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Geissele

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(54) **FIREARM ASSEMBLIES WITH MULTIPLE GAS PORTS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(65) **Prior Publication Data**

US 2022/0113100 A1 Apr. 14, 2022

(51) **Int. Cl.**
F41A 5/26 (2006.01)

(52) **U.S. Cl.**
CPC *F41A 5/26* (2013.01)

(58) **Field of Classification Search**
CPC F41A 5/18; F41A 5/20; F41A 5/26; F41A 5/28
USPC 89/191.01–193
See application file for complete search history.

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Primary Examiner — Jonathan C Weber
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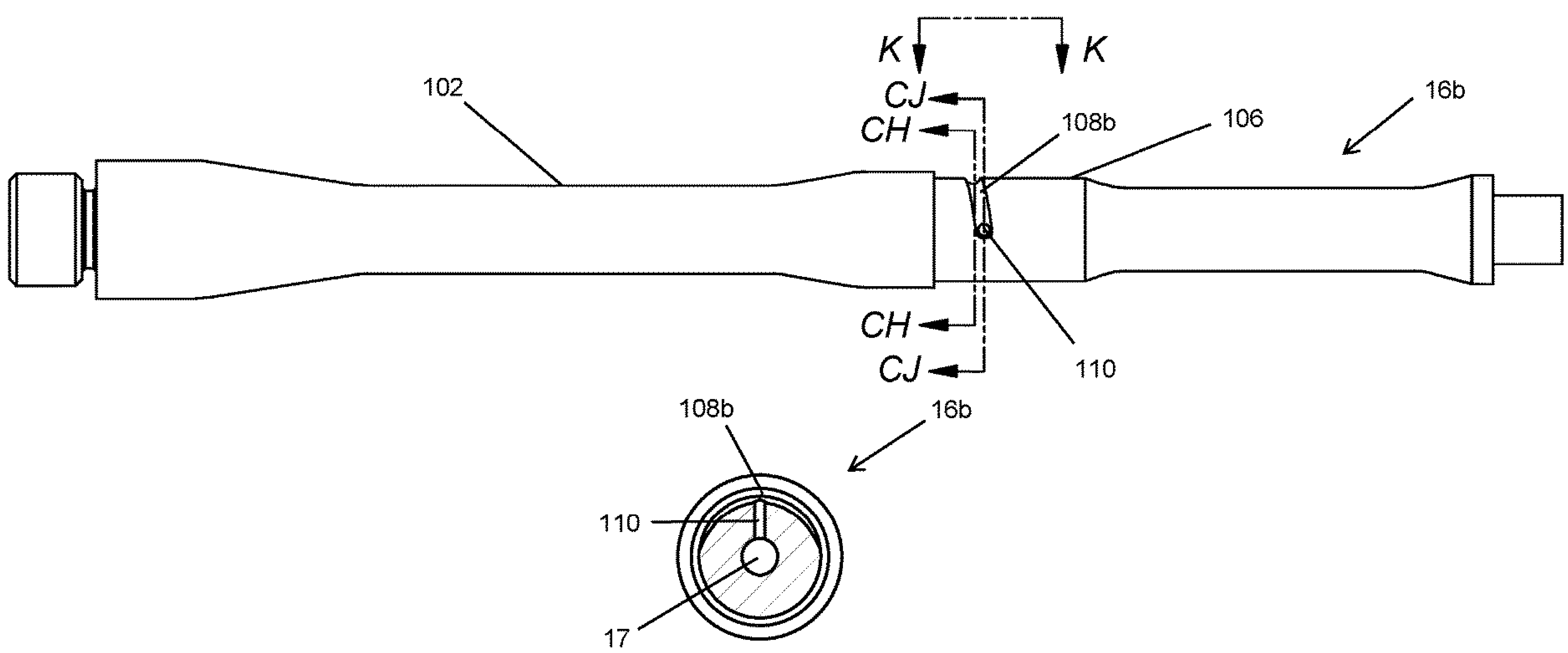
(57) **ABSTRACT**

An assembly for directing propellant gas to an action of a firearm includes a barrel and a gas block. The barrel has a plurality of gas ports that communicate with the bore of the barrel. The barrel and the gas block define a passage that receives pressurized propellant gas from the bore by way of the barrel gas ports, and directs the propellant gas to a gas port of the gas block. The plurality of barrel gas ports and the passage act as a manifold in which the propellant gas is taken from multiple locations within the barrel, combined into a single flow, and directed into the gas block via the gas block gas port. The pressurized gas is then routed to an action of the firearm by way of a gas tube and a gas key.

21 Claims, 17 Drawing Sheets



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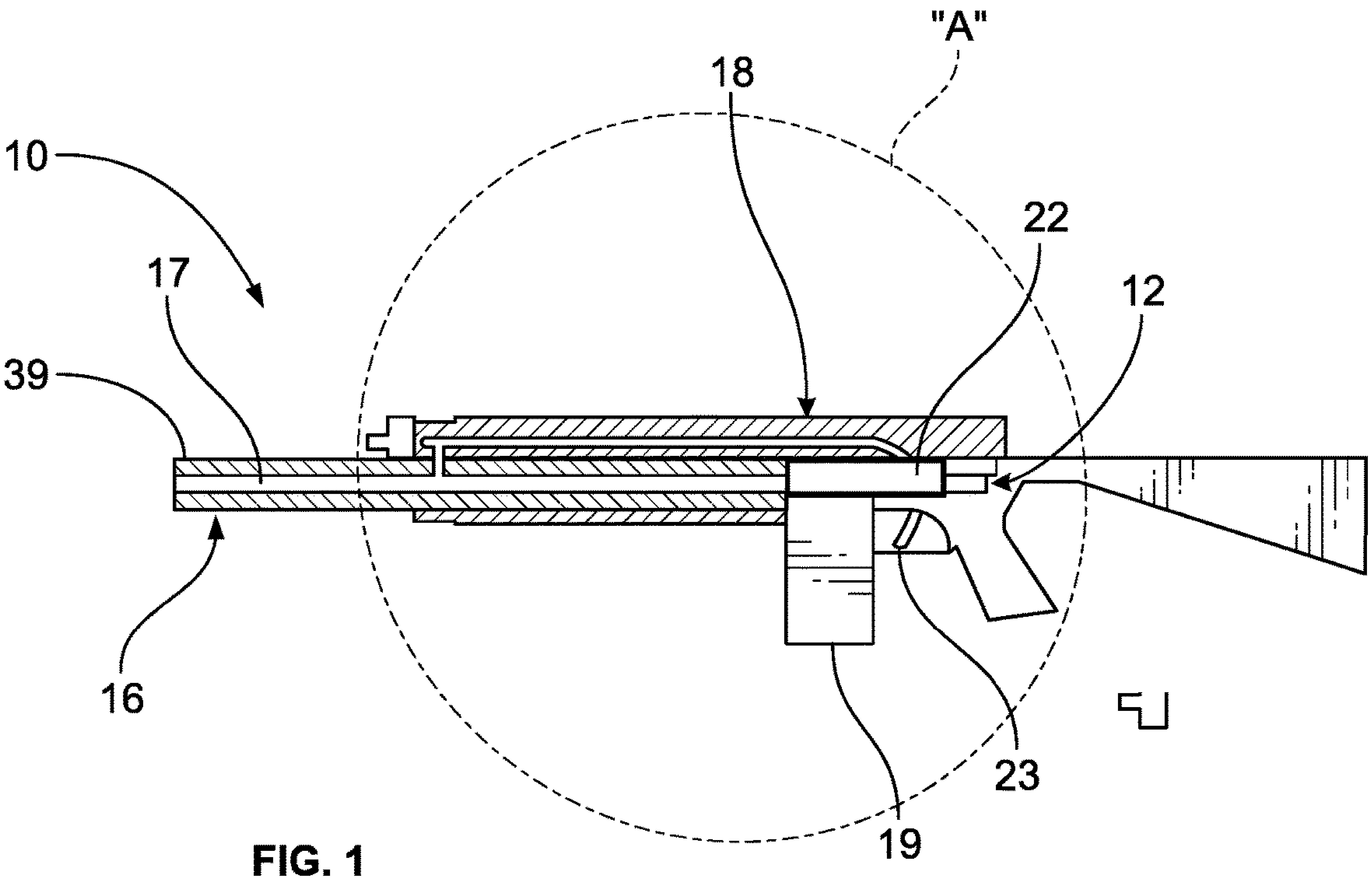

