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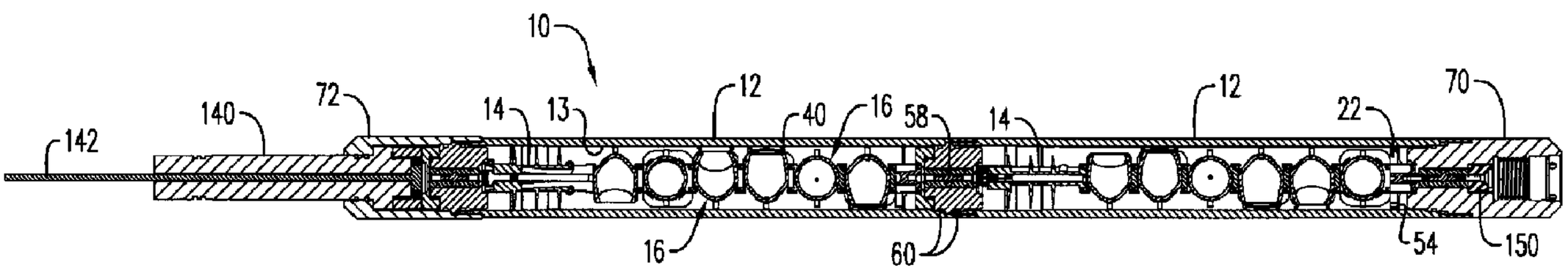

(57) Abrégé/Abstract:
A perforation gun system based on combinations of basic components including a top connector, a self-centralizing charge holder system and a bottom connector that can double as a spacer. Any number of spacers can be used with any number of holders for any desired specific metric or imperial shot density, phase and length gun system. A perforation gun system kit as well as a method of assembling a perforation gun system is also disclosed.

ABSTRACT

A perforation gun system based on combinations of basic components including a top connector, a self-centralizing charge holder system and a bottom connector that can double as a spacer. Any number of spacers can be used with any number of holders for any desired specific metric or imperial shot density, phase and length gun system. A perforation gun system kit as well as a method of assembling a perforation gun system is also disclosed.

PERFORATION GUN COMPONENTS AND SYSTEM

This application is a division of application number CA 2,821,506, filed July 18, 2013.

Field of the Invention

The invention generally relates to perforation gun systems. More particularly, the invention relates to various perforation gun components that can be modularly assembled into a perforation gun system, the assembled perforated gun system itself, a perforation gun system kit, and a method for assembling a perforation gun system.

Background of the Invention

Perforation gun systems are used in well bore perforating in the oil and natural gas industries to tie a bore hole with a storage horizon within which a storage reservoir of oil or natural gas is located.

A typical perforation gun system consists of an outer gun carrier, arranged in the interior of which there are perforators-usually hollow or projectile charges-that shoot radially outwards through the gun carrier after detonation. Penetration holes remain in the gun carrier after the shot.

In order to initiate the perforators, there is a detonating cord leading through the gun carrier that is coupled to a detonator.

Different perforating scenarios often require different phasing and density of charges or gun lengths. Moreover, it is sometimes desirable that the perforators shooting radially outwards from the gun carrier be oriented in different directions along the length of the barrel. Therefore, phasing may be required between different guns along the length.

Onsite assembly of perforation gun systems may also be problematic under certain conditions as there are certain safety hazards inherent to the assembly of perforation guns due to the explosive nature of certain of its sub-components, including the detonator and the detonating cord.

There is thus a need for a perforation gun system, which by virtue of its design and components would be able to address at least one of the above-mentioned needs, or overcome or at least minimize at least one of the above-mentioned drawbacks.

Summary of the Invention

The object of the invention is to provide a perforation gun system that addresses at least one of the above-mentioned needs.

According to the invention, there is provided a perforation gun system having an outer gun carrier and comprising:

-a top connector;

-at least one stackable charge holder for centralizing a single shaped charge within the gun carrier;

-a detonation cord connected to the top connector and to each stackable charge holder;

-at least one bottom connector for terminating the detonation cord in the gun system; and

-a detonator energetically coupled to the detonation cord,

wherein each of the top connector, at least one stackable charge holder and at least one bottom connector comprise a rotation coupling for providing a selectable clocking rotation between each of the top connector, at least one stackable charge holder and at least one bottom connector.

In some embodiments, the bottom connector may double as a spacer for spacing a plurality of stackable charge holders, and may either act as a metric dimensioned spacer or as an imperial dimensioned spacer for any specific metric or imperial shot density, phase and length gun system.

According to another aspect of the invention, there is also provided a perforation gun system kit having component parts capable of being assembled within an outer gun carrier, the kit comprising a combination of:

-a top connector;

-at least one stackable charge holder for centralizing a single shaped charge within the gun carrier;

-a detonation cord connectable to the top connector and to each stackable charge holder;

-at least one bottom connector adapted for terminating the detonation cord in the gun system; and

-a detonator energetically couplable to the detonation cord,

wherein each of the top connector, at least one stackable charge holder and at least one bottom connector comprise a coupling having a plurality of rotational degrees of freedom for providing a selectable rotation between each of the top connector, at least one stackable charge holder and at least one bottom connector.

According to another aspect of the invention, there is also provided a method for assembling a perforation gun system, comprising the steps of:

(a) providing a perforation gun system kit having component parts capable of being assembled within an outer gun carrier, the kit comprising a combination of:

-a top connector;

-at least one stackable charge holder for centralizing a single shaped charge within the gun carrier;

-a detonation cord connectable to the top connector and to each stackable charge holder;

-at least one bottom connector adapted for terminating the detonation cord in the gun system and adapted for doubling as a spacer for spacing a plurality of stackable charge holders; and

-a detonator energetically couplable to the detonation cord,

wherein each of the top connector, at least one stackable charge holder and at least one bottom connector comprise a coupling having a plurality of rotational degrees of freedom for providing a selectable rotation between each of the top connector, at least one stackable charge holder and at least one bottom connector;

(b) assembling a plurality of the stackable charge holders in a predetermined phase to form a first gun assembly;

(c) running the detonation cord into a bottommost bottom connector;

(d) assembling the bottommost bottom connector onto the assembled plurality of stackable charge holders;

(e) running a through wire between the bottommost bottom connector and the top connector, so that the through wire goes from the top connector to the bottom connector;

(f) clicking the detonation cord into recesses in capturing projections, the capturing projections being provided in each of the charge holders;

(g) running the detonation cord into the top connector;

(h) cutting the detonator cord; and

(i) installing charges into each of the charge holders.

A number of optional steps that are detailed below may be added to the above-described steps of the method.

According to another aspect of the invention, there is also provided a top connector for a perforation gun system comprising:

-a coupler for providing energetic coupling between a detonator and a detonating cord;

-at least one directional locking fin for locking the top connector within a gun carrier;

-a rotation coupling for providing a selectable clocking rotation between the top connector, and a charge holder

wherein the top connector is configured to receive electrical connections therethrough.

According to another aspect of the invention, there is also provided a stackable charge holder for a perforation gun system having an outer gun carrier, the charge holder comprising:

-a charge receiving structure for receiving a single shaped charge;

-a plurality of projections for centralizing the shaped charge within the gun carrier; and

-at least one rotation coupling for providing a selectable clocking rotation between the charge holder and an adjacent component in the perforation gun system;

wherein a pair of the plurality of projections is configured for capturing a detonation cord traversing the charge holder.

According to another aspect of the invention, there is also provided a bottom connector for a perforation gun system comprising:

-a terminating structure arranged for terminating a detonation cord in the gun system;

-a plurality of wings for axially locking the bottom connector to a snap ring fixed in the carrier.

-a rotation coupling for providing a selectable clocking rotation between the bottom connector and a charge holder;

wherein the rotation coupling is arranged such that bottom connector doubles as a spacer for spacing a plurality of stackable charge holders.

Brief Description of the Drawings

These and other objects and advantages of the invention will become apparent upon reading the detailed description and upon referring to specific embodiments thereof that are illustrated in the appended drawings. Understanding that these drawings depict only typical embodiments of the invention and are not therefore to be considered to be limiting of its scope, exemplary embodiments of the invention will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

Figure 1 is a side cut view of a perforation gun system according to an embodiment of the invention.

Figure 2 is a side view of a top connector, bottom connector and stackable charge holders of a perforation gun system in accordance with another embodiment of the invention.

Figure 3 is a side view of a top connector, bottom connector and stackable charge holders of a perforation gun system in accordance with another embodiment of the invention.

Figure 4 is a front perspective view of a bottom connector in accordance with an embodiment of the invention.

Figure 5 is a rear perspective view of the bottom connector shown in Figure 4.

Figure 6 is a front view of a stackable charge holder in accordance with an embodiment of the invention.

Figure 7 is a front perspective view of the stackable charge holder shown in Figure 6.

Figure 8 is a rear perspective view of the stackable charge holder shown in Figure 6.

Figure 9 is a bottom view of the stackable charge holder shown in Figure 6.

Figure 10 is a top view of the stackable charge holder shown in Figure 6.

Figure 11 is a bottom view of a half-portion of a top connector in accordance with an embodiment of the invention.

Figure 12 is a side view of the half-portion of the top connector shown in Figure 11.

Figure 13 is a top perspective view of the half-portion of the top connector shown in Figure 11.

Figure 14 is a bottom perspective view of the half-portion of the top connector shown in Figure 11.

Figure 15 is a perspective view of a top connector in accordance with an embodiment of the invention.

Figure 16 is a front end view of the top connector shown in Figure 15.

Figure 17 is a rear end view of the top connector shown in Figure 15.

Figure 18 is a rear perspective view of the top connector shown in Figure 15.

Figure 19 is an enlarged detailed side cut view of a portion of the perforation gun system including a bulkhead and stackable charge holders shown in Figure 1.

Figure 20 is a perspective view of a bottom sub of a gun system in accordance with an embodiment of the invention.

Figure 21 is a side view of a gun carrier of a gun system in accordance with an embodiment of the invention.

Figure 22 is a side cut view of the gun carrier shown in Figure 21.

Figure 23 is a side view of a top sub of a gun system in accordance with an embodiment of the invention.

Figure 24 is a side cut view of the top sub shown in Figure 23.

Figure 25 is a side view of a tandem seal adapter of a gun system in accordance with an embodiment of the invention.

Figure 26 is a perspective view of the tandem seal adapter shown in Figure 25.

Figure 27 is a perspective view of a detonator in accordance with an embodiment of the invention.

Figure 28 is a detailed perspective view of the detonator shown in Figure 27.

Figure 29 is another detailed perspective view of the detonator shown in Figure 27.

Figure 30 is another detailed perspective view of the detonator shown in Figure 27.

Figure 31 is another detailed perspective view of the detonator shown in Figure 27, with a crimp sleeve.

Figure 32 is a detailed side view of a tandem seal adapter and detonator in accordance with another embodiment of the invention.

Figure 33 is a side cut view of a portion of a perforation gun system illustrating the configuration of the top sub in accordance with another embodiment of the invention.

Figure 34 is a side cut view of a portion of a perforation gun system illustrating the configuration of the bottom sub in accordance with another embodiment of the invention.

Figures 35A and 35B are electrical schematic views of a detonator and of wiring within a perforated gun system in accordance with another embodiment of the invention.

Detailed Description of the Invention

In the following description and accompanying figures, the same numerical references refer to similar elements throughout the figures and text. Furthermore, for the sake of simplicity and clarity, namely so as not to unduly burden the figures with several reference numbers, only certain figures have been provided with reference numbers, and components and features of the invention illustrated in other figures can be easily inferred therefrom. The embodiments, geometrical configurations, and/or dimensions shown in the figures are preferred for exemplification purposes only. Various features, aspects and advantages of the embodiments will become more apparent from the following detailed description.

Moreover, although the invention was primarily designed for well bore perforating, for example, it may also be used in other perforating scenarios or in other fields, as apparent to a person skilled in the art. For this reason, expressions such as “gun system”, etc., as used herein should not be taken as to limit the scope of the invention and includes all other kinds of materials, objects and/or purposes with which the invention could be used and may be useful. Each example or embodiment are provided by way of explanation of the invention, and is not meant as a limitation of the invention and does not constitute a definition of all possible embodiments.

In addition, although the embodiment of the invention as illustrated in the accompanying drawings comprises various components and although the embodiment of the adjustment system as shown consists of certain geometrical configurations as explained and illustrated herein, not all of these components and geometries are essential to the invention and thus should not be taken in their restrictive sense, i.e. should not be taken as to limit the scope of the invention. It is to be understood, as also apparent to a person skilled in the art, that other suitable components and cooperations thereinbetween, as well as other suitable geometrical configurations may be used for the adjustment systems, and corresponding parts, according to the invention, as briefly explained and as can easily be inferred herefrom by a person skilled in the art, without departing from the scope of the invention.

Referring to Figures 1 to 3, an object of the invention is to provide a perforation gun system 10 having an outer gun carrier 12. The gun system 10 includes a top connector 14. At least one stackable charge holder 16 is provided for centralizing a single shaped charge 18 within the gun carrier 12. A detonation cord 20 is connected to the top connector 14 and to each stackable charge holder 16.

The gun system 10 includes at least one bottom connector 22 for terminating the detonation cord 20 in the gun system. As better shown in Figure 2, it is also possible that the bottom connector 22 double as or serve the function of a spacer 24 for spacing a plurality of stackable charge holders 16.

The gun system also includes a detonator 26 energetically coupled to the detonation cord 20.

As better shown in Figures 4 to 18, each of the top connector 14, stackable charge holder 16 and bottom connector 22 includes a rotation coupling 30 for providing a selectable clocking rotation between each of the above-mentioned components.

Hence a user can build multiple configurations of gun systems using various combinations of basic components. A first of these basic components includes a top connector. Another basic component is a single charge holder that centralizes a single shaped charge. The holder is adapted to be stacked and configured into 0, 30, 60, up to

360 degrees or any other combination of these phases for any specified length. Another basic component is a bottom connector that terminates the detonation cord in the gun. The bottom connector may carry as well an electrical connection therethrough. The bottom connector may also double as an imperial measurement stackable spacer to provide any gun shot density up to, for example, 6 shots per foot. Alternately, another bottom connector may be provided or configured to double as a metric measurement stackable spacer to provide any gun shot density up to, for example, 20 shots per meter. Another basic component includes a push-in detonator that does not use wires to make necessary connections. The push-in detonator may uses spring-loaded connectors, thus replacing any required wires and crimping.

Therefore, within the self-centralizing charge holder system, any number of spacers can be used with any number of holders for any specific metric or imperial shot density, phase and length gun system.

In an embodiment, only two pipe wrenches are required for assembly on site of the gun system, as no other tools are required.

In an embodiment, the top connector 14 provides energetic coupling between the detonator and detonating cord.

In an embodiment, each of the top connector 14, stackable charge holder 16 and bottom connector 22 are configured to receive electrical connections therethrough.

In an embodiment, all connections are made by connectors, such as spring-loaded connectors, instead of wires, with the exception of the through wire that goes from the top connector 14 to the bottom connector 22, whose ends are connectors.

In an embodiment, components of the assembly may include molded parts, which may also be manufactured to house the wiring integrally, through, for instance, overmolding, to encase the wiring and all connectors within an injection molded part. For example, the charge holder 16 could be overmolded to include the through wire.

In an embodiment, as shown in Figures 4 and 5, each bottom connector 22 includes a plurality of fins 32 for axially locking each bottom connector against a snap ring 54, or an equivalent retainment mechanism to keep the charge holder 16 from sliding out of the bottom of carrier 12 as it is handled, (shown on Figure 1). According to an aspect, and as illustrated in Figure 19, the bottom connector 22 may be recessed into the tandem seal adapter 48. The bottom connector 22 from a first gun assembly can accommodate or house an electrical connection through a bulkhead assembly 58 to the top connector 14 of a second or subsequent gun assembly, as seen for instance in Figure 19. The top and bottom connector, as well as the spacer, in an embodiment, are made of 15% glass fiber reinforced, injection molding PA6 grade material, commercially available from BASF under its ULTRAMID® brand, and can provide a positive snap connection for any configuration or reconfiguration. As better shown in Figure 5, a terminating means structure 34 is provided to facilitate terminating of the detonation cord. The snap ring 54 is preinstalled on the bottom of the carrier 12. The assembly can thus shoulder up to the snap ring 54 via the bottom connector fins 32.

In an embodiment and as shown in Figures 6 to 10, each stackable charge holder 16 has a plurality of projections 40 resting against an inner surface 13 or diameter of the gun carrier 12 (as shown in Figure 1) and thereby centralizing the shaped charge therewithin. A pair of the plurality of projections 42 may also be configured for capturing the detonation cord (not shown) traversing each stackable charge holder 16. The projections 42 are also used for centralizing the shaped charge within an inner surface of the gun carrier.

In an embodiment, as shown in Figures 11 to 18, the top connector 14 includes at least one directional locking fin 46. Although the use of directional locking fins is described, other methods of directional locking may be used, in order to eliminate a top snap ring that would otherwise be used to lock the assembly. As better shown in Figure 19, the locking fins 46 are engageable with corresponding complementarily-shaped structures 47 housed within the carrier 12, upon a rotation of the top connector 14, to lock the position of the top connector along the length of the carrier 12.

In an embodiment, as better shown in Figure 19, the bottom connector 22 on one end and the top connector 14 on the other end abuts/connects to the bulkhead assembly 58. The tandem

seal adapter 48 is configured to seal the inner components within the carrier 12 from the outside environment, using sealing means 60 (shown herein as a-rings). Thus, the tandem seal adapter 48 seals the gun assemblies from each other along with the bulkhead 58, and transmits a ground wire to the carrier 12. Hence, the top connector 14 and bulkhead 58 accommodate electrical and ballistic transfer to the charges of the next gun assembly for as many gun assembly units as required, each gun assembly unit having all the components of a gun assembly.

In an embodiment, the tandem seal adapter 48 is a two-part tandem seal adapter (not shown) that fully contains the bulkhead assembly 58 (comprised of multiple small parts as shown, for instance, in Fig. 19) and that is reversible such that it has no direction of installation.

In an embodiment and as better shown in Figures 27-31 and 35A, the detonator assembly 26 includes a detonator head 100, a detonator body 102 and a plurality of detonator wires 104, including a through wire 106, a signal-in wire 108 and a ground wire 110. The through wire 106 traverses from the top to the bottom of the perforating gun system 10, making a connection at each charge holder 16. The detonator head 100 further includes a through wire connector element 112 connected to the through wire 106 (not shown), a ground contact element 114 for connecting the ground wire 110 to the tandem seal adapter (also not shown), through ground springs 116, and a bulkhead connector element 118 for connecting the signal-in wire 108 to the bulkhead assembly 58 (also not shown). Different insulating elements 120A, 120B are also provided in the detonator head 100 for the purpose of insulating the detonator head 100 and detonator wires 104 from surrounding components. As better shown in Figure 31, a crimp sleeve 122 can be provided to cover the detonator head 100 and body 102, thus resulting in a more robust assembly. The above configuration allows the detonator to be installed with minimal tooling and wire connections.

In an embodiment as shown in Figures 32, 33 and 35B illustrate a connection of the above-described detonator assembly 26 to the tandem seal adapter 48 and a pressure bulkhead 124. The bulkhead 124 includes spring connector end interfaces comprising contact pins 126A, 126B, linked to coil springs 128A, 128B. This dual spring pin connector assembly including the bulkhead 124 and coil springs 128A, 128B is

positioned within the tandem seal adapter 48 extending from a conductor slug 130 to the bulkhead connector element 118. The dual spring pin connector assembly is connected to the through wire 106 of the detonator assembly 26.

