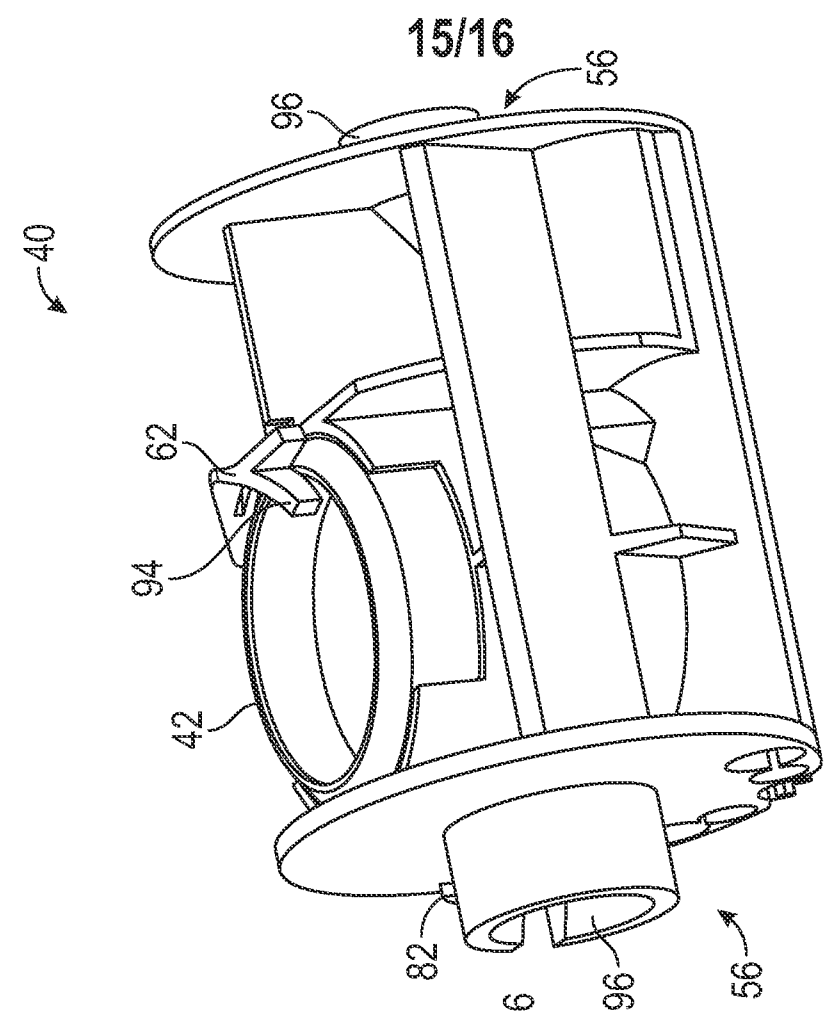


FIG. 17

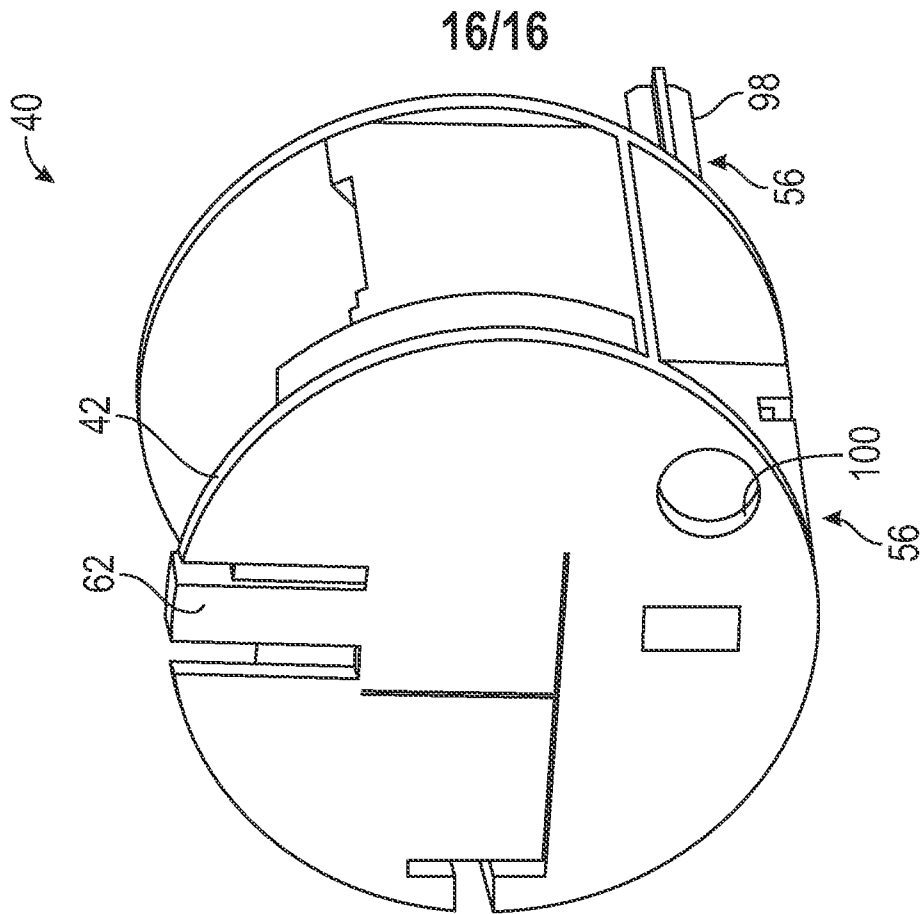


FIG. 19

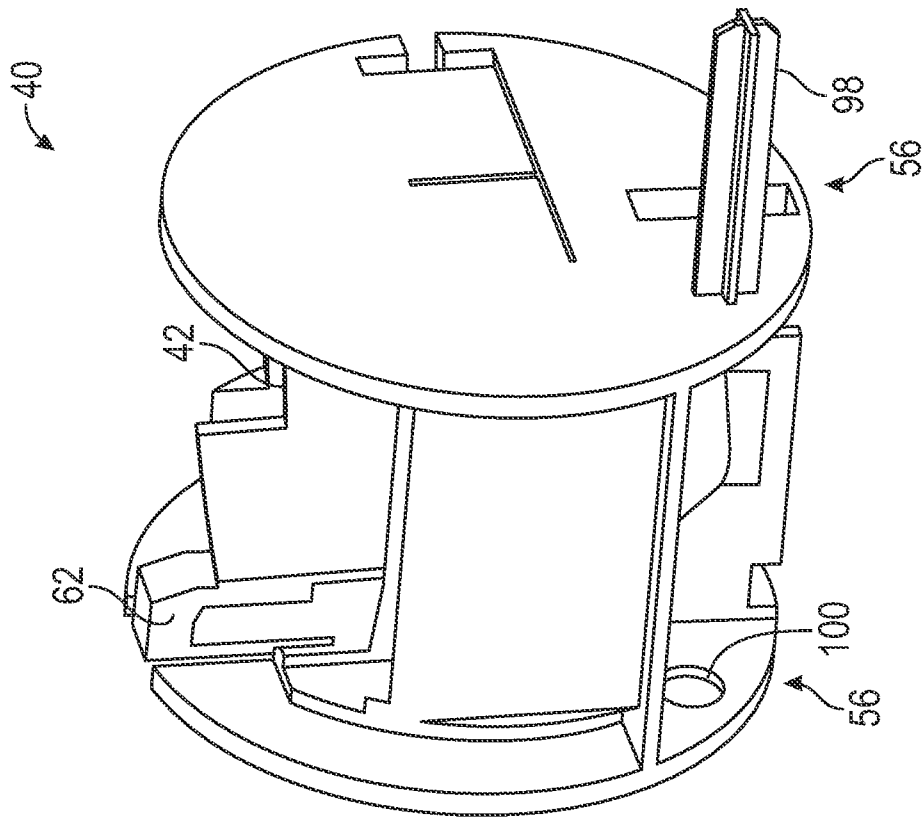


FIG. 18

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2023/018230

| <b>A. CLASSIFICATION OF SUBJECT MATTER</b><br><b>E21B 43/119(2006.01)i; E21B 43/116(2006.01)i; E21B 47/125(2012.01)i</b><br><br>According to International Patent Classification (IPC) or to both national classification and IPC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                           |                                                                                                                  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| <b>B. FIELDS SEARCHED</b><br><br>Minimum documentation searched (classification system followed by classification symbols)<br>E21B 43/119(2006.01); E21B 43/117(2006.01); E21B 43/1185(2006.01)<br><br>Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched<br>Korean utility models and applications for utility models<br>Japanese utility models and applications for utility models<br><br>Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)<br>eKOMPASS(KIPO internal) & Keywords: perforating gun, modular perforating gun sections, snap, charge holder, charge retainer, connection features, weight, rod                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                           |                                                                                                                  |
| <b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                           |                                                                                                                  |
| Category*                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Citation of document, with indication, where appropriate, of the relevant passages                                                                        | Relevant to claim No.                                                                                            |
| X<br><br>Y                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | US 2020-0318465 A1 (HALLIBURTON ENERGY SERVICES, INC.) 08 October 2020 (2020-10-08) paragraphs [0027]-[0040], [0043], [0049], and figures 1-4B, 6A, 6B, 9 | 1-5,11-15,17<br><br>6-10,16,18-20                                                                                |
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| Y                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | US 2022-0074289 A1 (HARRISON JET GUNS II, L.P. et al.) 10 March 2022 (2022-03-10) paragraphs [0050]-[0053] and figure 17                                  | 7-10,18-20                                                                                                       |