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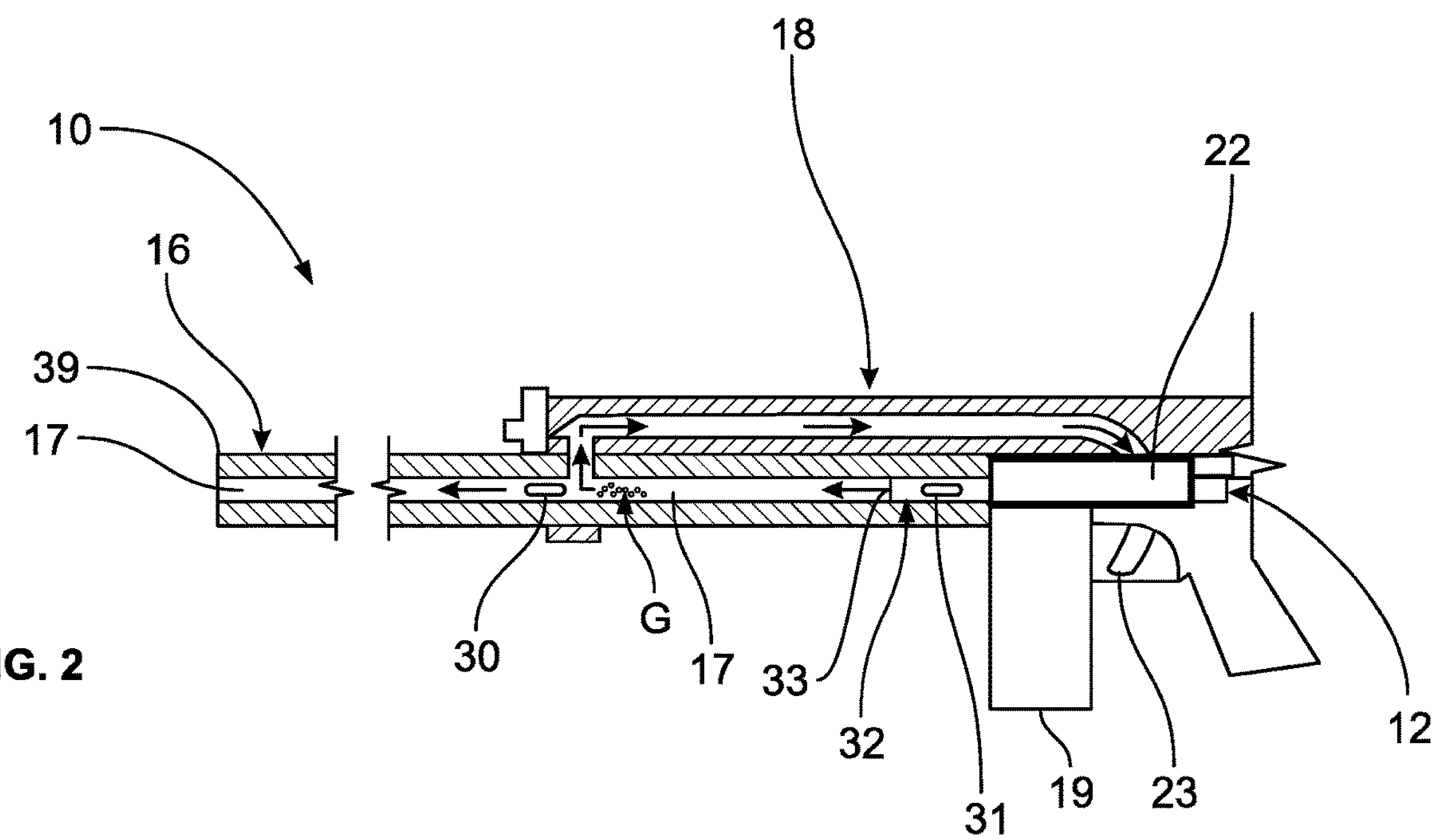

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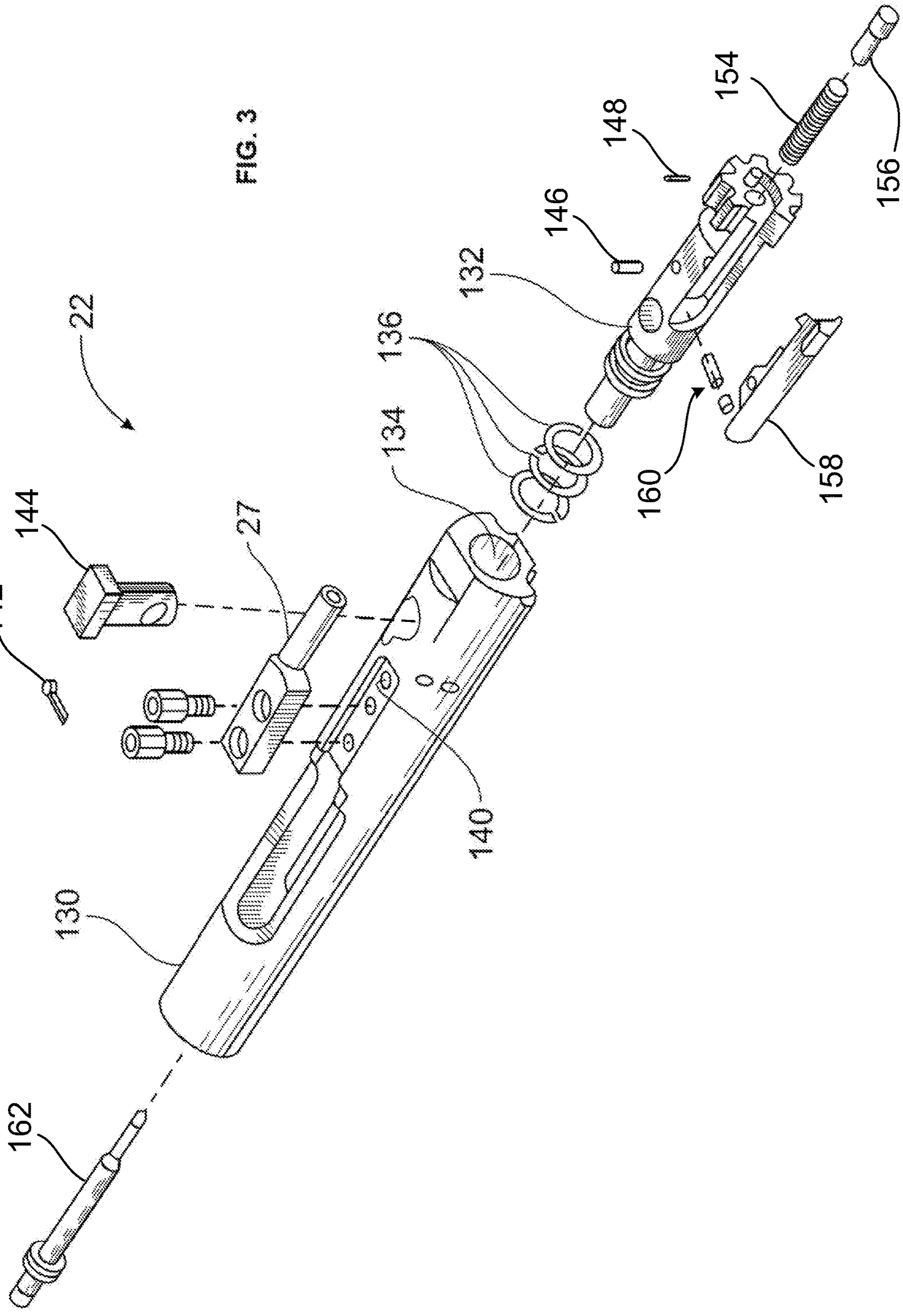

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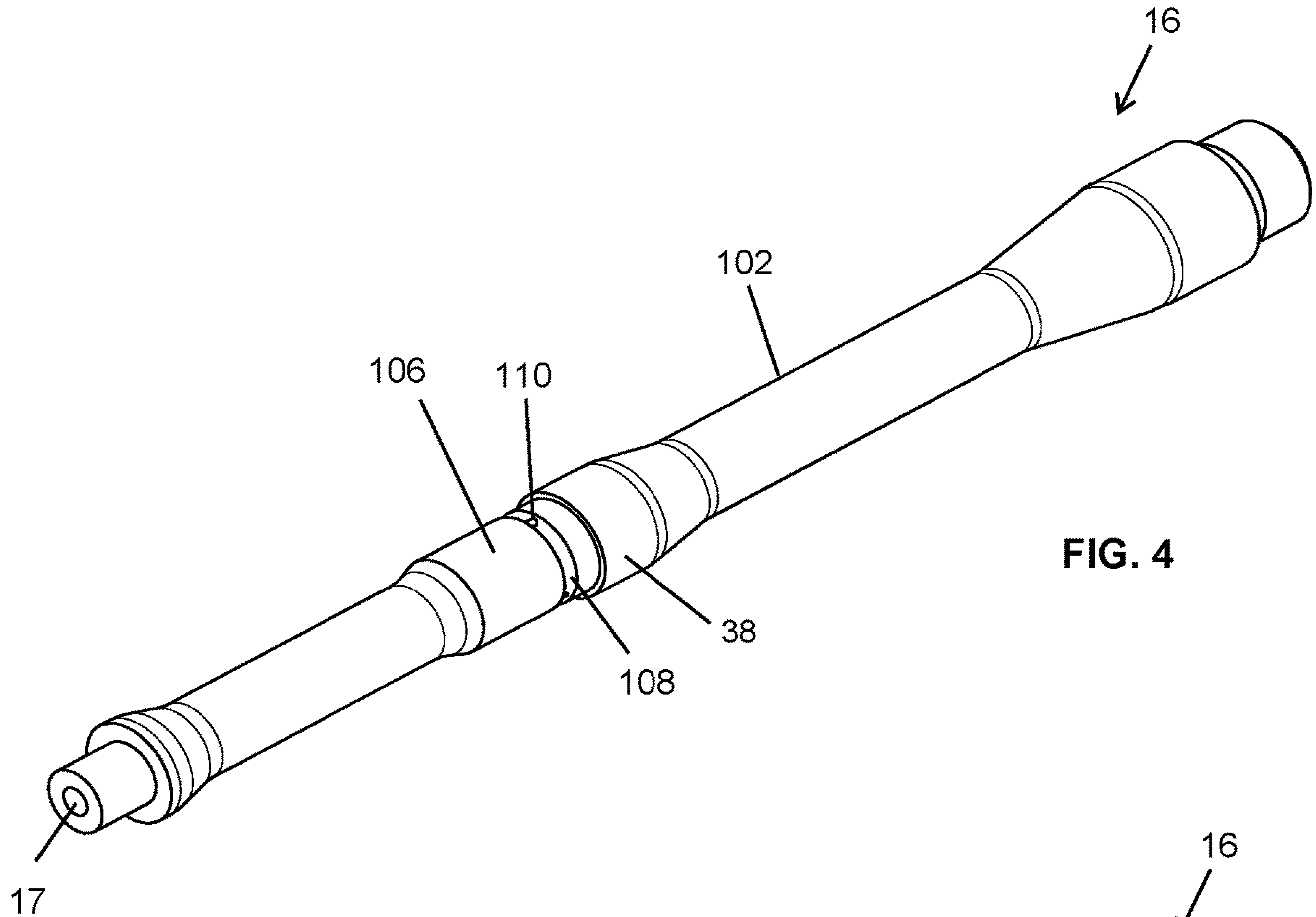