In an embodiment and as better shown in Figures 11 to 18, the top connector 14 may have a split design to simplify manufacturing and aid in assembly. By "split design" what is meant is that the top connector 14 can be formed of two halves - a top half 15A and a bottom half 15B. As better shown in Figures 15 or 18, the top connector 14 may also include a blind hole 47 to contain or house the detonation cord, thus eliminating the need for crimping the detonation cord during assembly.

In an embodiment and as shown for example in Figures 4 to 18, the rotation coupling 30 may either include a plurality of pins 50 (Figure 5) symmetrically arranged about a central axis of the rotation coupling 30, or a plurality of sockets 52 (Figure 4) symmetrically arranged about the central axis of the rotation coupling 30 and configured to engage the plurality of pins 50 of an adjacent rotation coupling 30.

In another embodiment, the rotation coupling 30 may either include a polygon-shaped protrusion, or a polygon-shaped recess configured to engage the polygon-shaped protrusion of an adjacent rotation coupling. The polygon can be 12-sided for example for 30 degree increments.

In another embodiment of the invention, the top and bottom subs work with off the shelf running/setting tools as would be understood by one of ordinary skill in the art.

In one embodiment and as shown in Figure 33, the top sub 72 facilitates use of an off the shelf quick change assembly 140 to enable electrical signals from the surface, as well as to adapt perforating gun system to mechanically run with conventional downhole equipment. The quick change assembly 140 may include a threaded adapter 143 to set an offset distance between an electrical connector 142 and the contact pin 126B extending from the bulkhead assembly 58.

In one embodiment and as shown in Figure 34, the bottom sub 70 may be configured as a sealing plug shoot adapter (SPSA) to be used specifically with this embodiment of the

invention. The SPSA may receive an off the shelf quick change assembly 140 (not shown) and insulator 150 that communicates with a firing head threaded below it (not shown). A setting tool (not shown) may run on the bottom side of the perforating gun.

In an embodiment, final assembly of the tool string requires only two pipe wrenches. No tools are required to install the detonator or any electrical connections.

An object of the invention is to also provide a perforation gun system kit having the basic component parts described above and capable of being assembled within an outer gun carrier.

The invention also provides a method for assembling a perforation gun system, to which a certain number of optional steps may be provided. The steps for assembling the gun system for transport include the steps of:

(a) providing a perforation gun system kit having component parts capable of being assembled within an outer gun carrier (element 12 in Figures 1, 21 and 22), the kit comprising a combination of:

-a top connector;

-at least one stackable charge holder for centralizing a single shaped charge within the gun carrier;

-a detonation cord connectable to the top connector and to each stackable charge holder;

-at least one bottom connector adapted for terminating the detonation cord in the gun system and adapted for doubling as a spacer for spacing a plurality of stackable charge holders; and

-a detonator energetically couplable to the detonation cord,

wherein each of the top connector, at least one stackable charge holder and at least one bottom connector comprise a coupling having a plurality of rotational degrees of freedom for providing a selectable rotation between each of the top connector, at least one stackable charge holder and at least one bottom connector;

(b) assembling a plurality of the stackable charge holders in a predetermined phase to form a first gun assembly;

(c) running the detonation cord into a bottommost bottom connector;

(d) assembling the bottommost bottom connector onto the assembled plurality of stackable charge holders;
(e) running a through wire between the bottommost bottom connector and the top connector, so that the through wire goes from the top connector to the bottom connector;
(f) clicking the detonation cord into recesses in capturing projections, the capturing projections being provided in each of the charge holders;
(g) running the detonation cord into the top connector;
(h) cutting the detonator cord, if the detonator cord is not precut a predetermined length; and
(i) installing charges into each of the charge holders.

In an embodiment, the method further includes, prior to transport, the steps of:
(j) pushing assembled components together to engage all pin connections therebetween; and
(k) carrying out a continuity test to ensure complete connectivity of the detonating chord.

In an embodiment, on location, to complete the assembly, the method further comprises the steps of
(l) threading on the previously assembled components a bottom sub (element 70 on Figures 1 and 20);
(m) installing and connecting the detonator;
(n) pushing in a tandem seal adapter with o-rings onto the first gun assembly;
(o) pushing in a bulkhead (element 58 in Figure 19) onto the tandem seal adapter, if the bulkhead and the tandem seal adapter are not pre-assembled;
(p) threading a subsequent gun assembly onto the first gun assembly or threading a top sub (element 72 in Figures 1, 23 and 24) onto a topmost assembled gun assembly, for connection to a quick change assembly.

Of course, the scope of the invention should not be limited by the various embodiments set forth herein, but should be given the broadest interpretation consistent with the description as a whole. The components and methods described and illustrated are not limited to the specific embodiments described herein, but rather, features illustrated or described as part of one embodiment can be used on or in conjunction with other

embodiments to yield yet a further embodiment. Further, steps described in the method may be utilized independently and separately from other steps described herein. Numerous modifications and variations could be made to the above-described embodiments without departing from the scope of the invention and claims, as apparent to a person skilled in the art.

In this specification and the claims that follow, reference will be made to a number of terms that have the following meanings. The singular forms "a," "an" and "the" include plural referents unless the context clearly dictates otherwise. Further, reference to "top," "bottom," "front," "rear," and the like are made merely to differentiate parts and are not necessarily determinative of direction. Similarly, terms such as "first," "second," etc. are used to identify one element from another, and unless otherwise specified are not meant to refer to a particular order or number of elements.

As used herein, the terms "may" and "may be" indicate a possibility of an occurrence within a set of circumstances; a possession of a specified property, characteristic or function; and/or qualify another verb by expressing one or more of an ability, capability, or possibility associated with the qualified verb. Accordingly, usage of "may" and "may be" indicates that a modified term is apparently appropriate, capable, or suitable for an indicated capacity, function, or usage, while taking into account that in some circumstances the modified term may sometimes not be appropriate, capable, or suitable. For example, in some circumstances an event or capacity can be expected, while in other circumstances the event or capacity cannot occur--this distinction is captured by the terms "may" and "may be."

As used in the claims, the word "comprises" and its grammatical variants logically also subtend and include phrases of varying and differing extent such as for example, but not limited thereto, "consisting essentially of" and "consisting of."

Advances in science and technology may make equivalents and substitutions possible that are not now contemplated by reason of the imprecision of language; these variations should be covered by the appended claims. This written description uses examples to disclose the invention, including the best mode, and also to enable any person of ordinary skill in the art to practice the invention, including making and using

any devices or systems and performing any incorporated methods. The patentable scope of the invention may include other examples that occur to those of ordinary skill in the art in view of the description. Such other examples are intended to be within the scope of the invention.

WHAT IS CLAIMED IS:

1. A top connector for a perforation gun system comprising:

-a coupler for providing energetic coupling between a detonator and a detonating cord;

-at least one directional locking fin for locking the top connector within a gun carrier;

-a rotation coupling for providing a selectable clocking rotation between the top connector, and a charge holder

wherein the top connector is configured to receive electrical connections therethrough.

2. A stackable charge holder for a perforation gun system having an outer gun carrier, the charge holder comprising:

-a charge receiving structure for receiving a shaped charge, the structure comprising a pair of arms extending between a first rotation coupling and a second rotation coupling; and

-a plurality of projections extending from each of the arms of the charge receiving structure,

wherein the plurality of projections is configured for centralizing the shaped charge in the outer gun carrier.

3. The stackable charge holder according to claim 2, wherein a pair of the plurality of projections is configured for capturing a detonation cord traversing the charge holder.

4. The stackable charge holder according to any one of claims 2 to 3, wherein at least one of the first rotation coupling and the second rotation coupling is configured for providing a selectable clocking rotation between the charge holder and an adjacent component in the perforation gun system.

5. The stackable charge holder according to any one of claims 2 to 4, wherein

the first rotation coupling comprises a plurality of pins symmetrically arranged about a central axis of the first rotation coupling, and

the second rotation coupling comprises a plurality of sockets symmetrically arranged about the central axis of the second rotation coupling.

6. The stackable charge holder according to any one of claims 2 to 5, wherein the plurality of projections are also configured for retaining the shaped charge.

7. The stackable charge holder according to any one of claims 2 to 6, wherein the first rotation coupling and the second rotation coupling are positioned on opposite ends of the charge receiving structure.

8. The stackable charge holder according to any one of claims 2 to 7, wherein the charge receiving structure is injection molded.

9. A perforation gun system comprising:

at least one top connector comprising a coupler for providing energetic coupling between a detonator and a detonation cord, and at least one directional locking fin for locking the top connector within a gun carrier; and

at least one bottom connector for terminating the detonation cord in the perforation gun system, wherein

the at least one bottom connector optionally doubles as a spacer for spacing a plurality of stackable charge holders, and

the top and bottom connectors receive electrical connections therethrough.

10. The perforation gun system according to claim 9, wherein each of the top connector and the bottom connector comprises:

at least one rotation coupling for providing a selectable clocking rotation between other components of the perforation gun system.

11. The perforation gun system according to claim 10, wherein the at least one rotation coupling provides the selectable clocking rotation between the top connector, the bottom connector and a charge holder.

12. The perforation gun system according to any one of claims 9 to 11, wherein at least one of the top connector and the bottom connector is injection molded.

13. The perforation gun system according to claim 10, wherein the at least one rotation coupling comprises:

a first rotation coupling; and

a second rotation coupling, wherein

the first rotation coupling and the second rotation coupling are positioned on opposite ends of the bottom connector, and

each of the first rotation coupling and the second rotation coupling comprises at least a plurality of pins and/or a plurality of sockets arranged about a central axis of the bottom connector.

14. The perforation gun system according to any one of claims 9 to 13, wherein the bottom connector comprises:

a terminating structure for terminating the detonation cord; and

a plurality of fins for axially locking the bottom connector in the perforation gun system.

15. A component for a perforation gun system, comprising:

at least one bottom connector for terminating a detonation cord in the perforation gun system, wherein

the at least one bottom connector optionally doubles as a spacer for spacing a plurality of stackable charge holders, and

the at least one bottom connector comprises at least one rotation coupling for providing a selectable clocking rotation between other components of the perforation gun system.

16. The component according to claim 15, wherein the at least one bottom connector receives electrical connections therethrough.

17. The component according to any one of claims 15 to 16, wherein the at least one bottom connector is injection molded.

18. The component according to any one of claims 15 to 17, wherein the at least one rotation coupling comprises:

a first rotation coupling; and

a second rotation coupling, wherein

the first rotation coupling and the second rotation coupling are positioned on opposite ends of the bottom connector, and

each of the first rotation coupling and the second rotation coupling comprises at least a plurality of pins and/or sockets arranged about a central axis of the bottom connector.

19. The component according to any one of claims 15 to 18, further comprising:

a plurality of wings for axially locking the bottom connector to a snap ring.

20. A perforation gun system comprising an outer gun carrier, comprising:

a top connector;

a plurality of stackable charge holders, wherein each of the stackable charge holders positions a single shaped charge within the charge holder;

a detonating cord connected to the top connector and to each of the stackable charge holders; and

a plurality of bottom connectors,

wherein at least one of the bottom connectors doubles as a spacer for spacing the stackable charge holders.

21. The perforation gun system of claim 20, further comprising:

a wireless push-in detonator energetically coupled to the detonating cord.

22. The perforation gun system of claim 21, wherein the detonator comprises:

a detonator head;

a detonator body; and

a plurality of detonator wires between the detonator head and the detonator body, wherein the detonator wires comprise a through wire, a signal-in wire and a ground wire.

23. The perforation gun system of claim 20, wherein the top connector comprises a tandem seal adapter for grounding the detonator to the gun carrier.

24. The perforation gun system of claim 22, wherein the detonator head comprises:

a through wire connector element connected to the through wire;

a ground contact element configured to connect the ground wire to the tandem seal adapter through ground springs; and

a bulkhead connector element for connecting the signal-in wire to the bulkhead assembly.

25. The perforation gun system of claim 20, wherein the stackable charge holders comprise a bottommost stackable charge holder, and the detonating cord is terminated at the bottommost stackable charge holder.

26. The perforation gun system of claim 22, wherein the through wire traverses from the top connector to the bottom connector of the perforating gun system, making a connection at each charge holder.

27. The perforation gun system of claim 20, wherein the stackable charge holder comprises:

a charge receiving structure configured for receiving a shaped charge, the structure comprising a pair of arms extending between a first rotation coupling and a second rotation coupling; and

a plurality of projections extending from each of the arms of the charge receiving structure,

wherein the projections are configured for positioning and holding the shaped charge within the charge holder.

28. A perforating gun system comprising:

a bottom connector; and

at least one rotation coupling integrated with the bottom connector, the rotation coupling comprising at least one of a plurality of pins and a plurality of sockets, wherein

the pins and sockets are symmetrically arranged about a central axis of the rotation coupling, and

the pins and sockets are configured to engage the plurality of sockets or the plurality of pins of an adjacent rotation coupling,

wherein the rotation coupling provides a plurality of rotational degrees of freedom for providing a selectable clocking rotation between the bottom connector and components of the perforation gun system.

29. The perforation gun system of Claim 28, wherein the bottom connector comprises:

a cylindrical body comprising a first base and a second base, wherein

the pins outwardly extend from the first base, each pin being spaced apart from an adjacent pin, and

the sockets at least partially extend into the second base, each socket being spaced apart from an adjacent socket.

30. The perforation gun system of Claim 29, wherein the cylindrical body comprises:

a plurality of alternating v-shaped channels and v-shaped walls, the v-shaped channels partially extending from the first base towards the second base, and the v-shaped walls extend from the second base to the first base,

wherein at least one of the pins extend from one of the v-shaped walls.

31. The perforation gun system of Claim 29, wherein the bottom connector comprises a plurality of wings radially extending from the body, adjacent the first base, the wings being configured to axially lock the bottom connector against a snap ring arranged in the perforation gun system.

32. The perforation gun system of Claim 30, wherein each of the pins comprise:

a first end; and

a second end opposite the first end,

wherein the first end extends from one of the v-shaped walls and the second end is wider than the first end.

33. The perforation gun system of Claim 28, further comprising:

a tandem seal adapter having a recess,

wherein the bottom connector is configured to be received in the recess.

34. The perforation gun system of Claim 29, wherein the at least one rotation coupling comprises:

a first rotation coupling; and

a second rotation coupling, wherein

the cylindrical body of the bottom connector extends between the first rotation coupling and the second rotation coupling, and

each of the first rotation coupling and the second rotation coupling comprises at least a plurality of pins and/or a plurality of sockets arranged about the central axis.

35. The perforation gun system of Claim 29, wherein the cylindrical body comprises:

a terminating structure formed in the first base,

wherein the terminating structure is arranged for terminating a detonation cord in the perforation gun system.

36. The perforation gun system of Claim 28, when the components comprise at least one of a top connector, and at least one stackable charge holder.

37. A perforating gun system comprising:

at least one stackable charge holder comprising a charge receiving structure configured for receiving a shaped charge, and a plurality of projections extending from the charge receiving structure; and

at least one rotation coupling integrated with the stackable charge holder, the rotation coupling comprising at least one of a plurality of pins and a plurality of sockets, wherein

the pins and sockets are symmetrically arranged about a central axis of the rotation coupling, and

the pins and sockets are configured to engage the plurality of sockets or the plurality of pins of an adjacent rotation coupling,

wherein the rotation coupling provides a plurality of rotational degrees of freedom for providing a selectable clocking rotation between the stackable charge holder and components of the perforation gun system.

38. The perforating gun system of Claim 37, wherein the charge receiving structure comprises a pair of arms, and each projection extends from at least one of the arms.

39. The perforation gun system of Claim 38, wherein the stackable charge holder comprises:

a first base; and

a second base spaced apart from the first base, wherein

the arms extend between the first and second bases,

the pins outwardly extend from the first base, each pin being spaced apart from an adjacent pin, and

the sockets at least partially extend into the second base, each socket being spaced apart from an adjacent socket.

40. The perforation gun system of Claim 39, wherein the at least one rotation coupling comprises:

a first rotation coupling; and

a second rotation coupling, wherein

the first rotation coupling is integrated with the first base and the second rotation coupling is integrated with the second base, and

each of the first rotation coupling and the second rotation coupling comprises at least a plurality of pins and/or a plurality of sockets arranged about the central axis.

41. The perforation gun system of Claim 40, wherein

the pins of the first rotation coupling are configured to engage the sockets of an adjacent rotation coupling; and

the sockets of the second rotation coupling are configured to engage the pins of another adjacent coupling.

42. The perforation gun system of Claim 37, further comprising:

a pair of the plurality of projections, wherein the pair is configured for at least one of capturing a detonation cord traversing the stackable charge holder, and centralizing the shaped charge within an inner surface of a perforating gun carrier.

43. A perforating gun system comprising:

at least one top connector comprising a first end, a second end, and a coupler formed at the first end, the top connector being configured for providing energetic coupling between a detonator and a detonation cord; and

a rotation coupling formed at the second end, the rotation coupling comprising at least one of a plurality of pins and a plurality of sockets, wherein

the pins and sockets are symmetrically arranged about a central axis of the rotation coupling, and

the pins and sockets are configured to engage the plurality of sockets or the plurality of pins of an adjacent rotation coupling,

wherein the top connector is configured to receive electrical connections therethrough, and the rotation coupling provides a plurality of rotational degrees of freedom for providing a selectable clocking rotation between the top connector and components of the perforation gun system.

44. The perforation gun assembly of Claim 43, wherein the top connector further comprises:

an elongated opening extending from the second end towards the first end, wherein the elongated opening is flanked by side walls that provide the energetic coupling between the detonator and the detonation cord.

45. The perforation gun assembly of Claim 43, wherein the top connector comprises:

a top half, and

a bottom half for being coupled with the top half.

46. The perforating gun assembly of Claim 45, further comprising a plurality of securing mechanisms to couple the top half to the bottom half.