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| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | US 2020-0048996 A1 (GR ENERGY SERVICES MANAGEMENT, LP) 13 February 2020 (2020-02-13) paragraphs [0047]-[0049] and figure 3                                | 1-20                                                                                                             |
| <input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                           |                                                                                                                  |
| <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>* Special categories of cited documents:</p> <p>“A” document defining the general state of the art which is not considered to be of particular relevance</p> <p>“D” document cited by the applicant in the international application</p> <p>“E” earlier application or patent but published on or after the international filing date</p> <p>“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>“O” document referring to an oral disclosure, use, exhibition or other means</p> <p>“P” document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>“&amp;” document member of the same patent family</p> </div> </div> |                                                                                                                                                           |                                                                                                                  |
| Date of the actual completion of the international search<br><div style="text-align: center;"><b>26 July 2023</b></div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                           | Date of mailing of the international search report<br><div style="text-align: center;"><b>26 July 2023</b></div> |
| Name and mailing address of the ISA/KR<br><div style="text-align: center;"> <b>Korean Intellectual Property Office</b><br/> <b>189 Cheongsa-ro, Seo-gu, Daejeon</b><br/> <b>35208, Republic of Korea</b> </div> Facsimile No. +82-42-481-8578                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                           | Authorized officer<br><div style="text-align: center;"><b>PARK, Tae Wook</b></div> Telephone No. +82-42-481-3405 |

**INTERNATIONAL SEARCH REPORT**  
**Information on patent family members**

International application No.

**PCT/US2023/018230**

| Patent document<br>cited in search report |              |    | Publication date<br>(day/month/year) | Patent family member(s) |              |    | Publication date<br>(day/month/year) |
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