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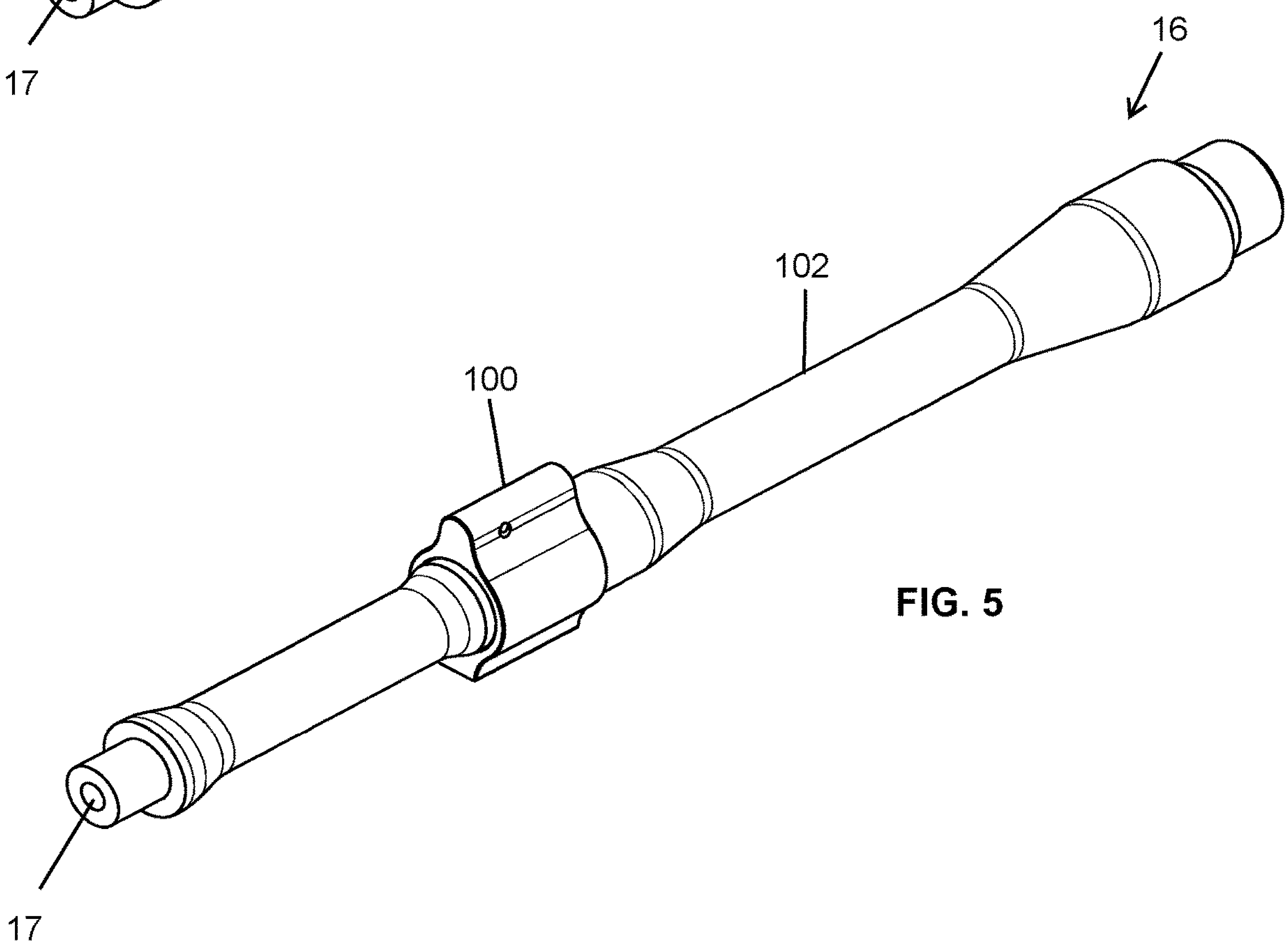

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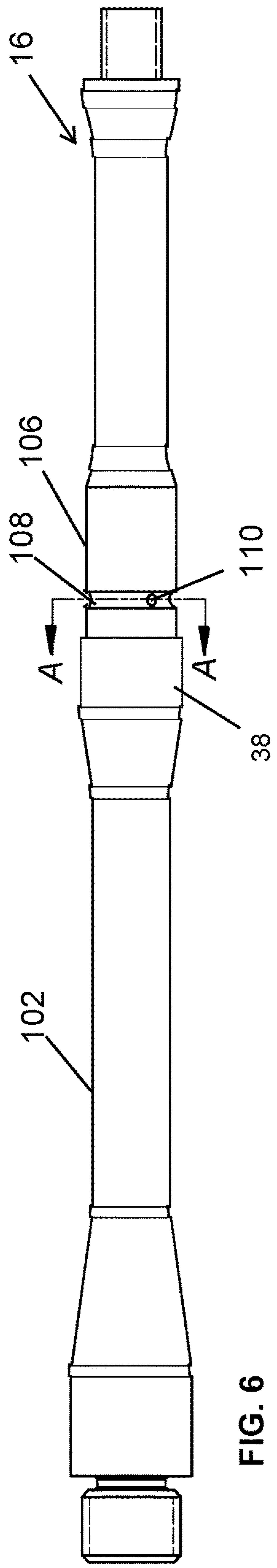

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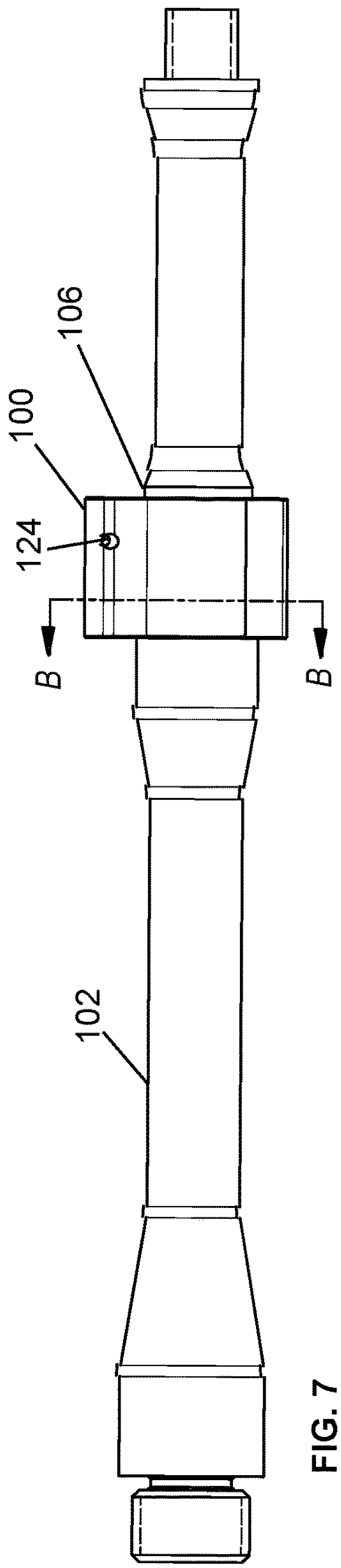

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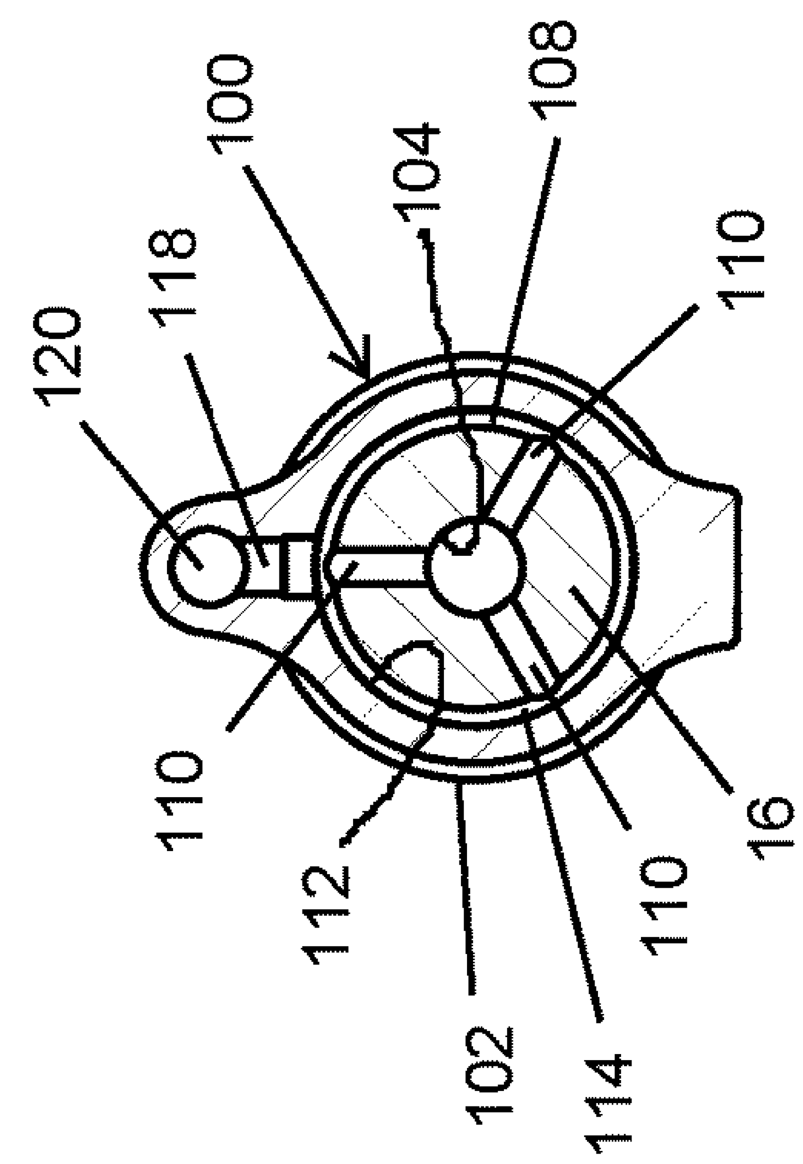