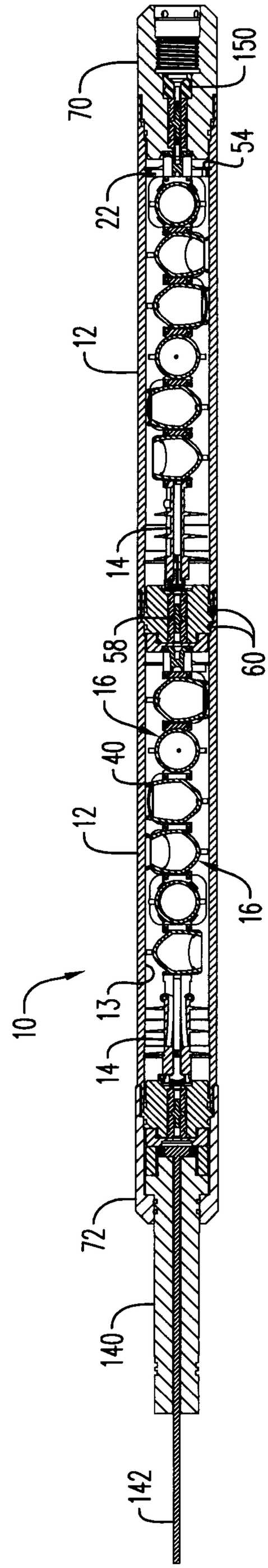

FIG. 1

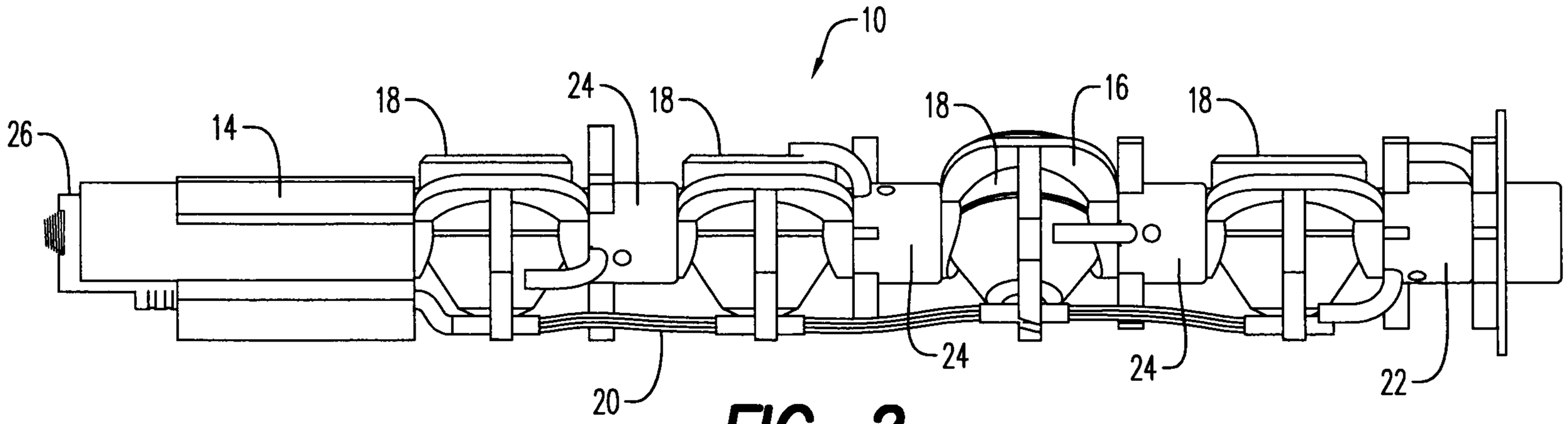
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FIG. 2

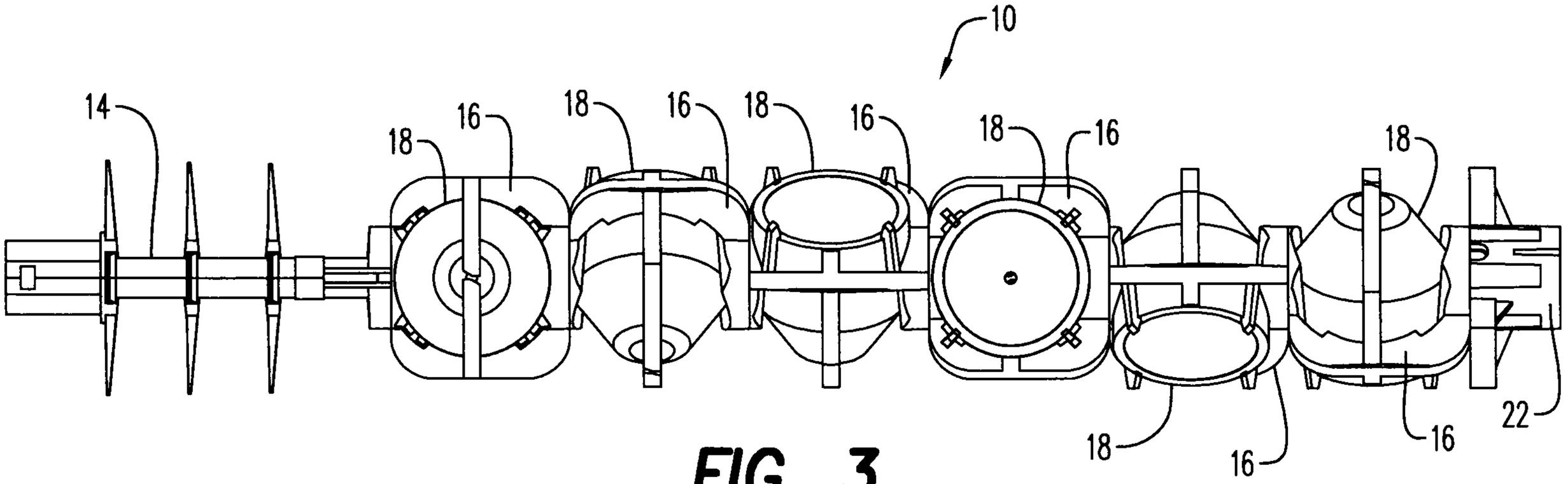
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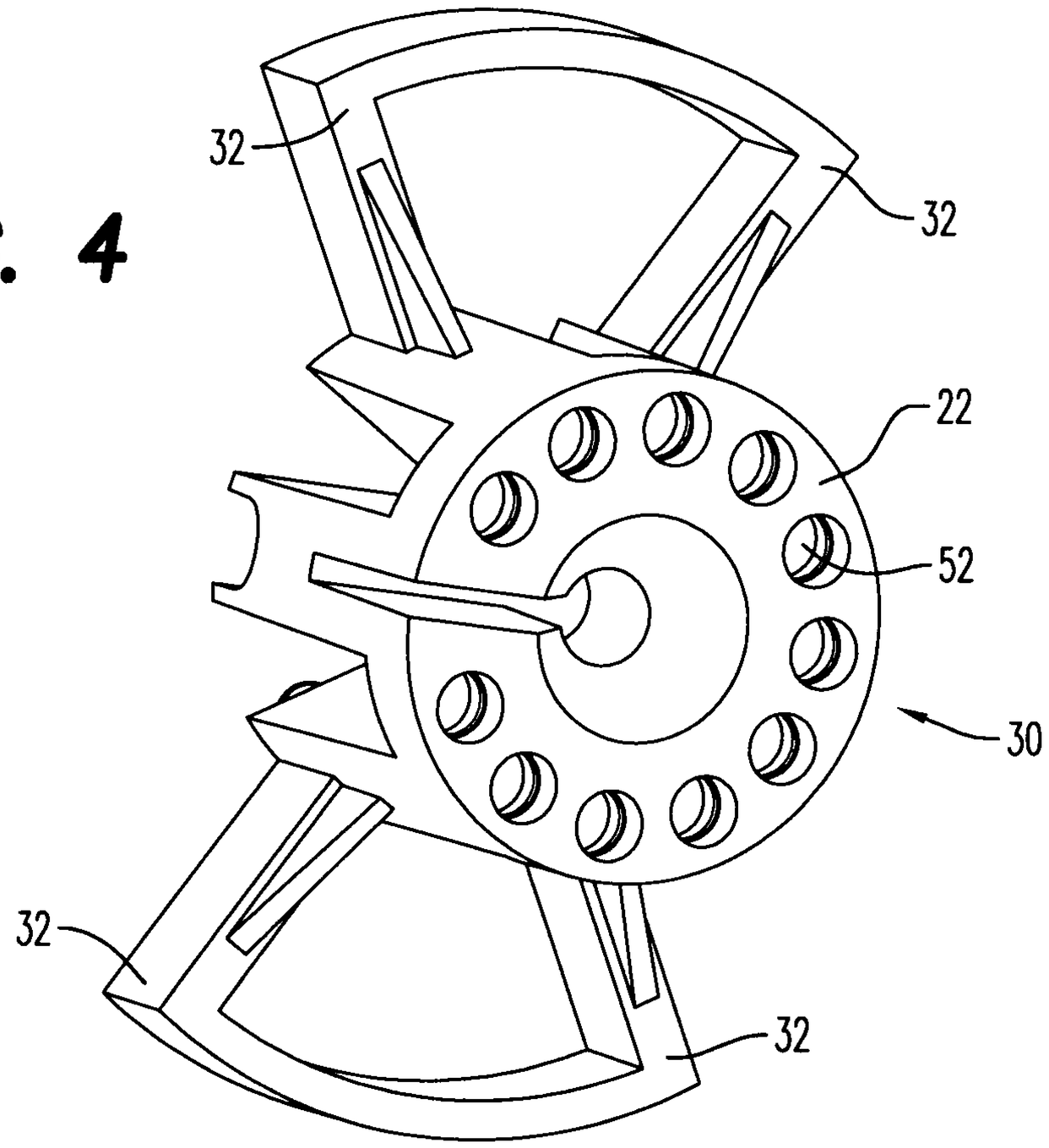
FIG. 3