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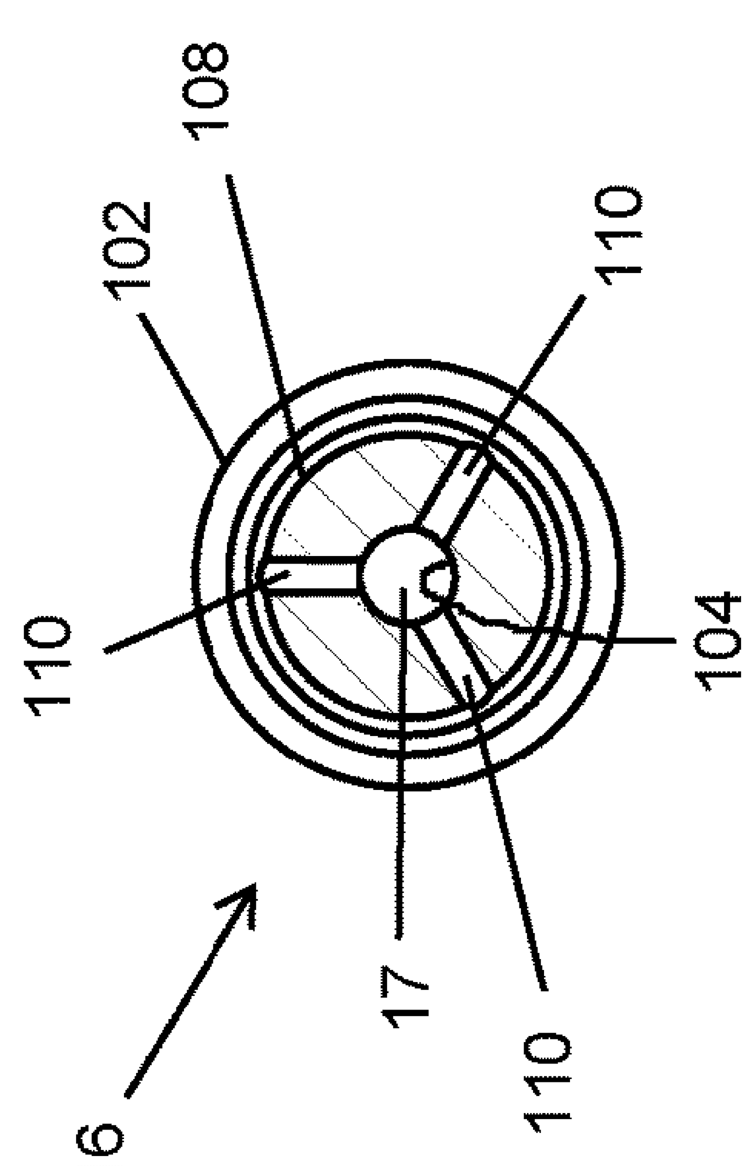

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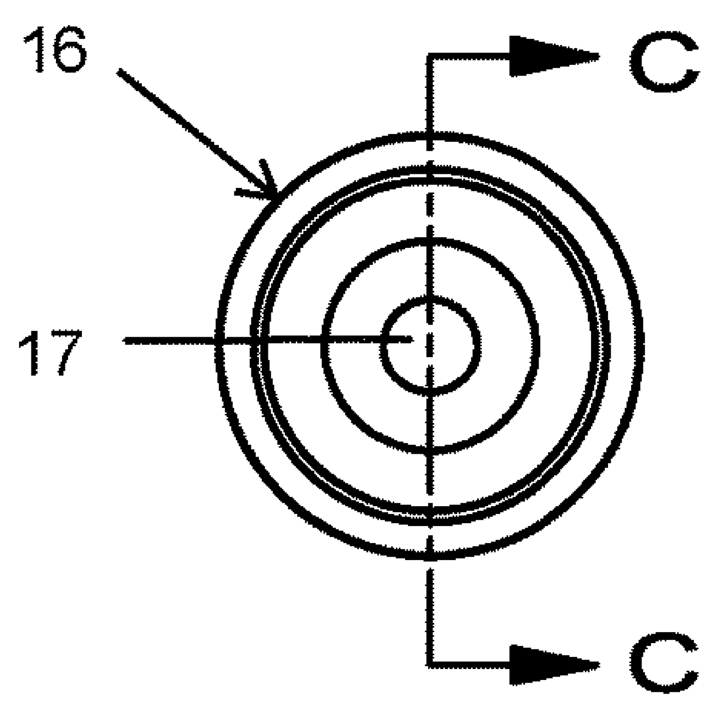

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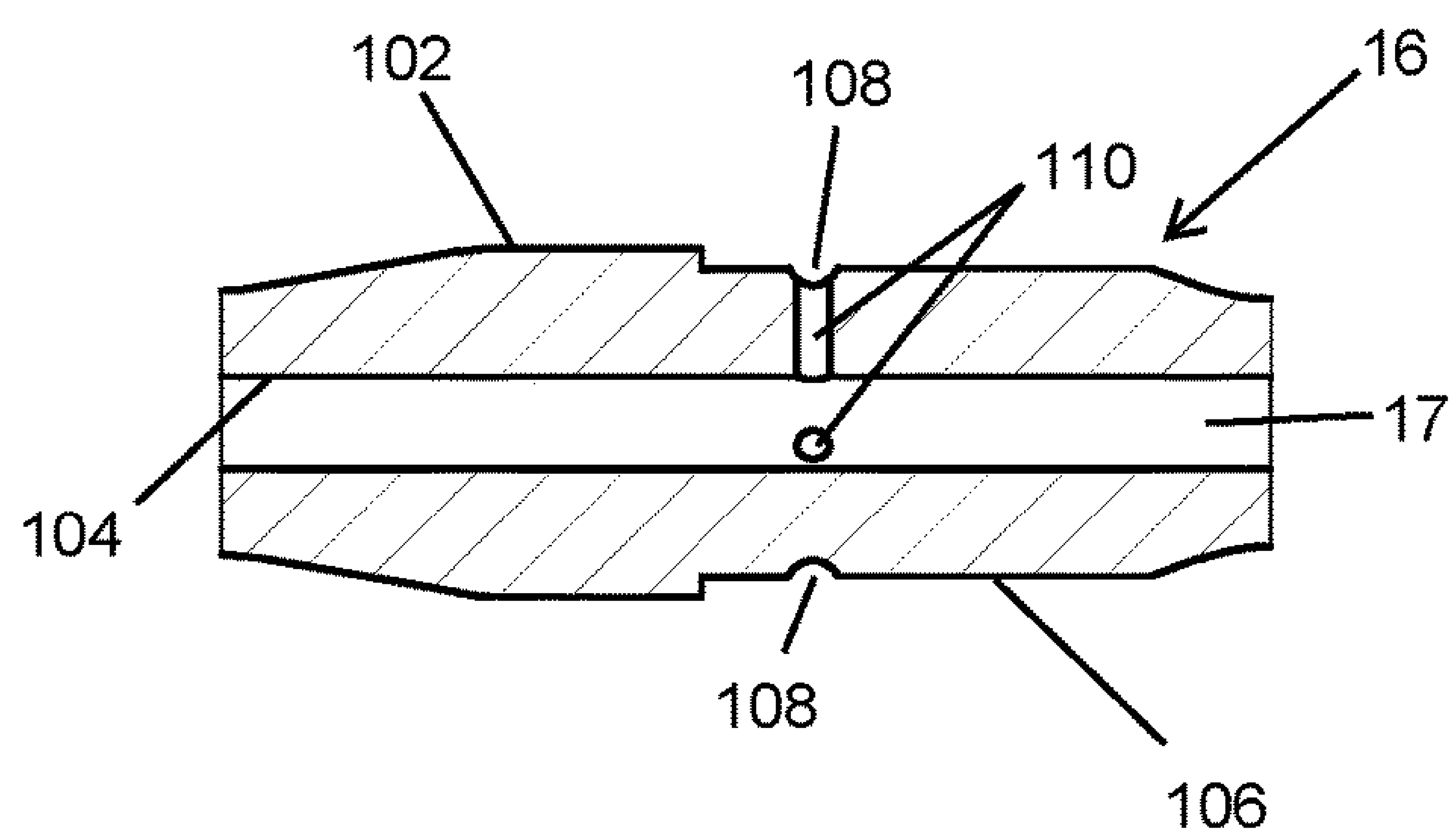

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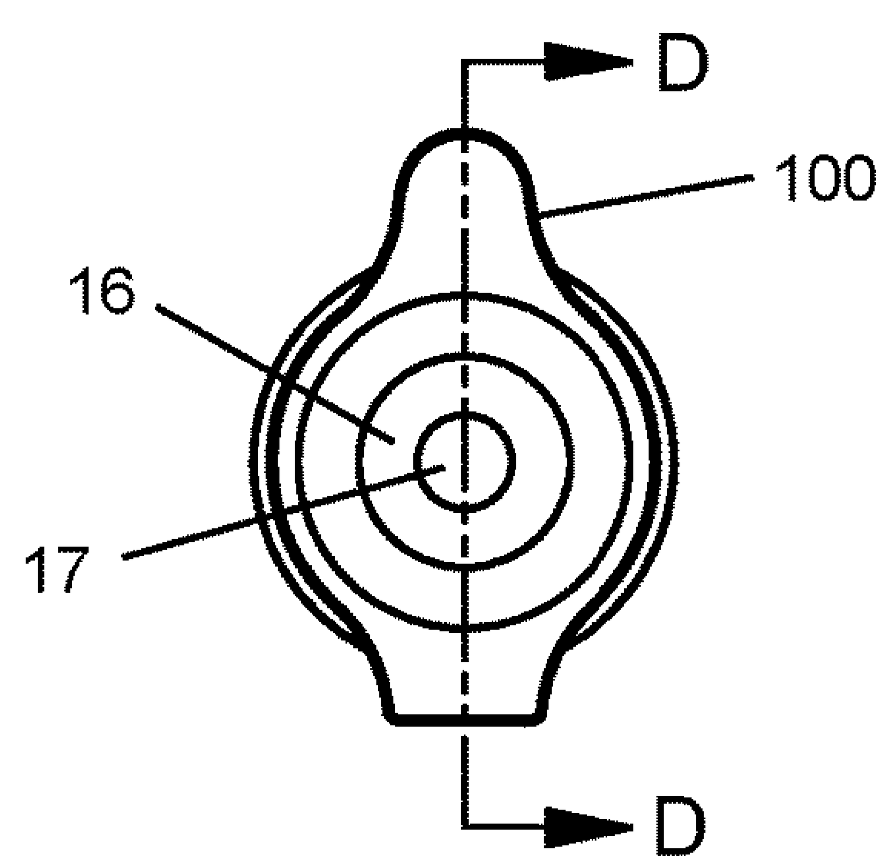

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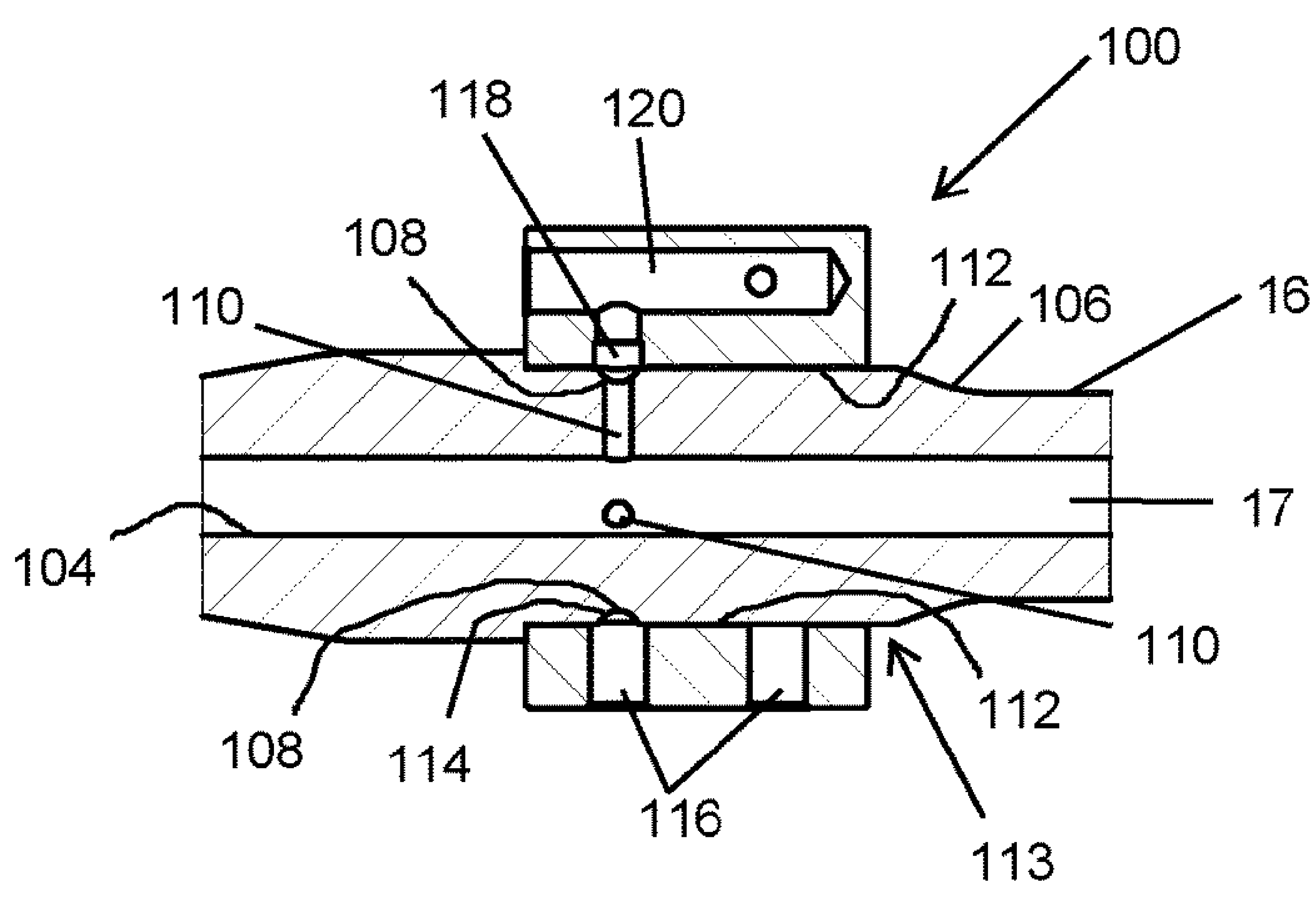

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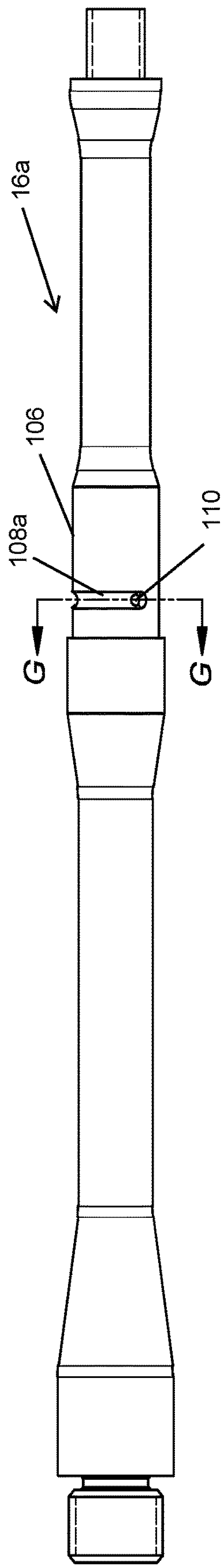

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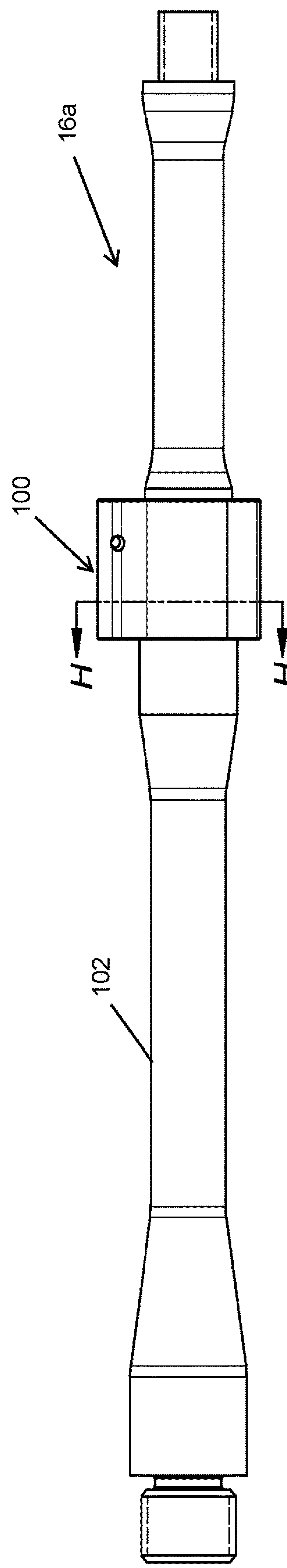

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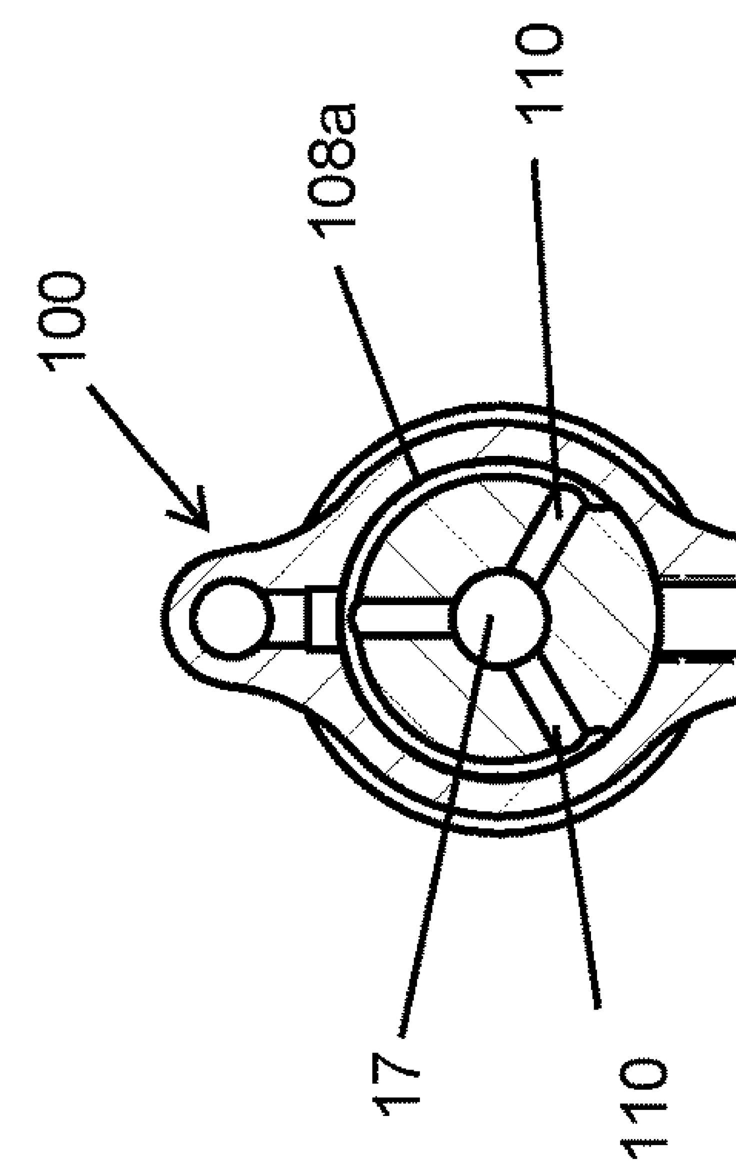