FIG. 4



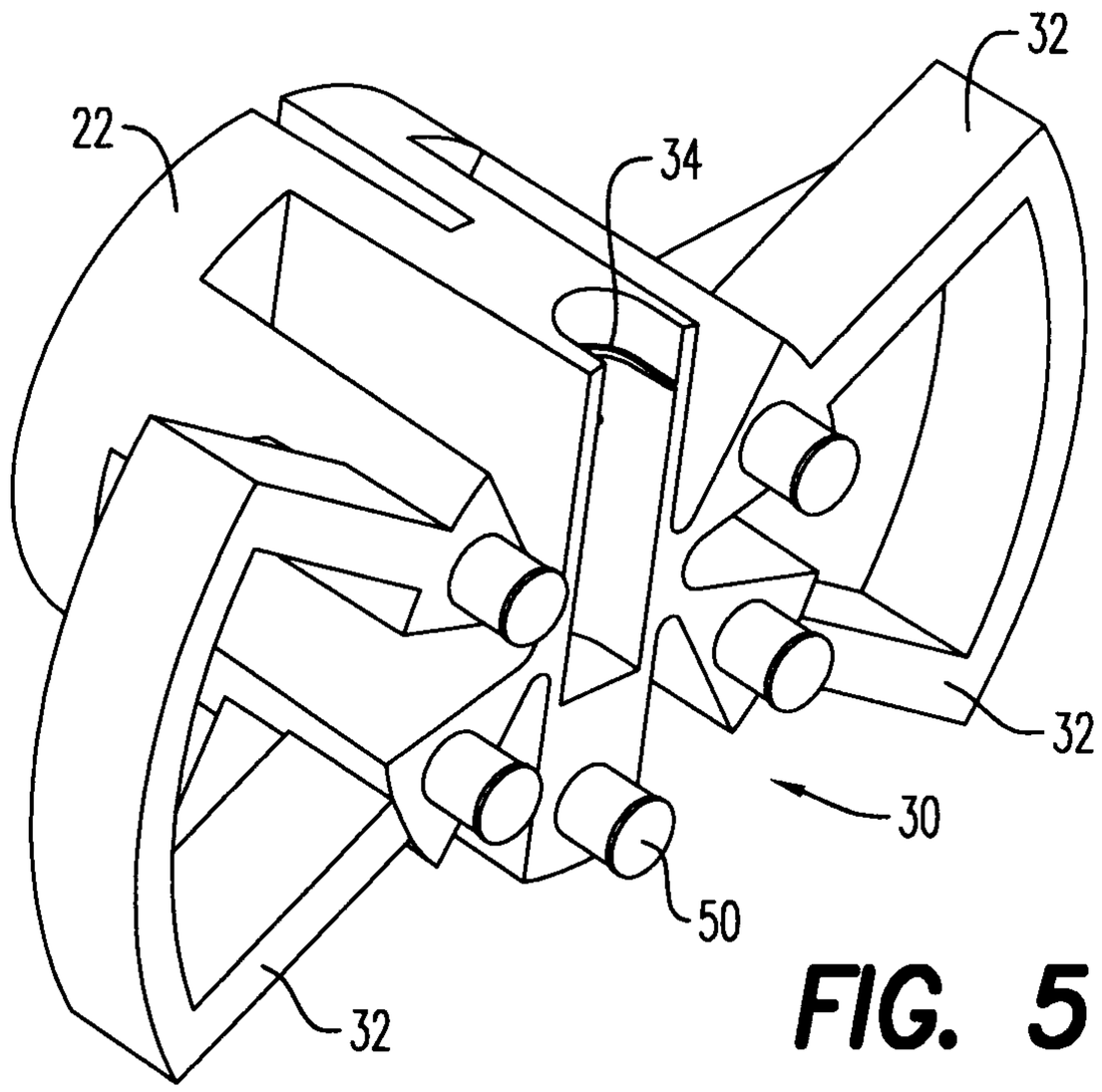


FIG. 5

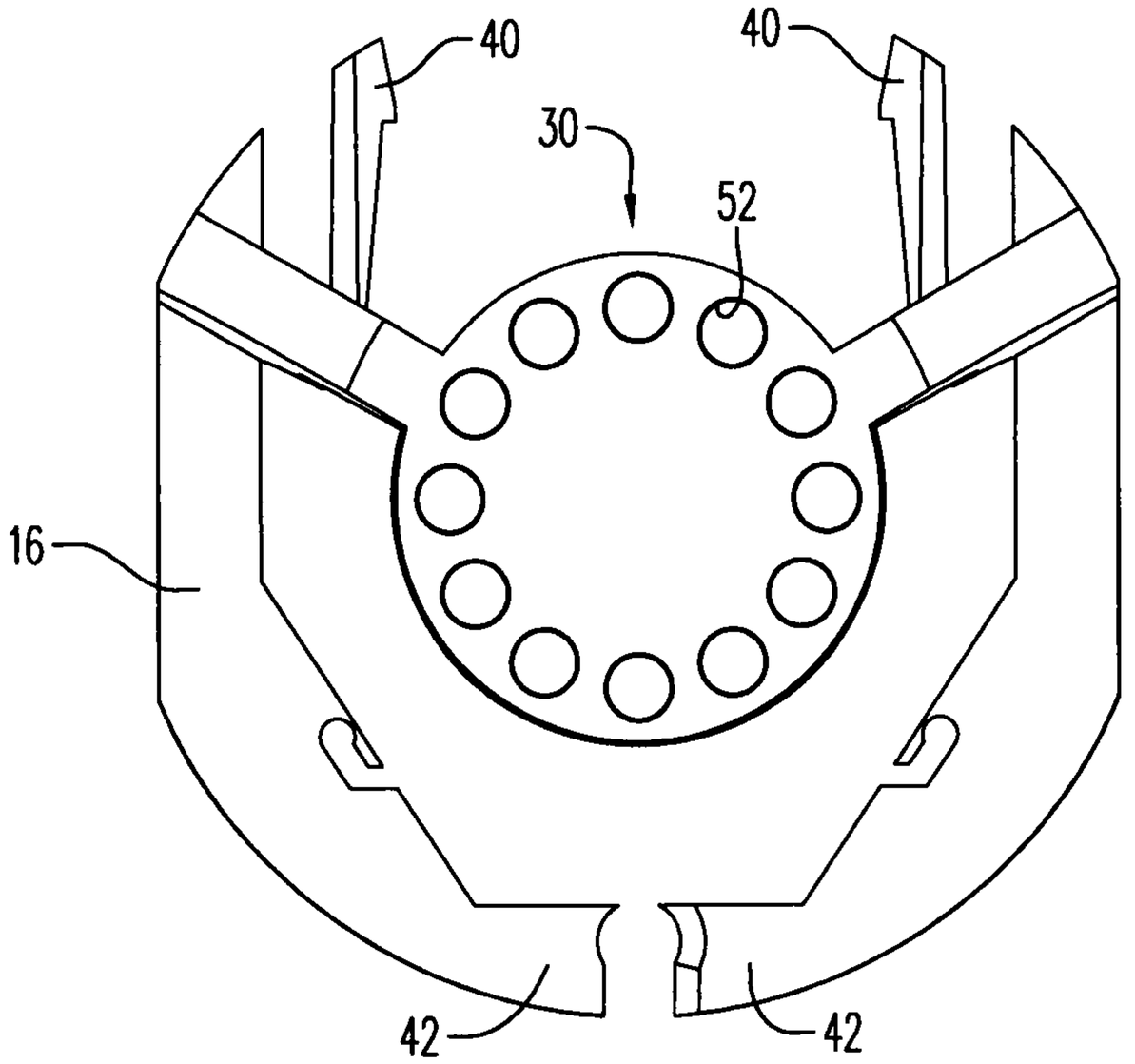


FIG. 6

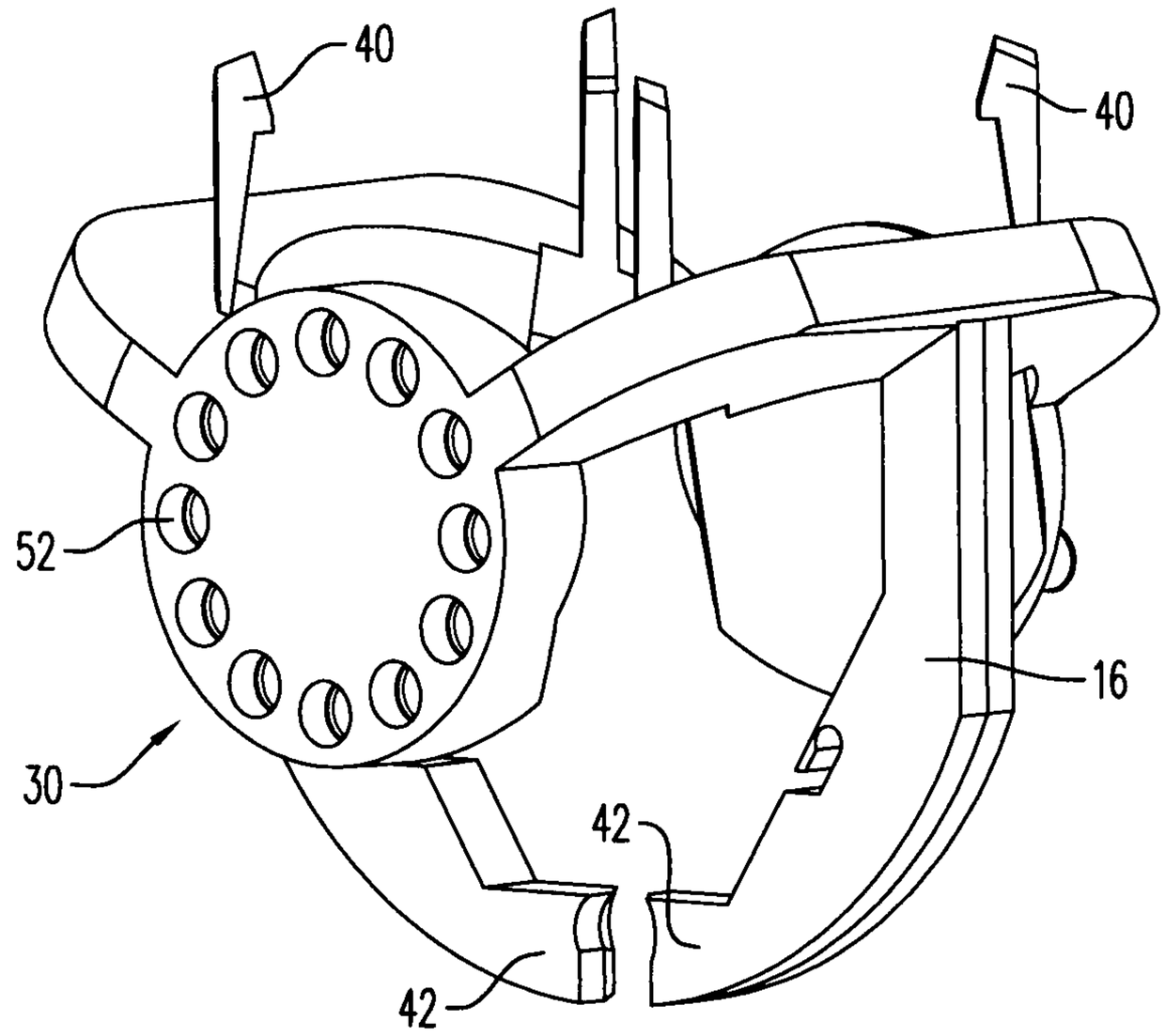
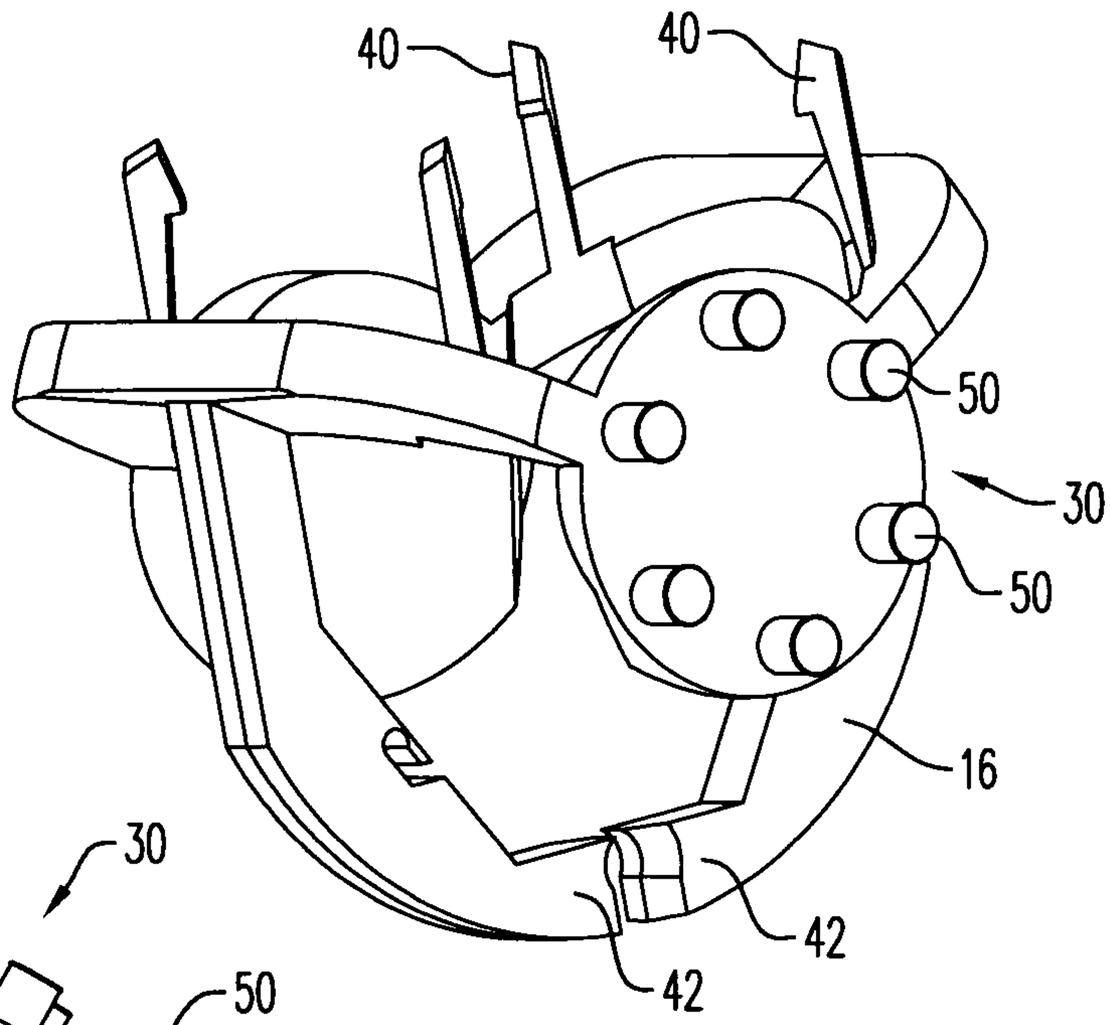