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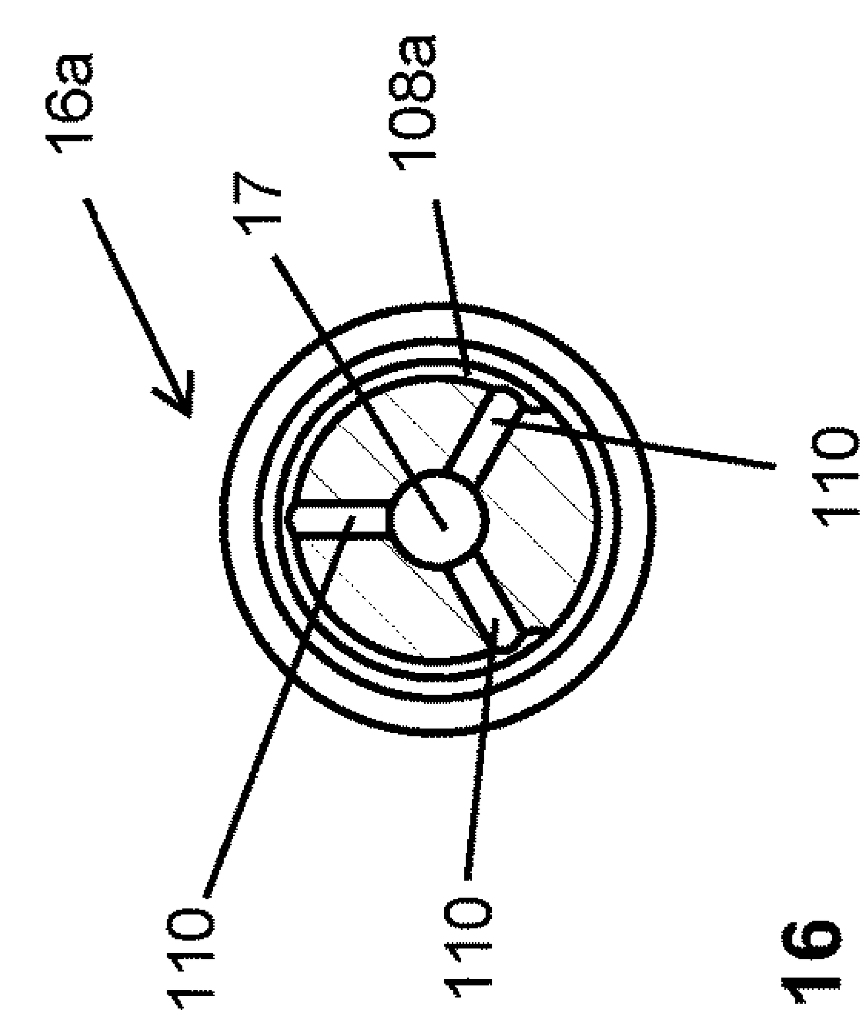

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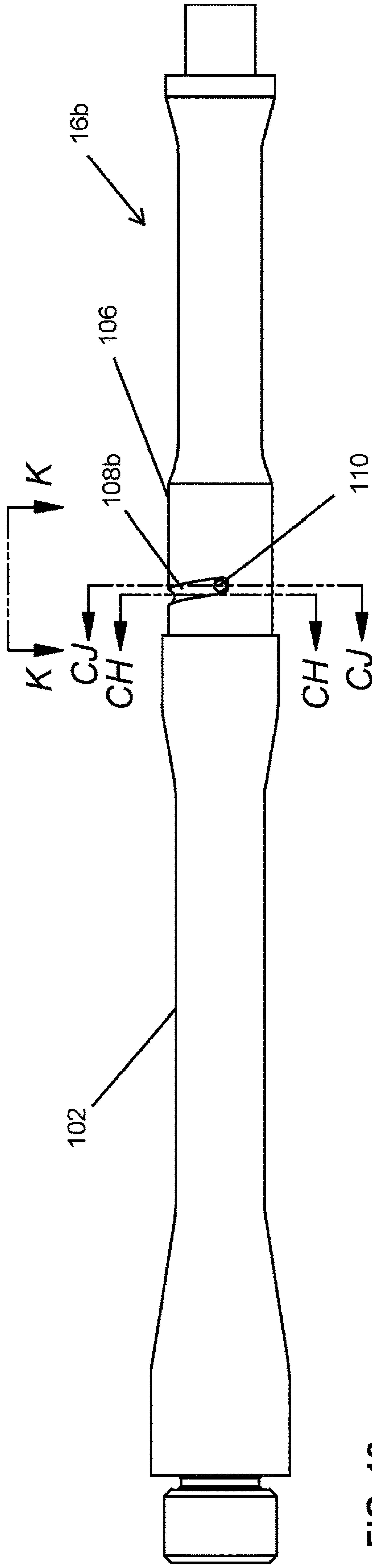

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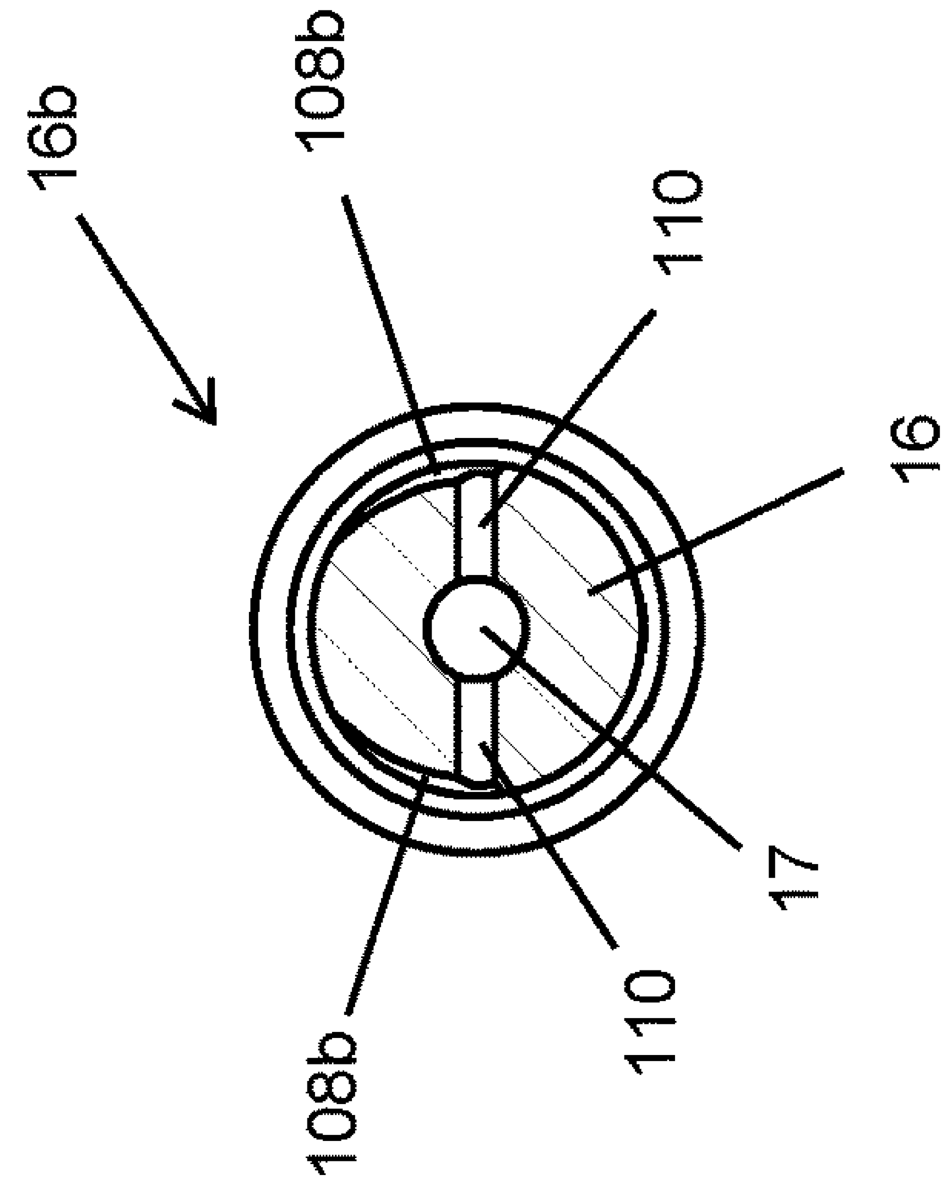

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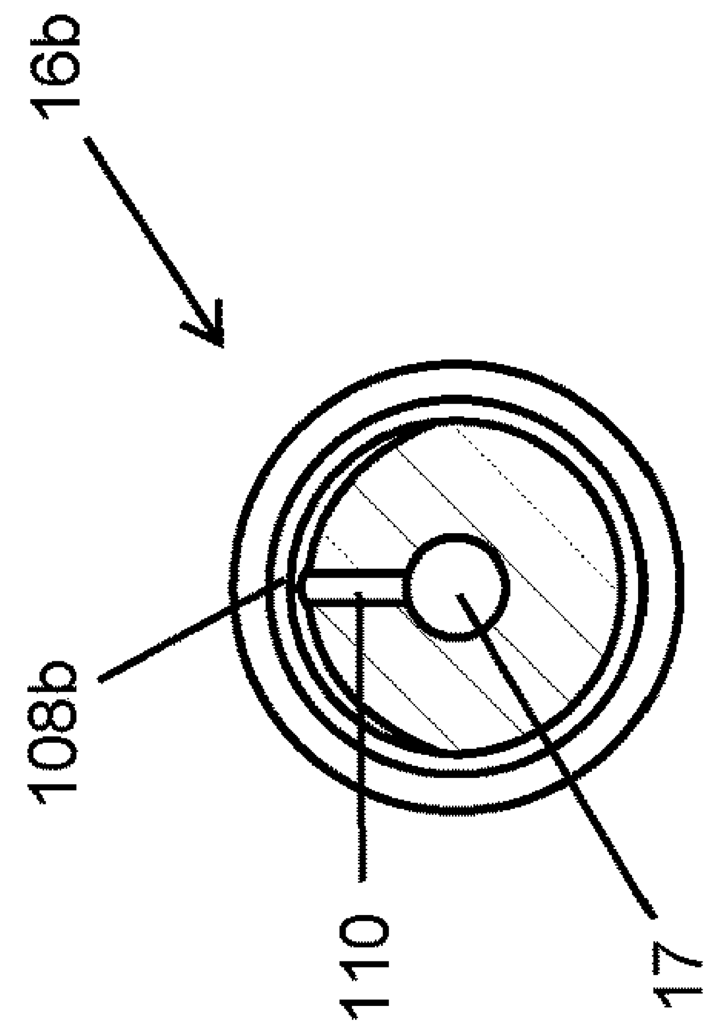