FIG. 7

FIG. 8



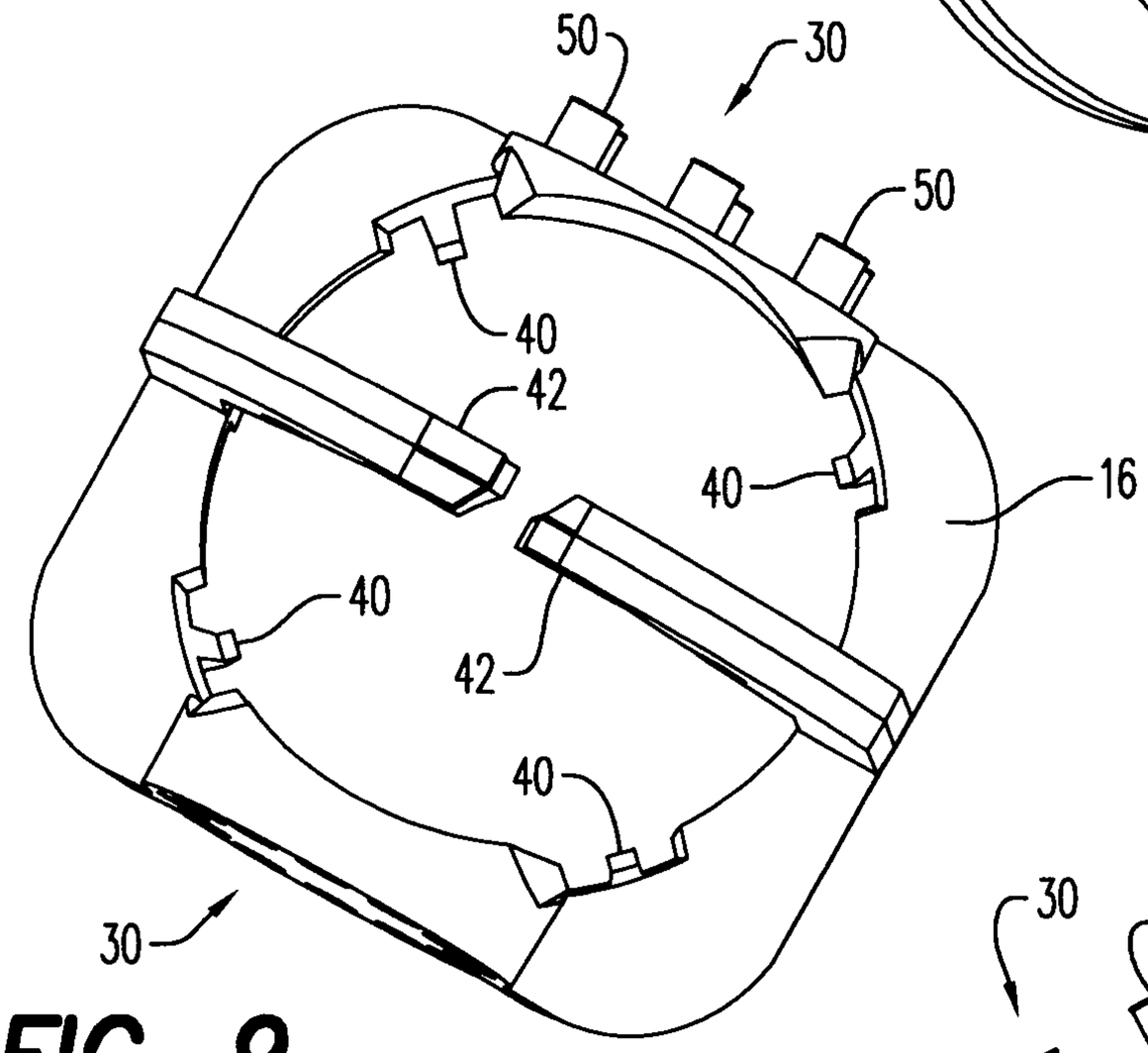


FIG. 9

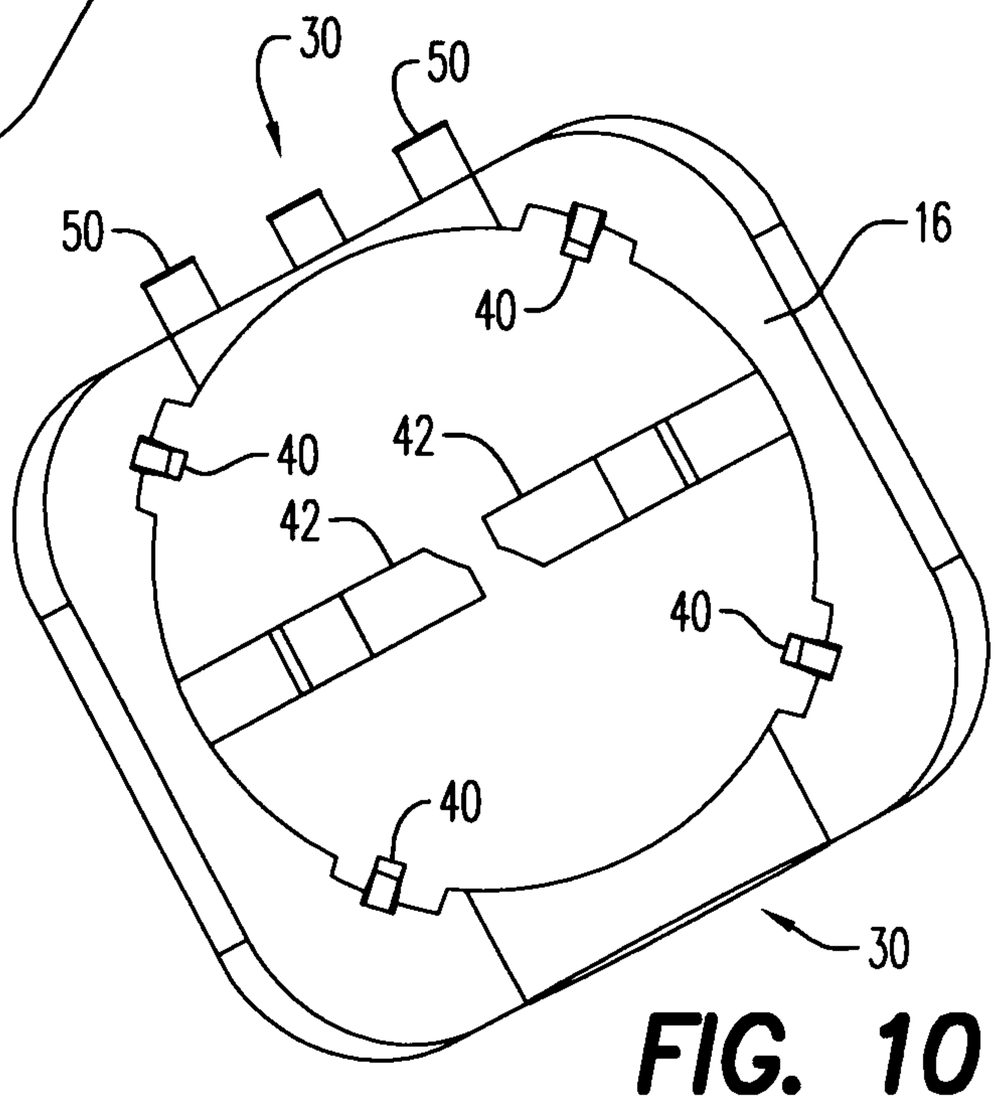


FIG. 10

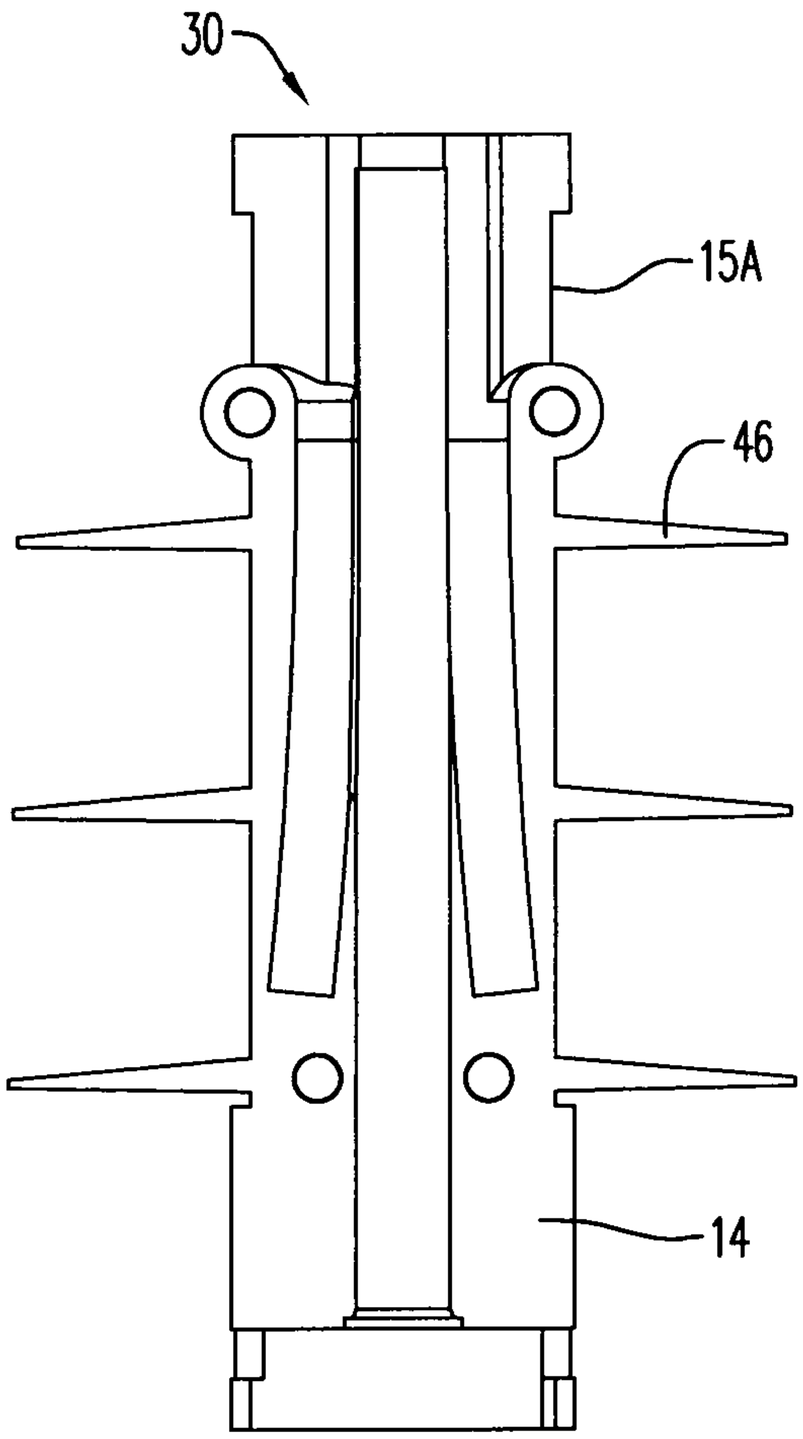


FIG. 11

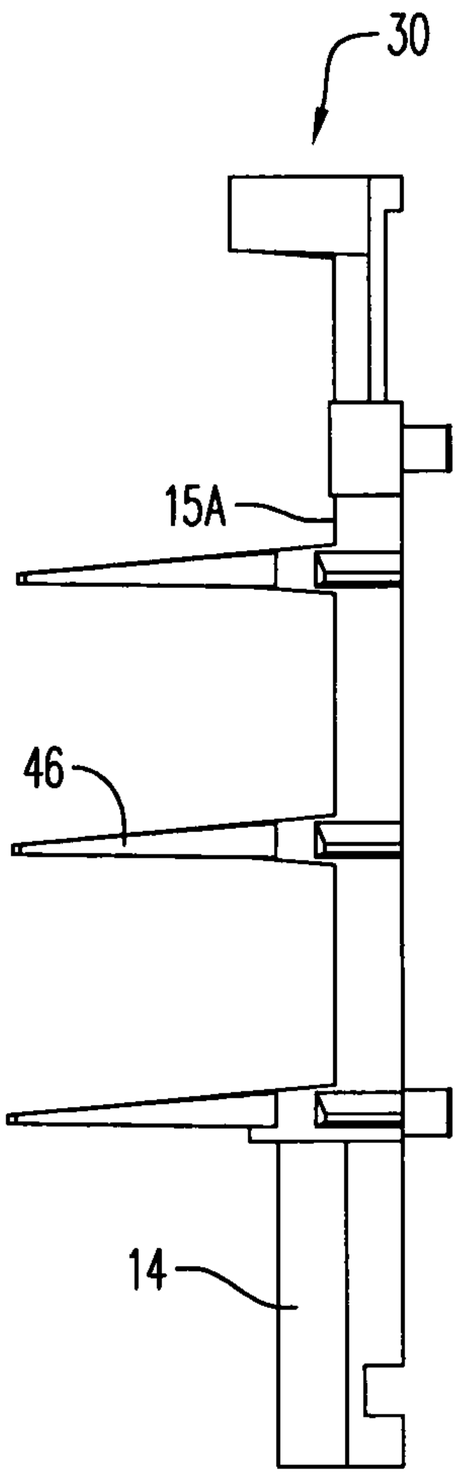


FIG. 12

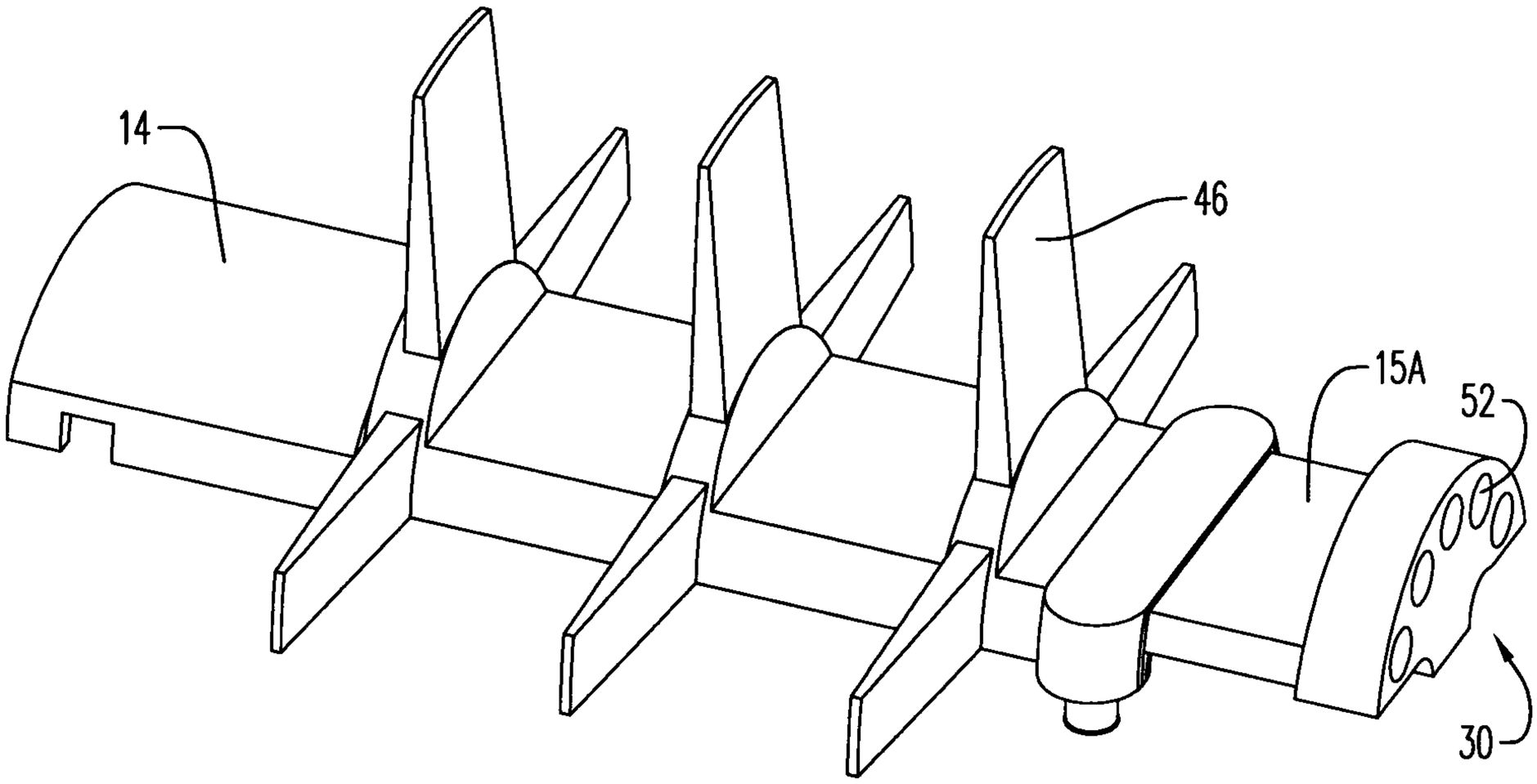


FIG. 13

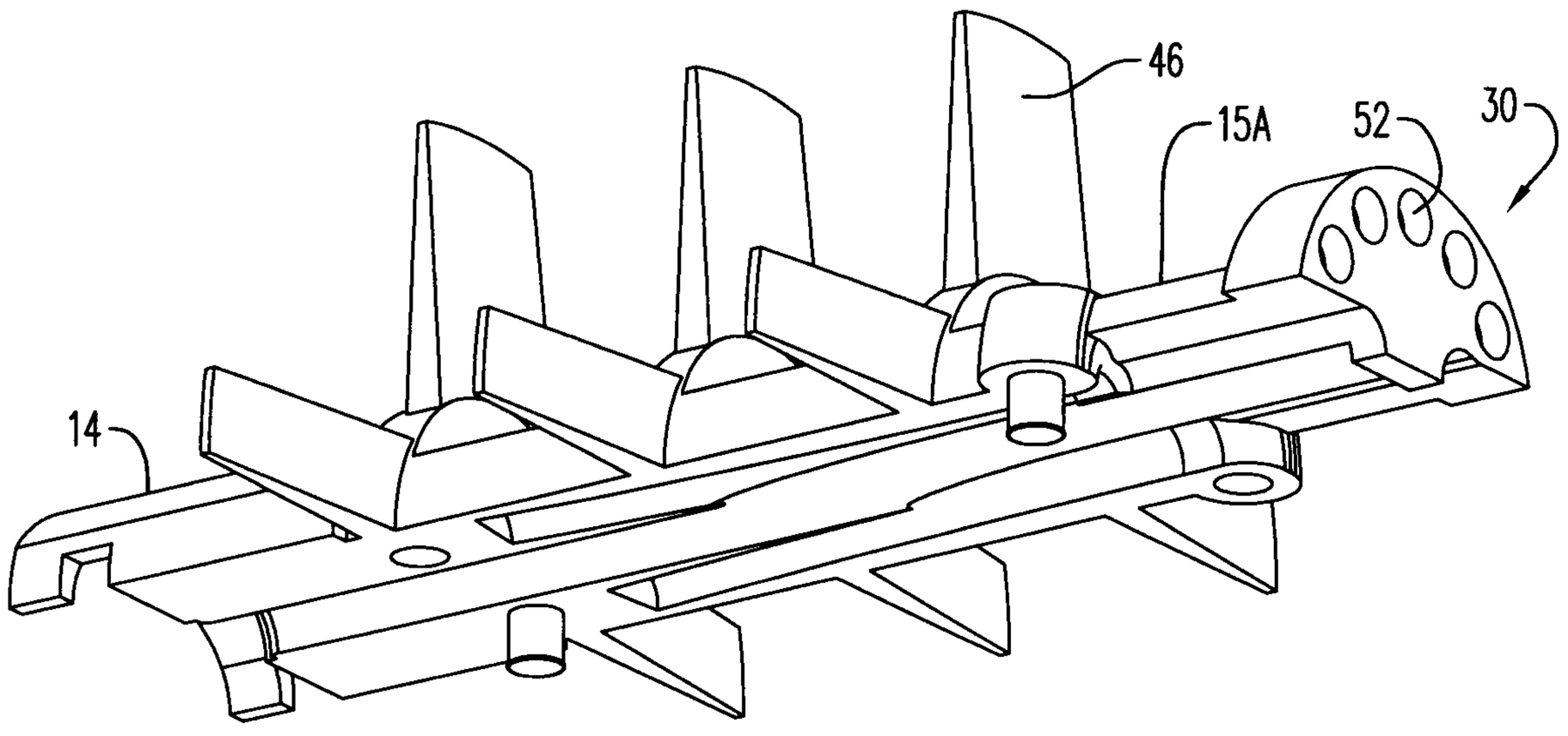


FIG. 14

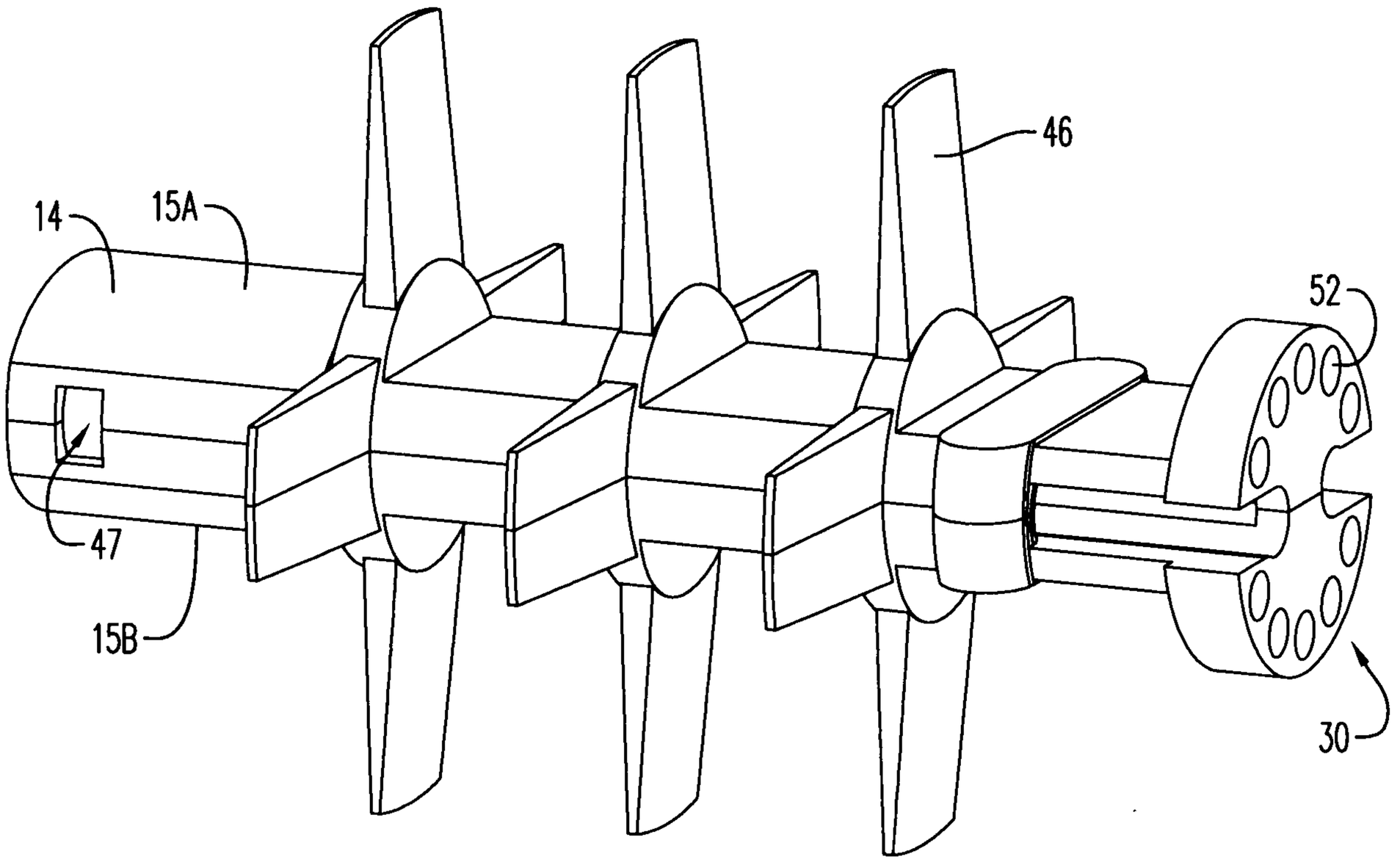


FIG. 15

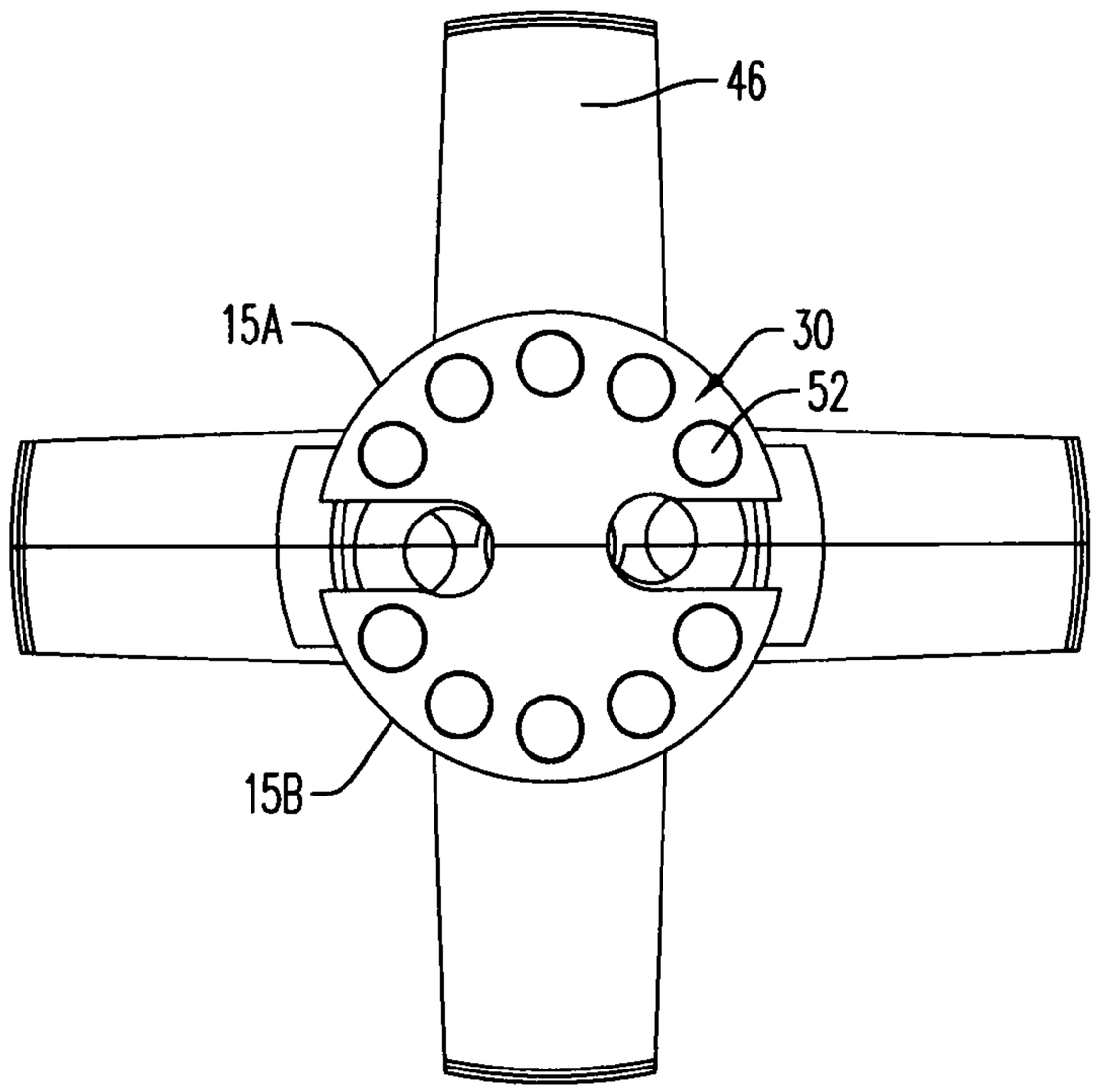


FIG. 16

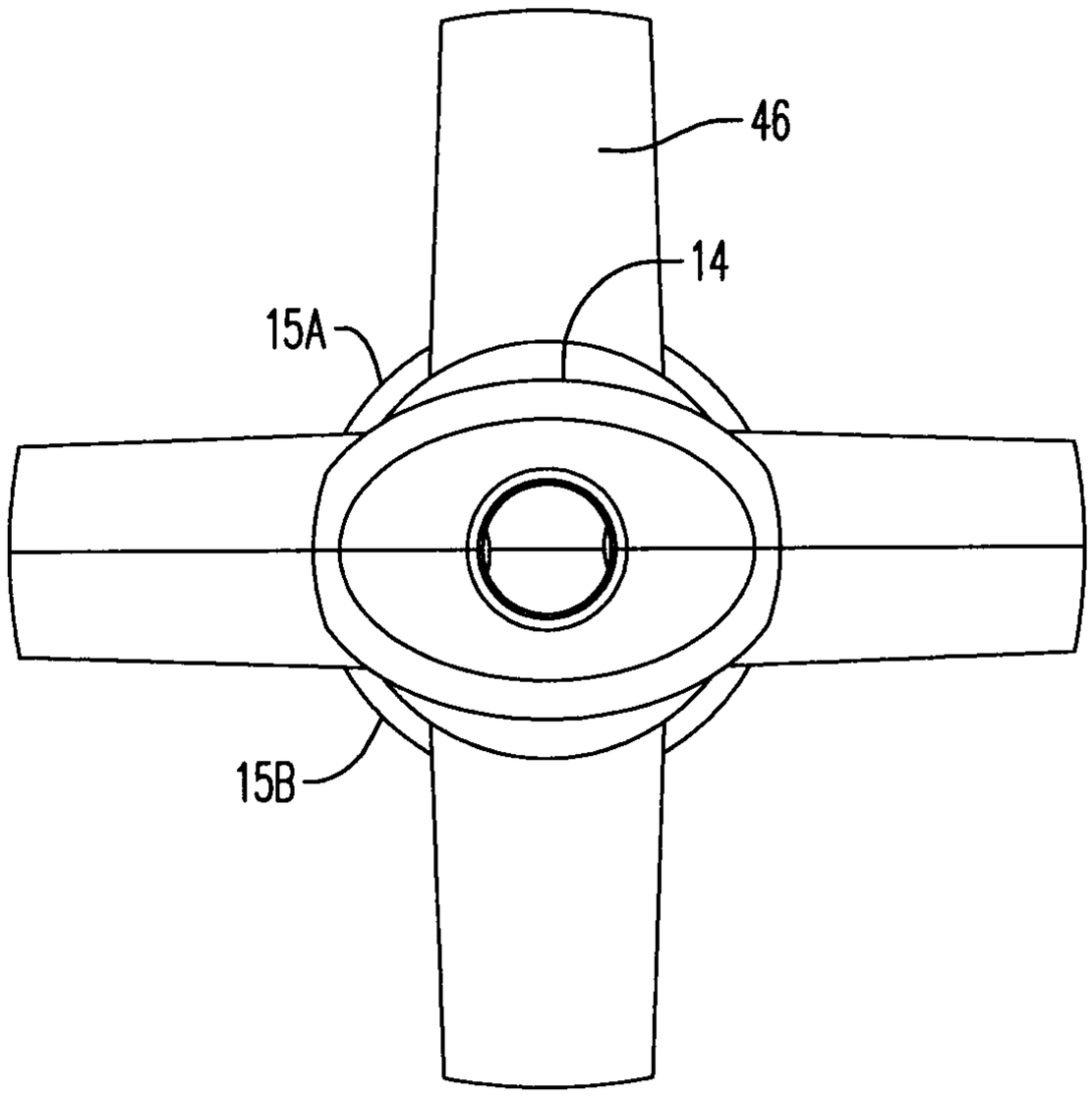


FIG. 17

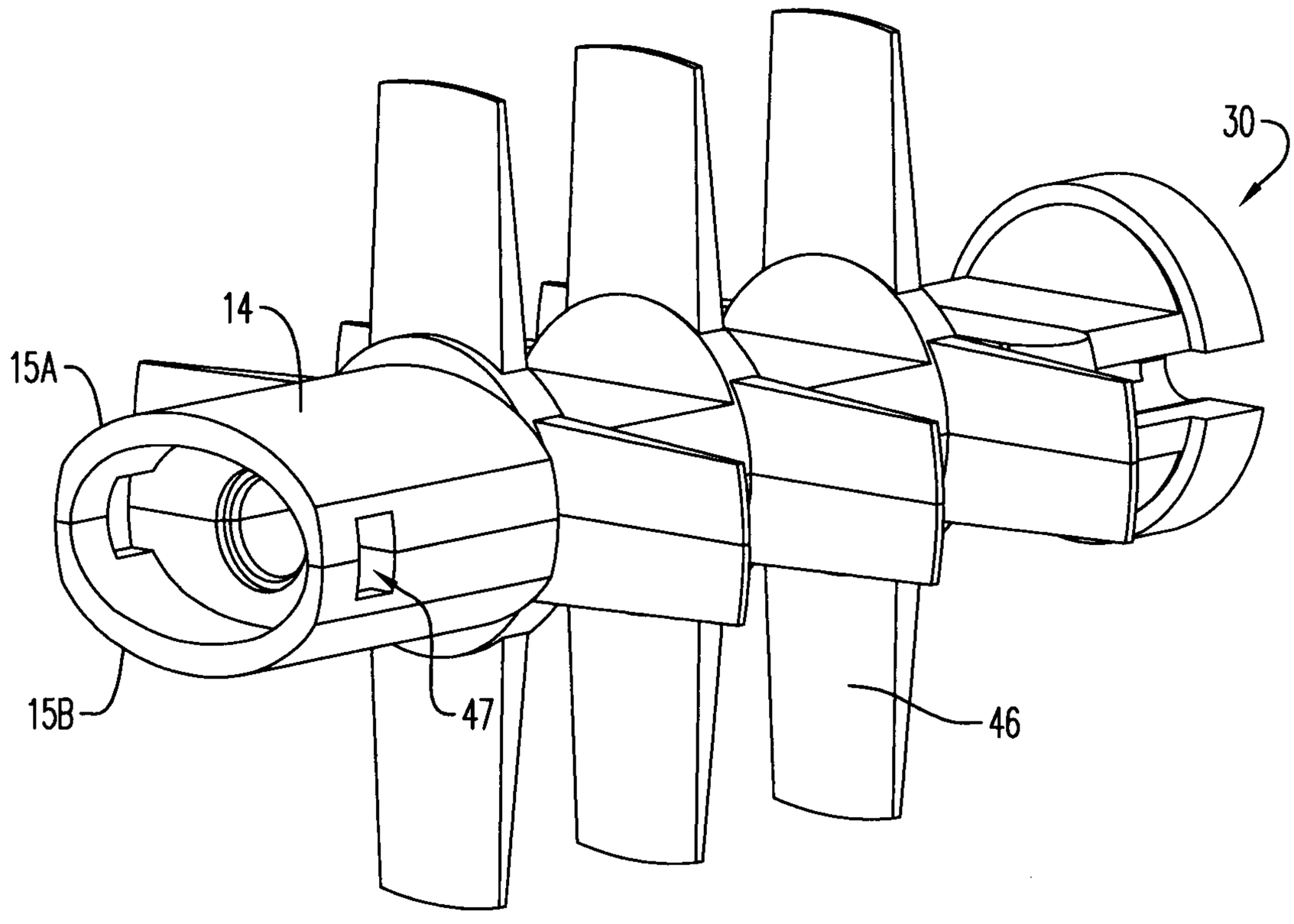


FIG. 18

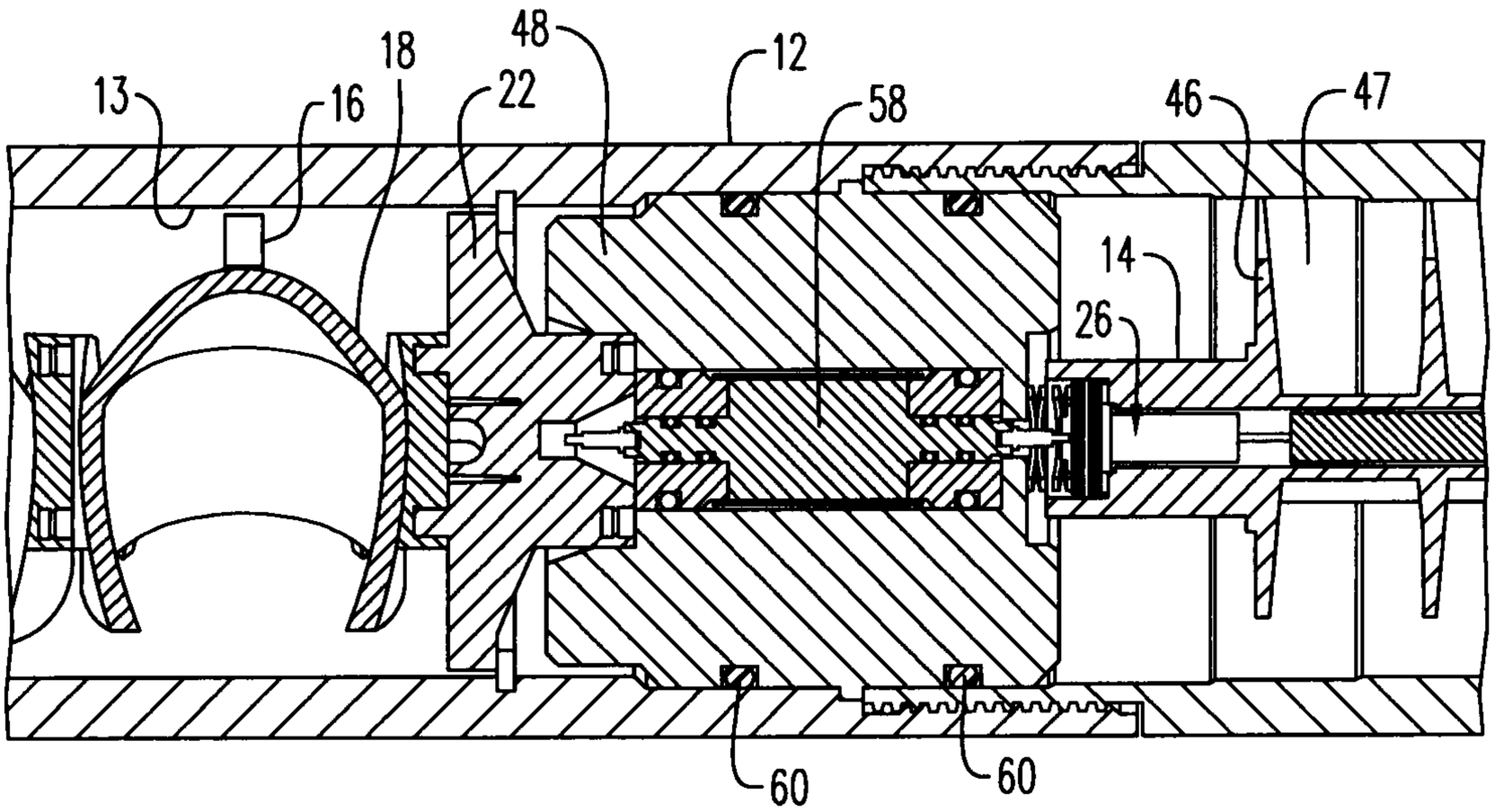


FIG. 19

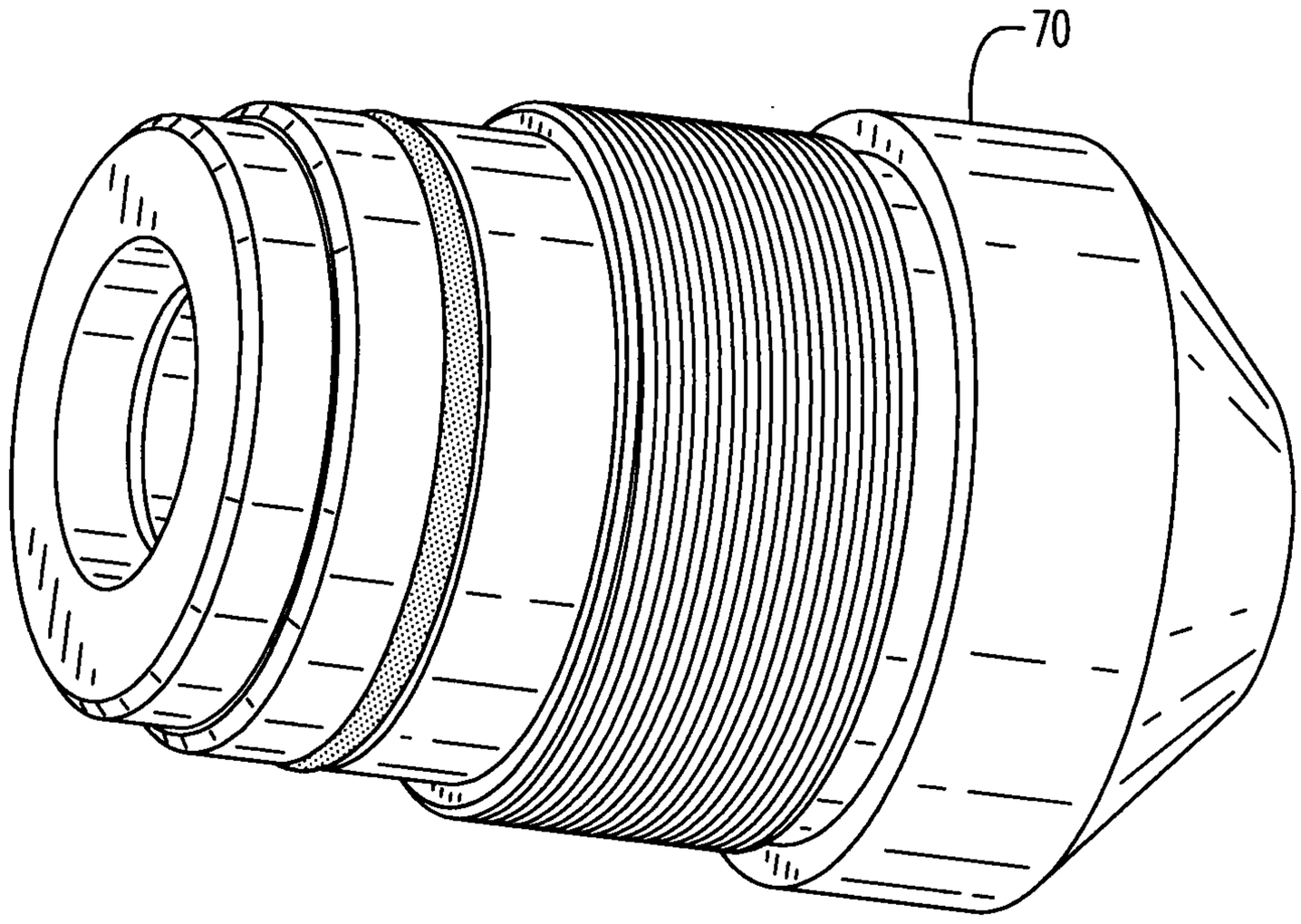


FIG. 20

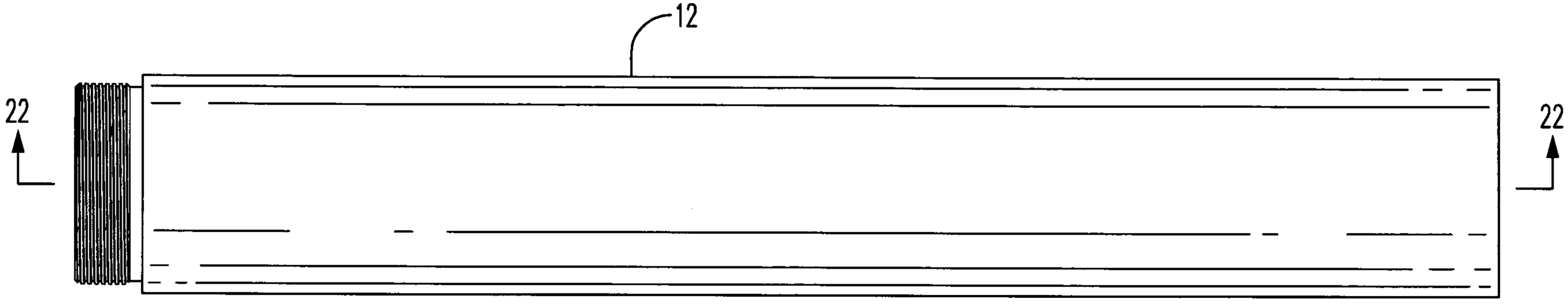


FIG. 21

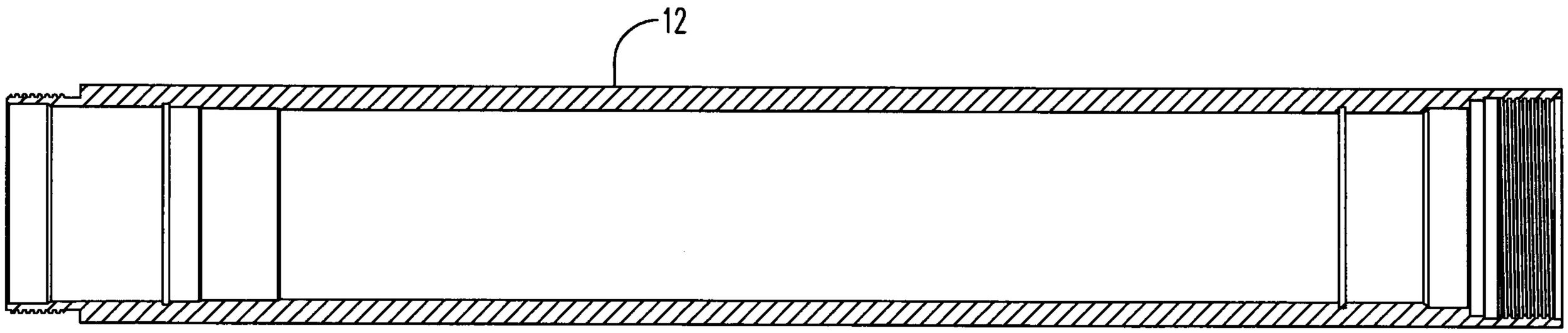


FIG. 22

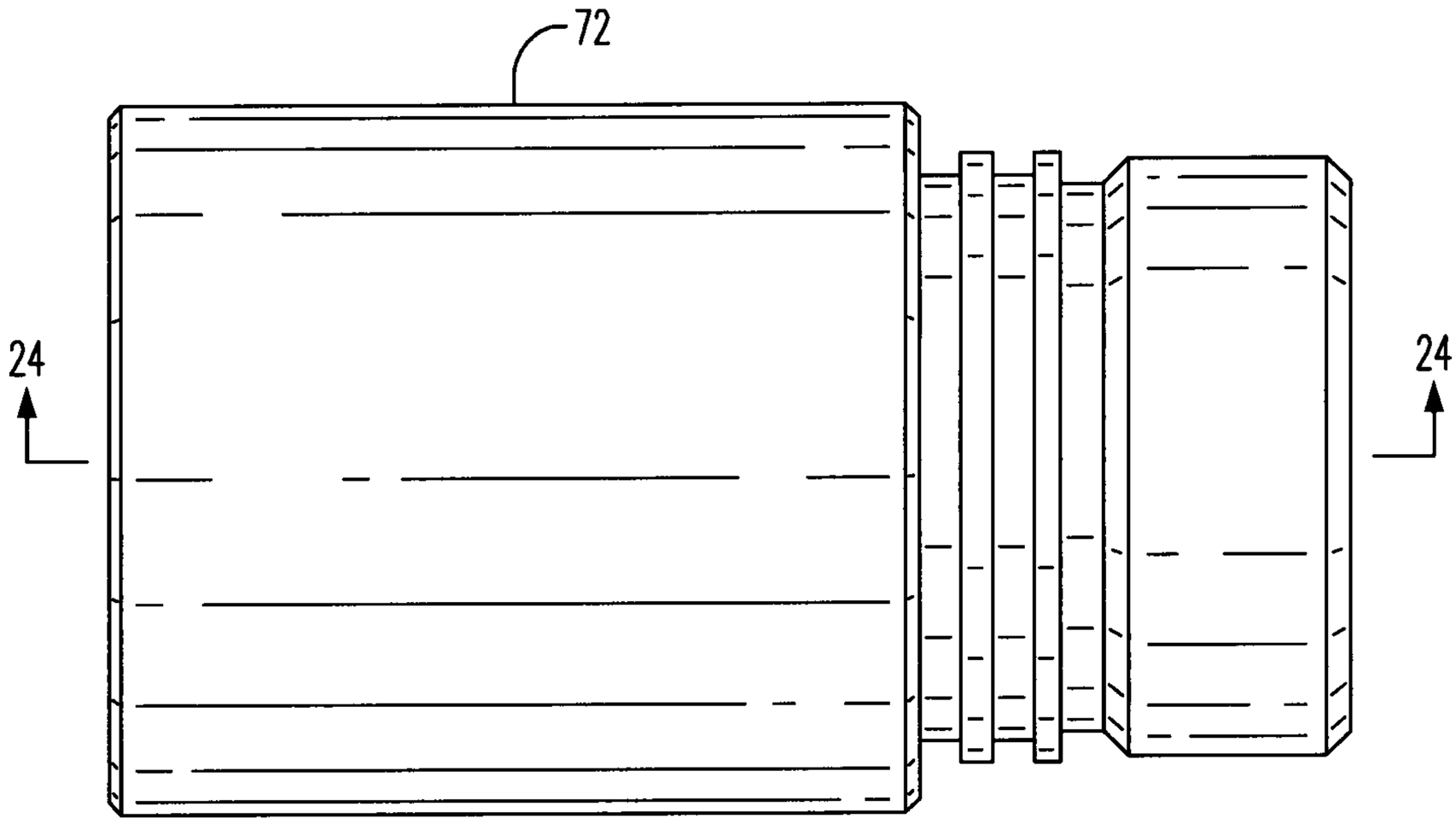


FIG. 23