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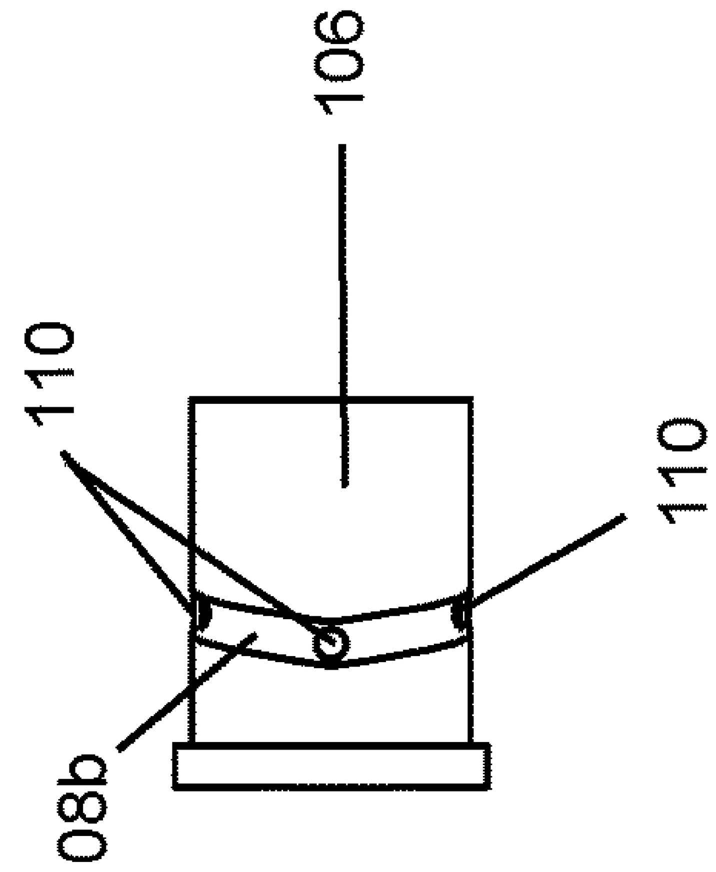

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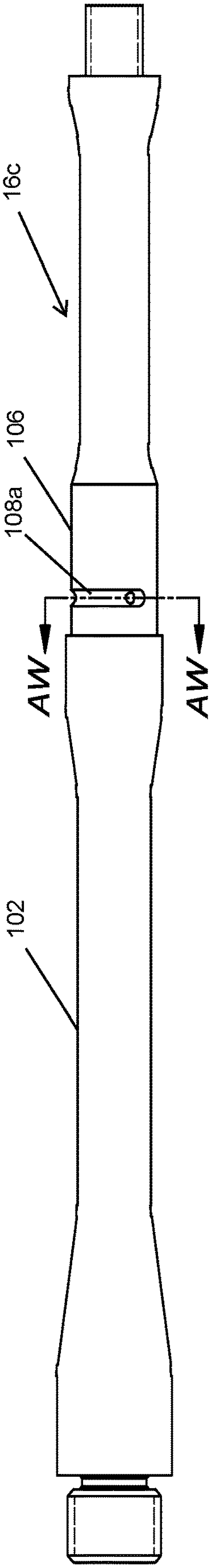

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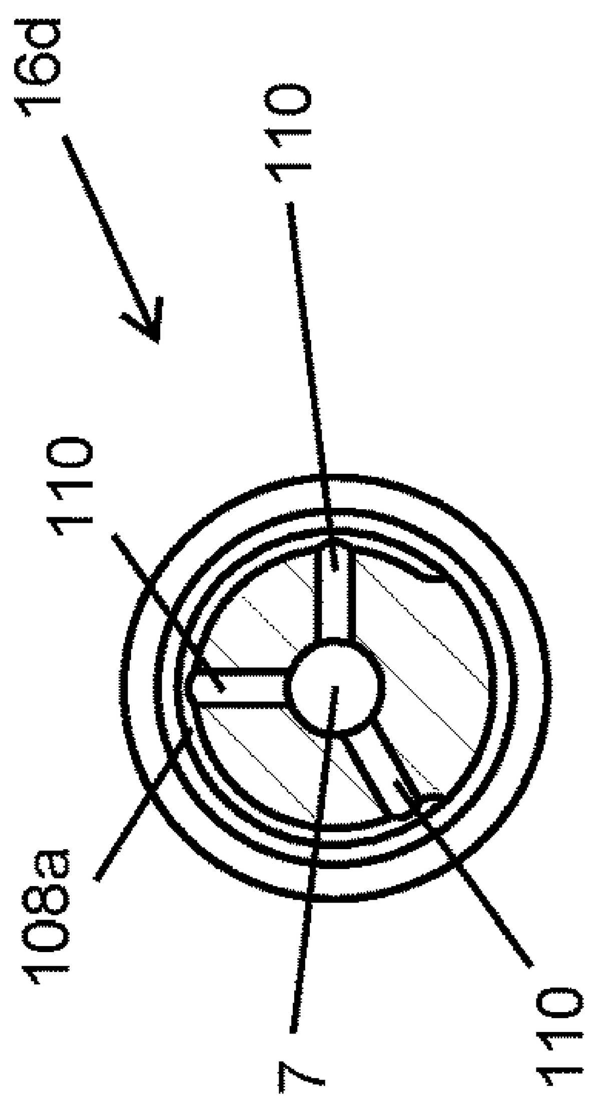

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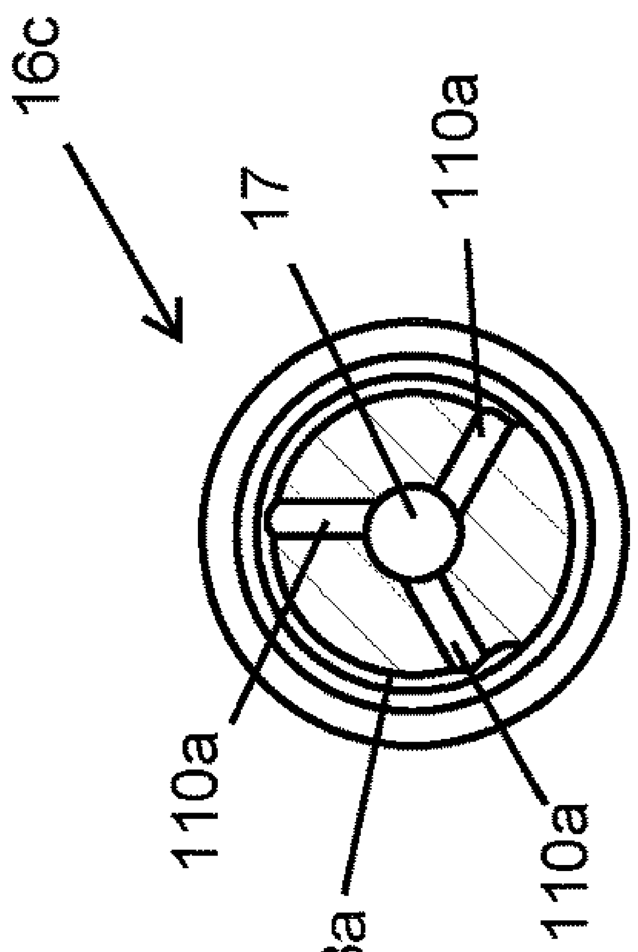

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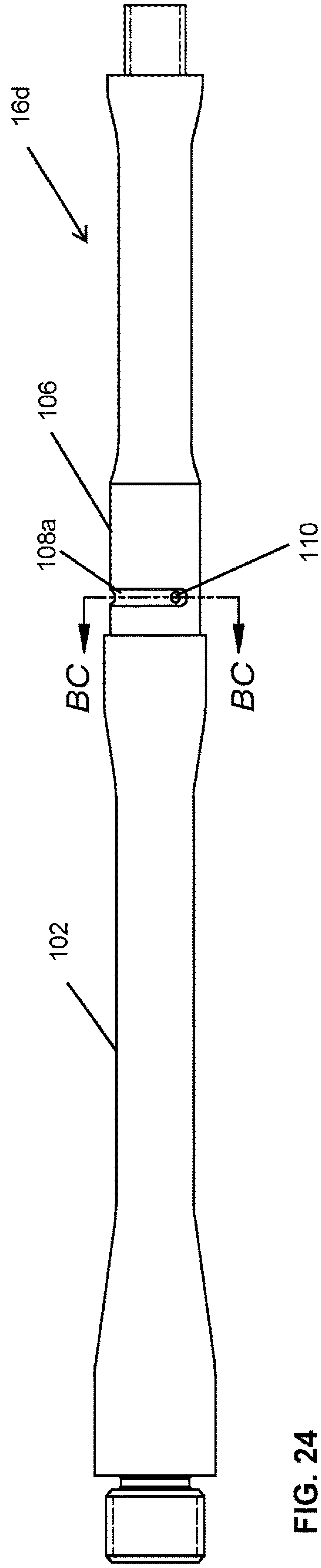

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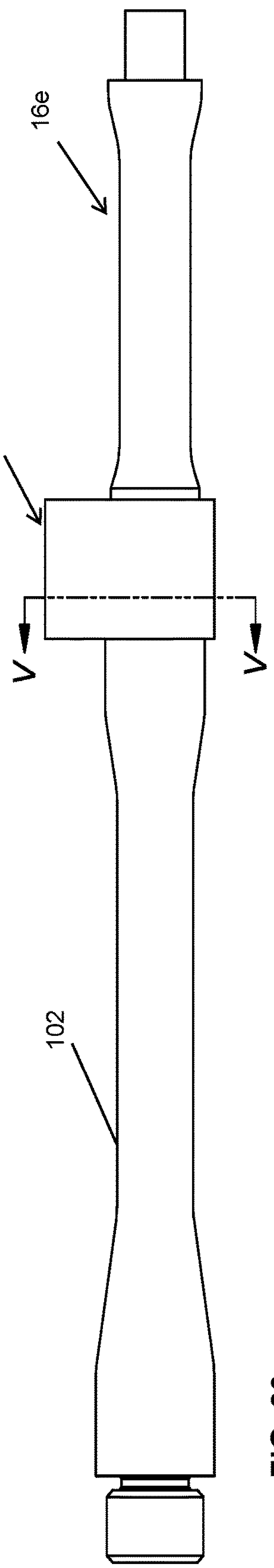