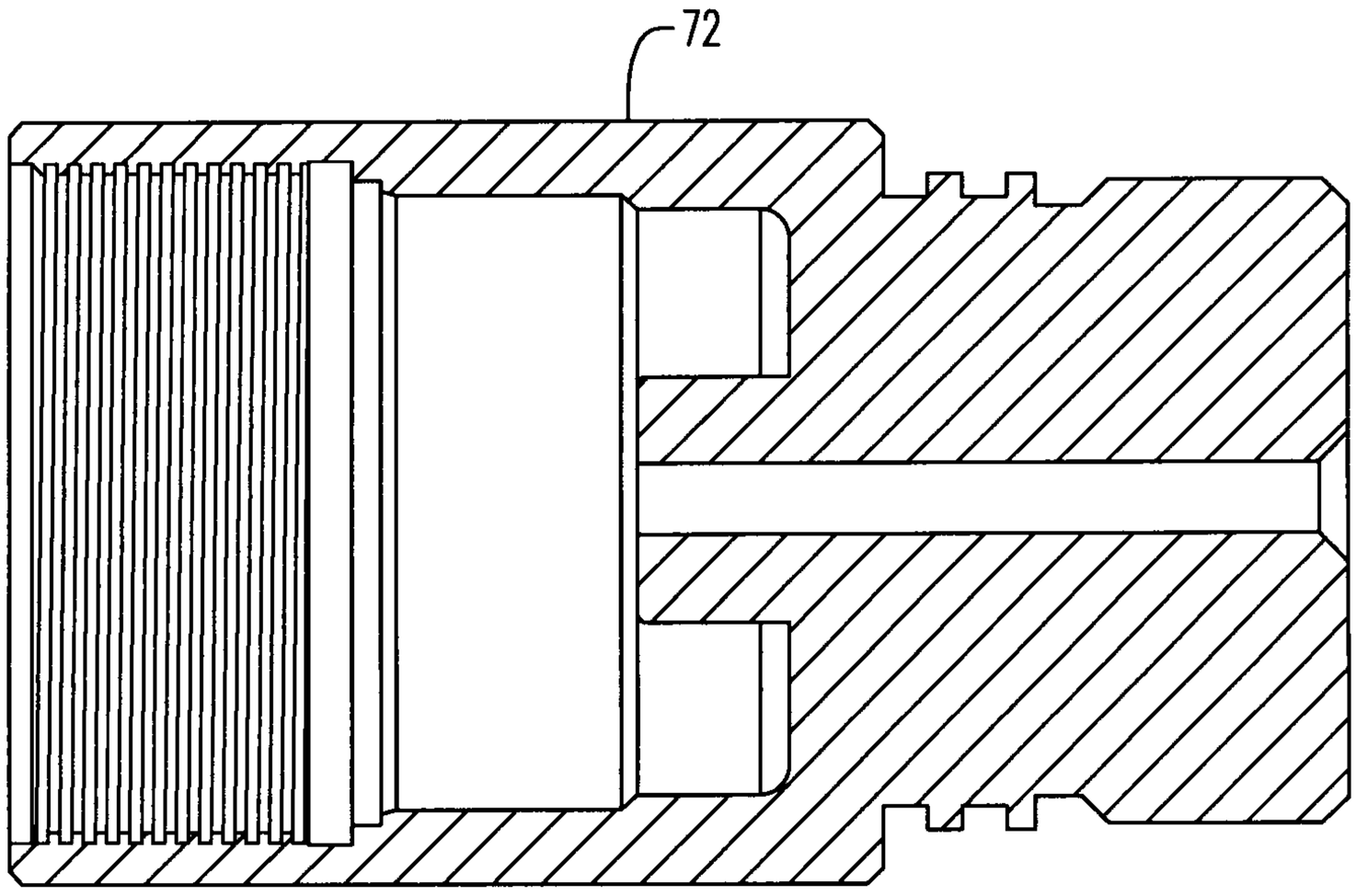


FIG. 24

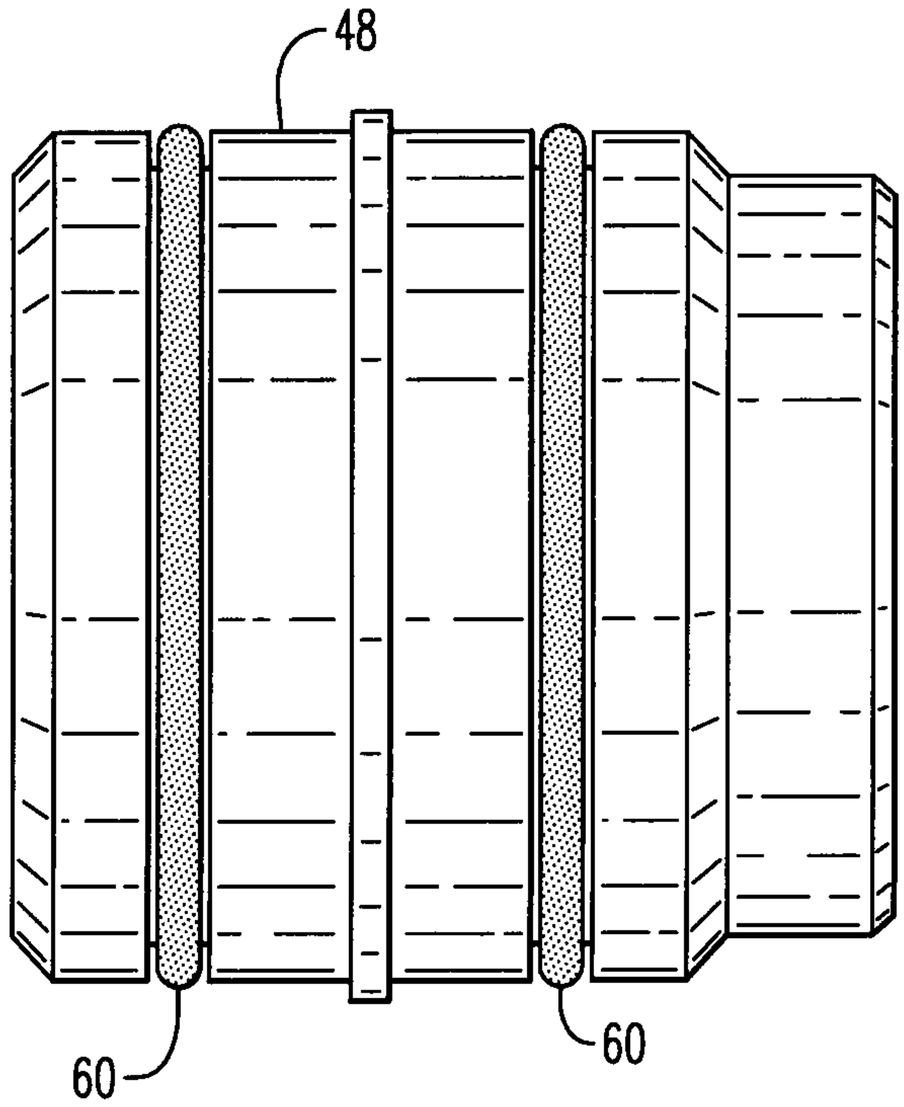


FIG. 25

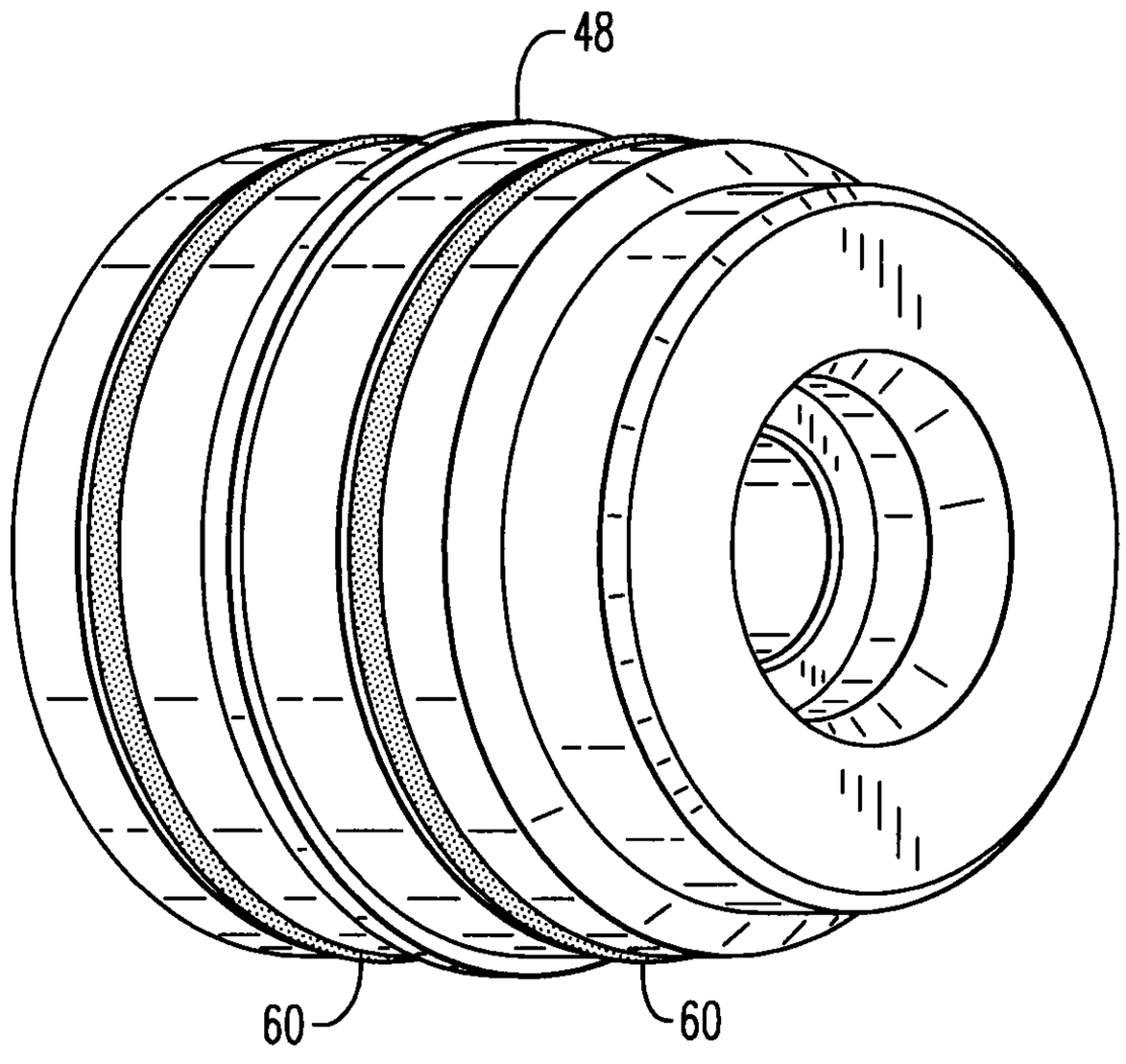


FIG. 26

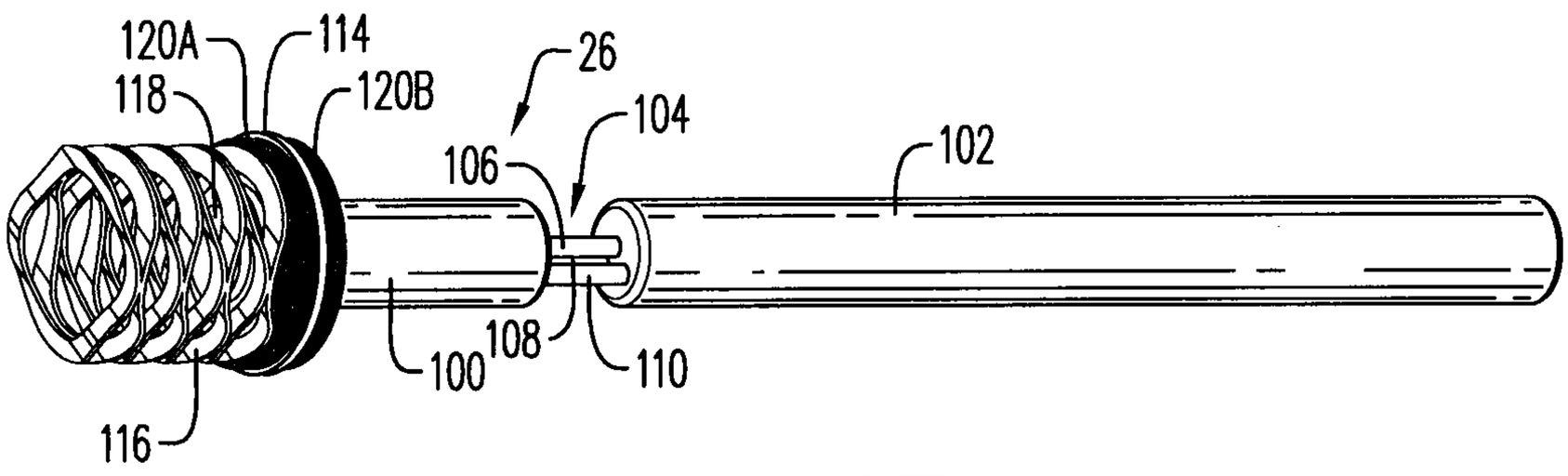

120A
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FIG. 27

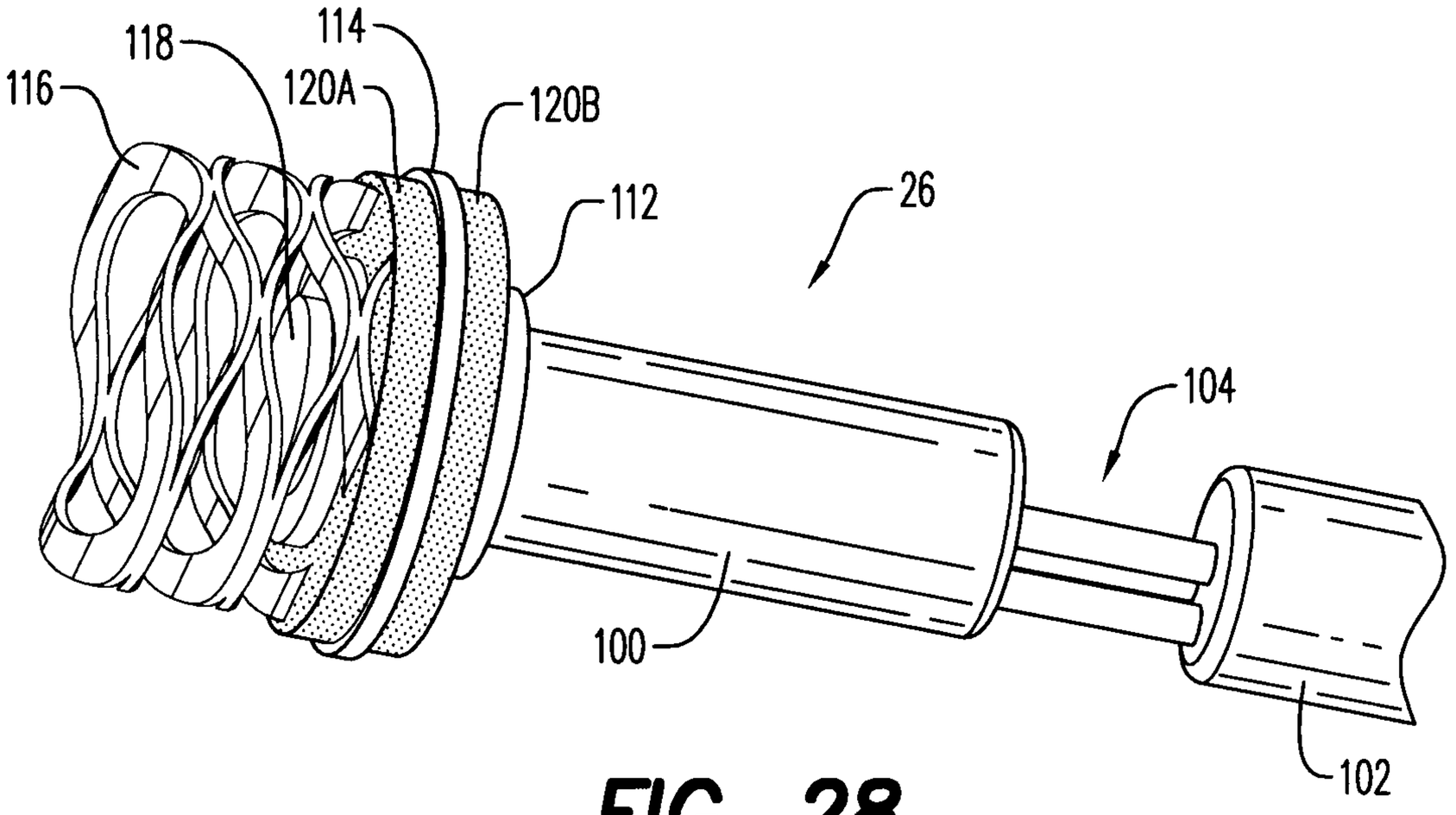
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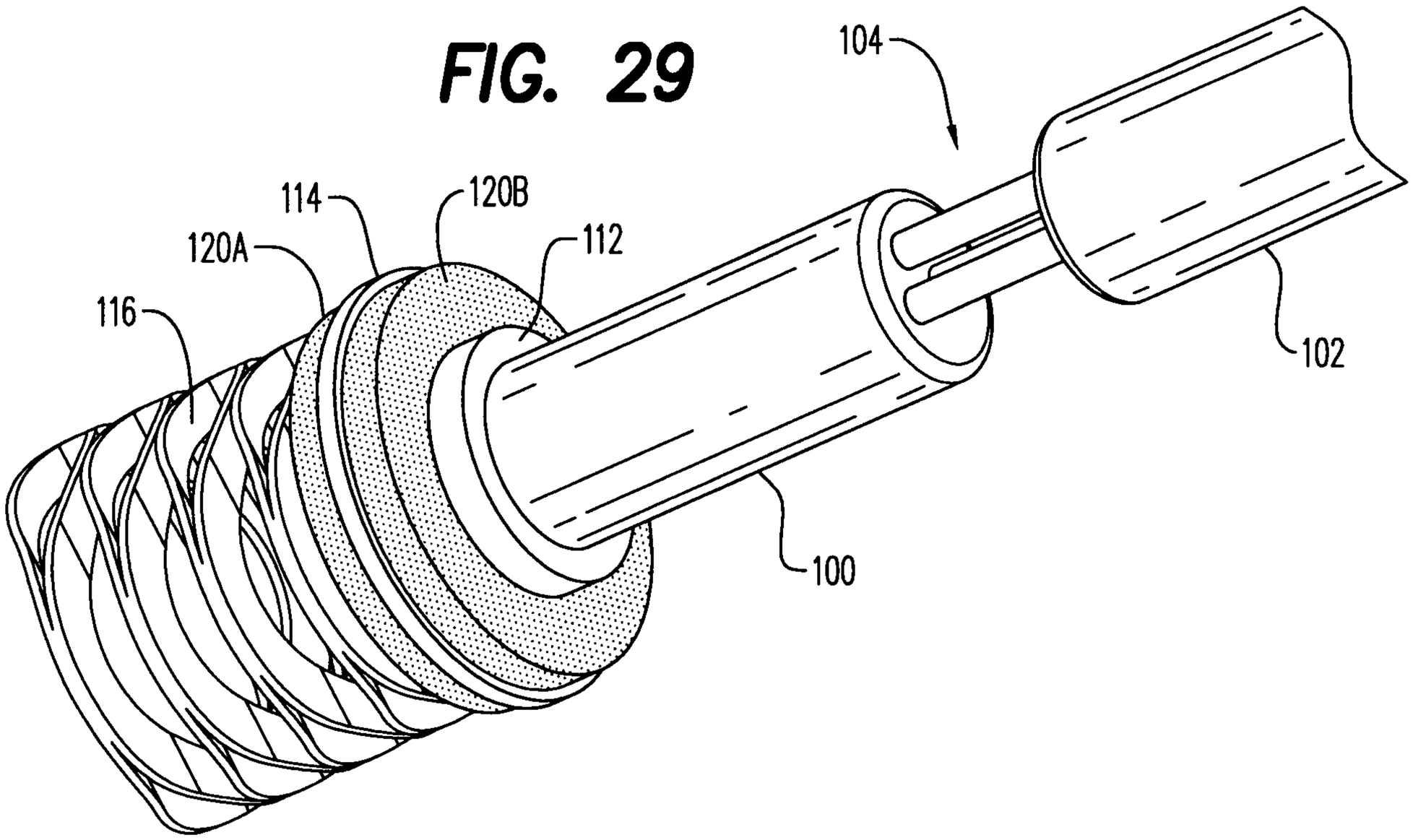
FIG. 28

FIG. 29



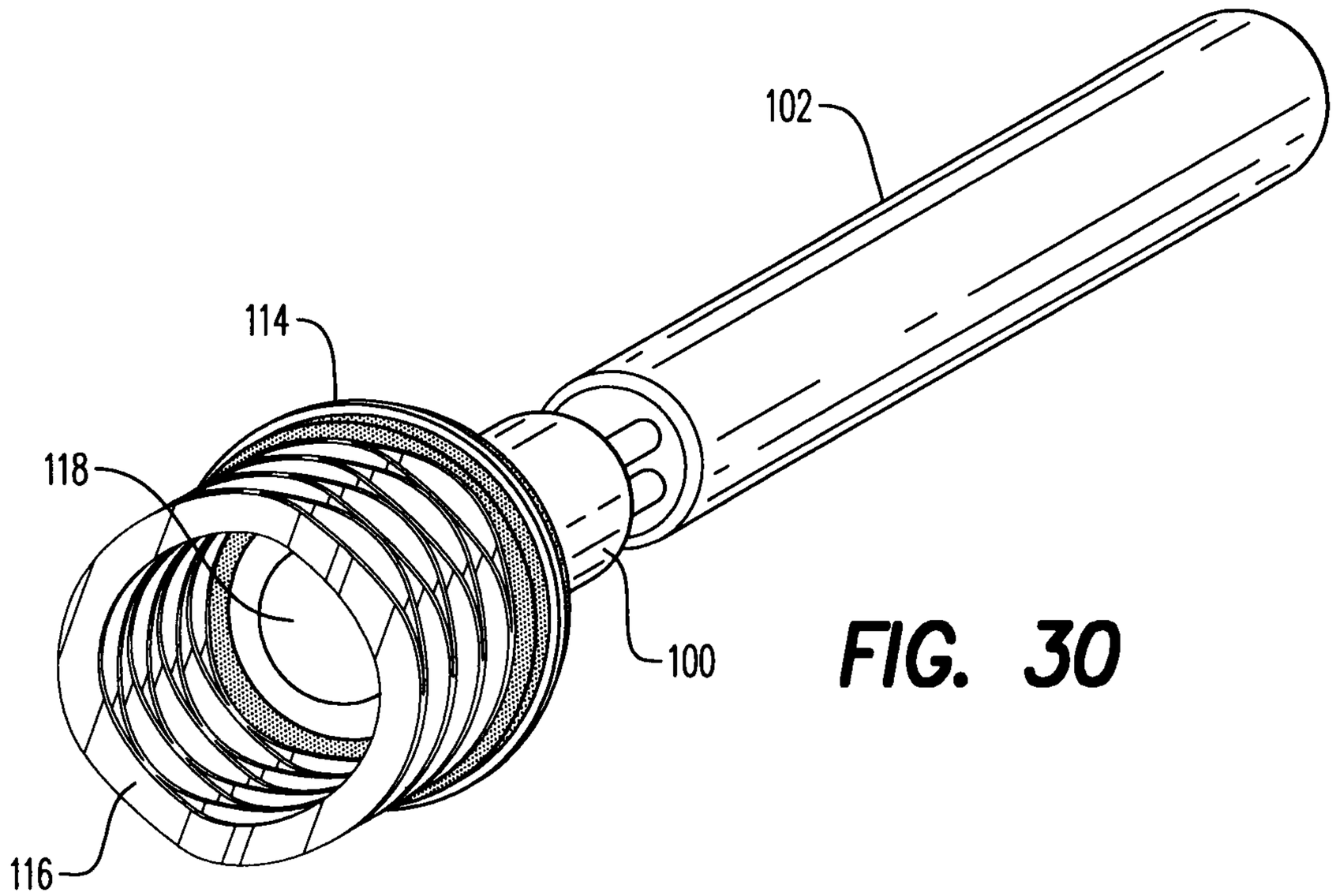


FIG. 30

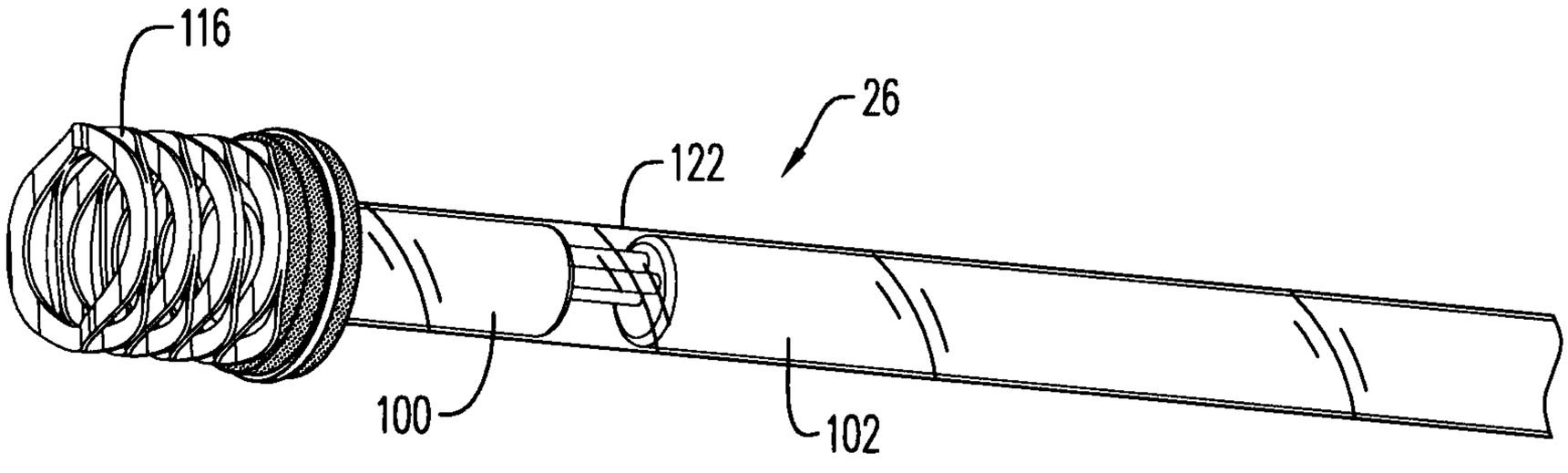

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FIG. 31

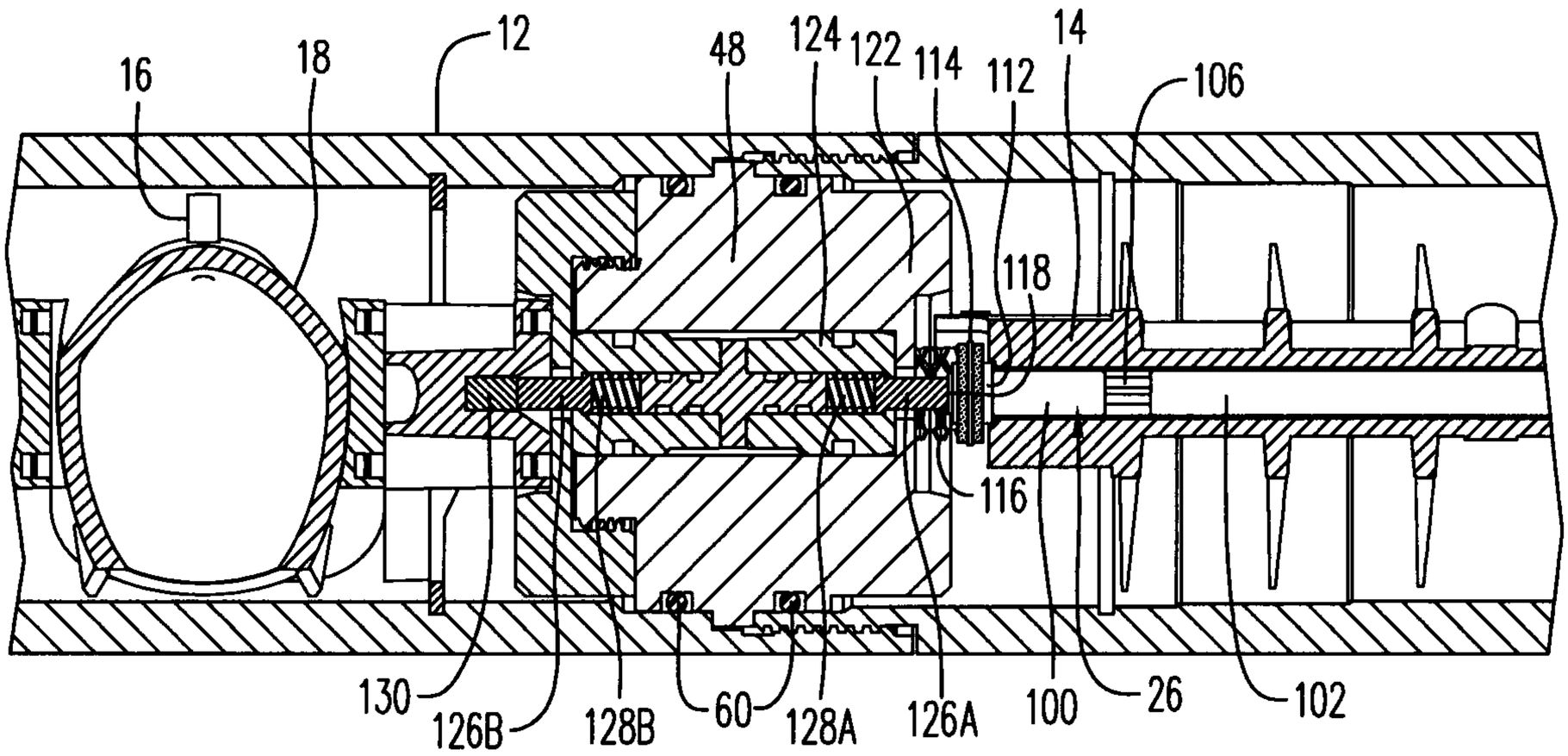
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FIG. 32

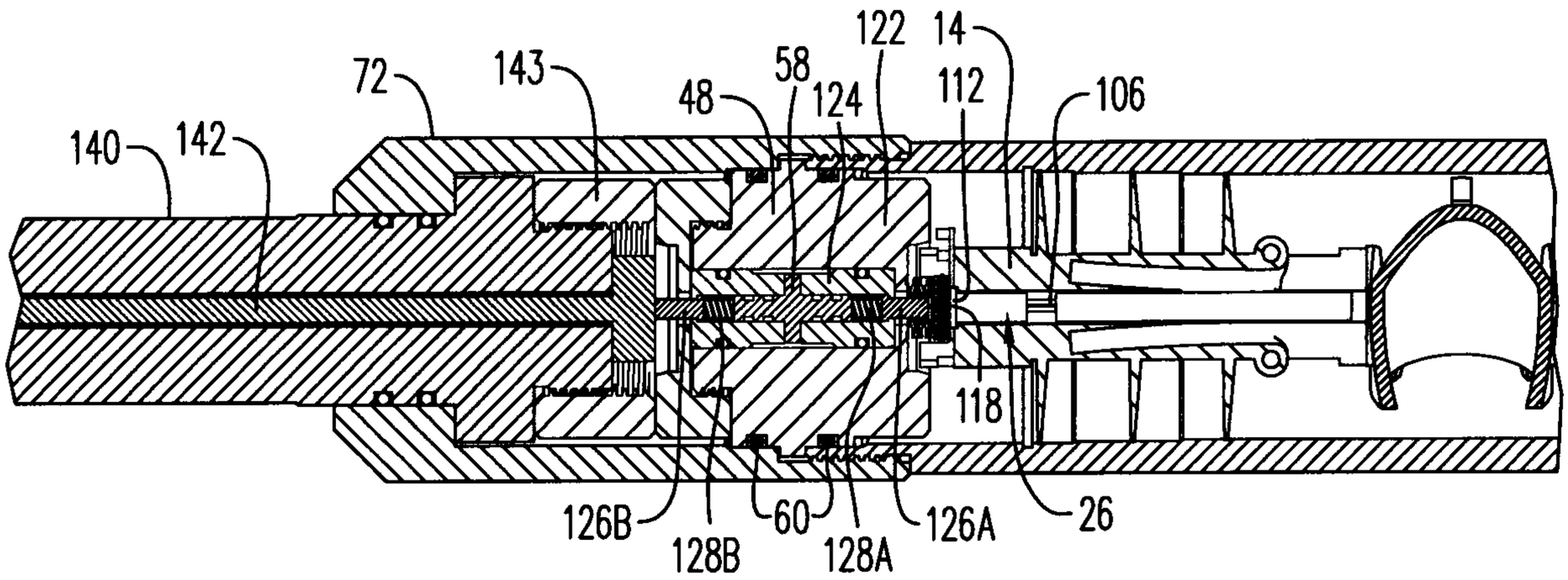
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FIG. 33

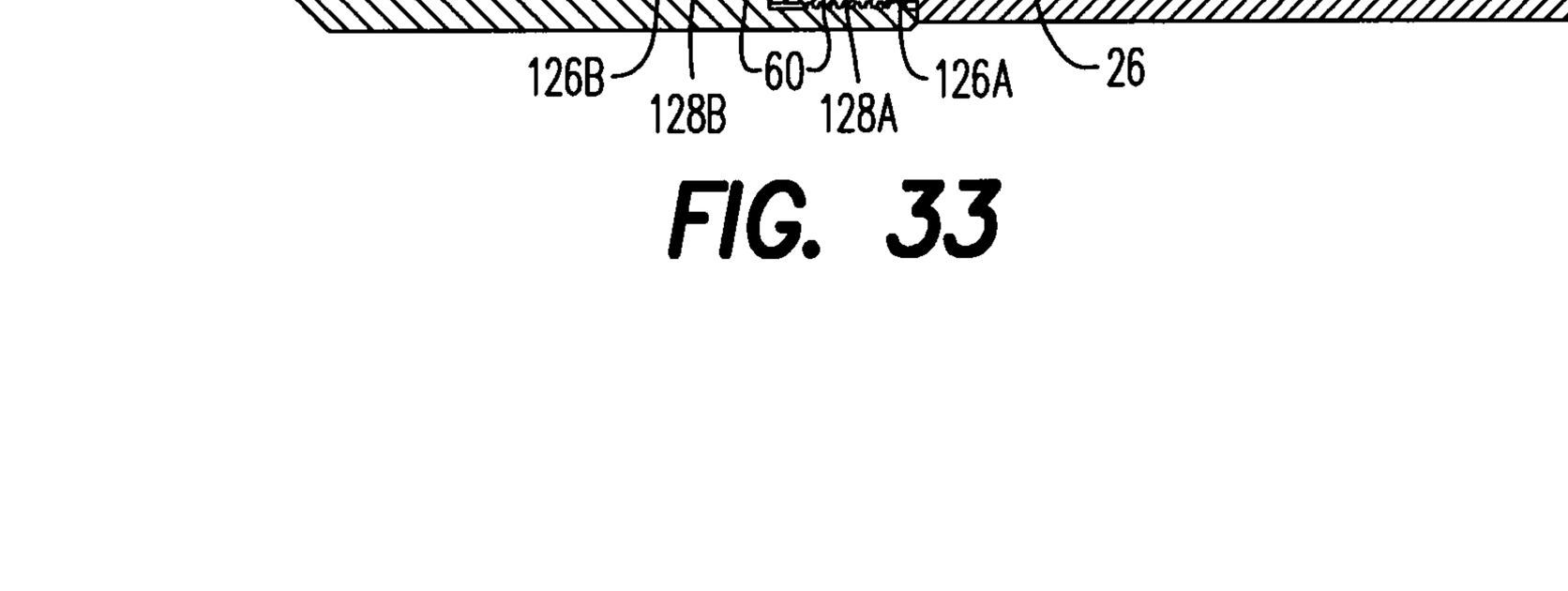
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FIG. 34

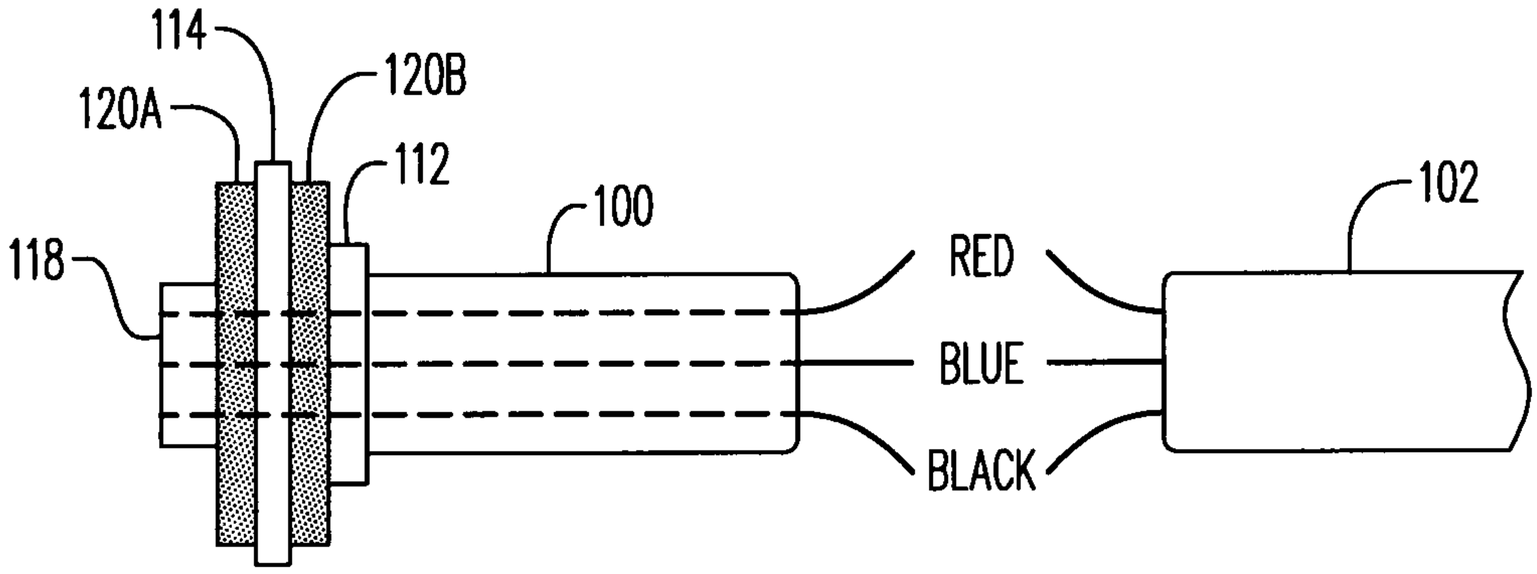

FIG. 35A

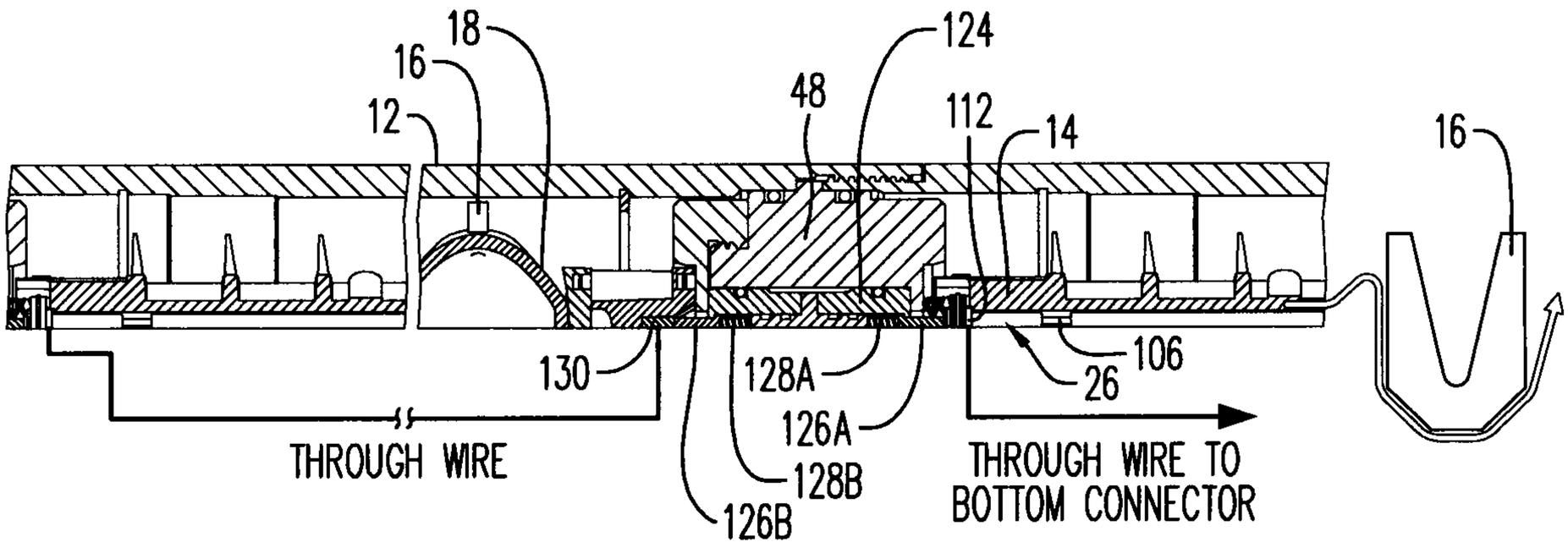

FIG. 35B