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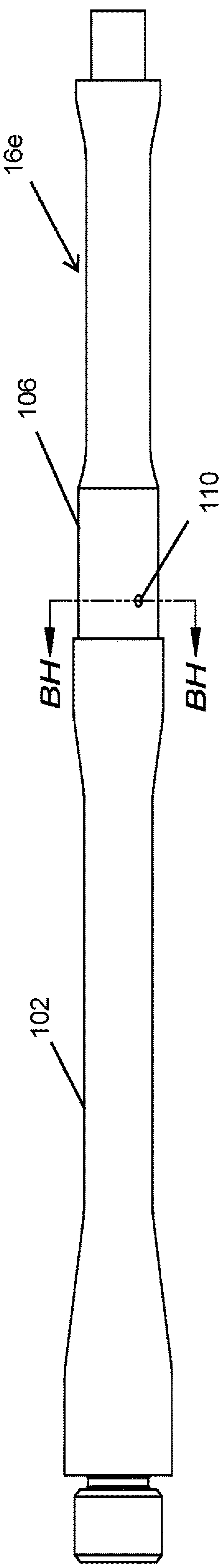

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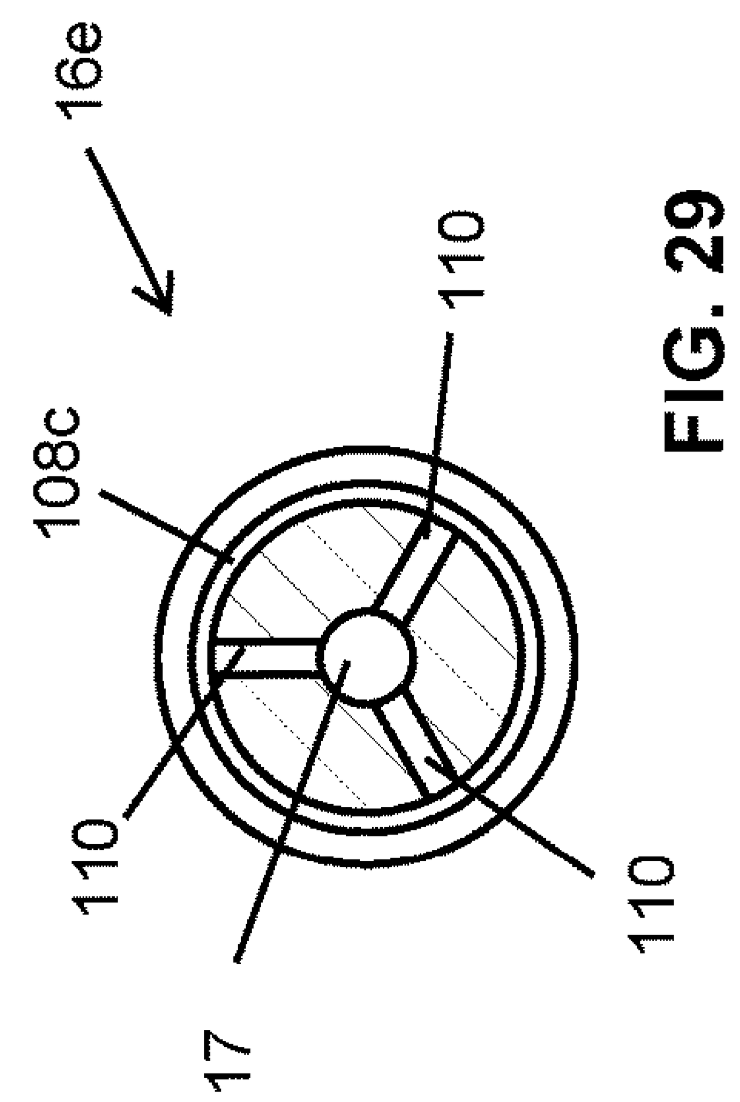

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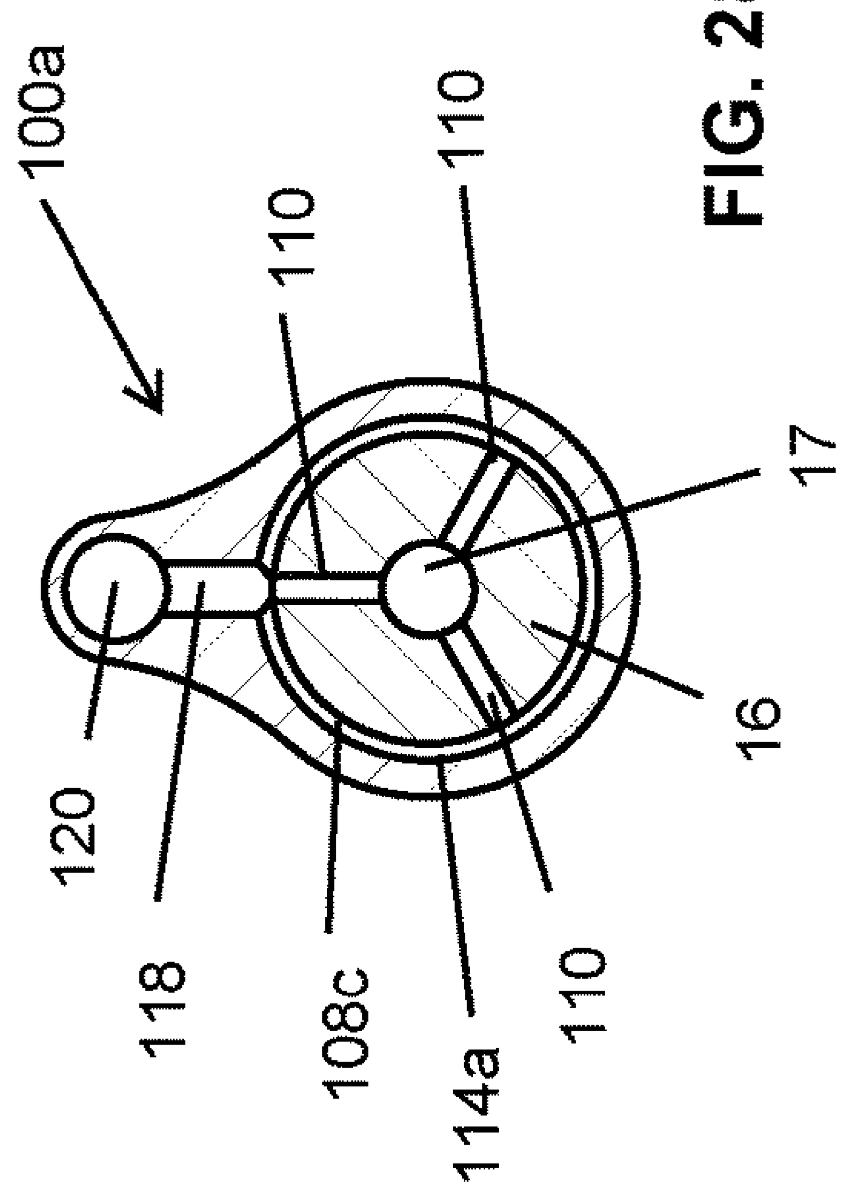

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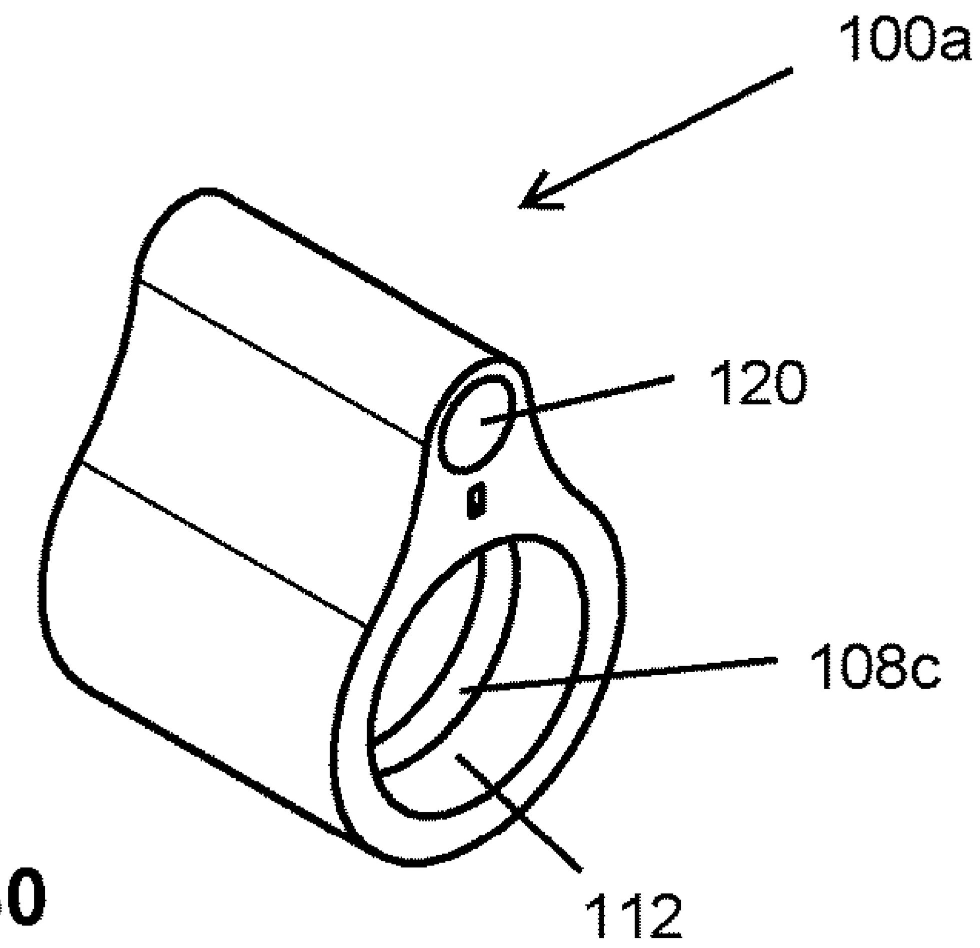

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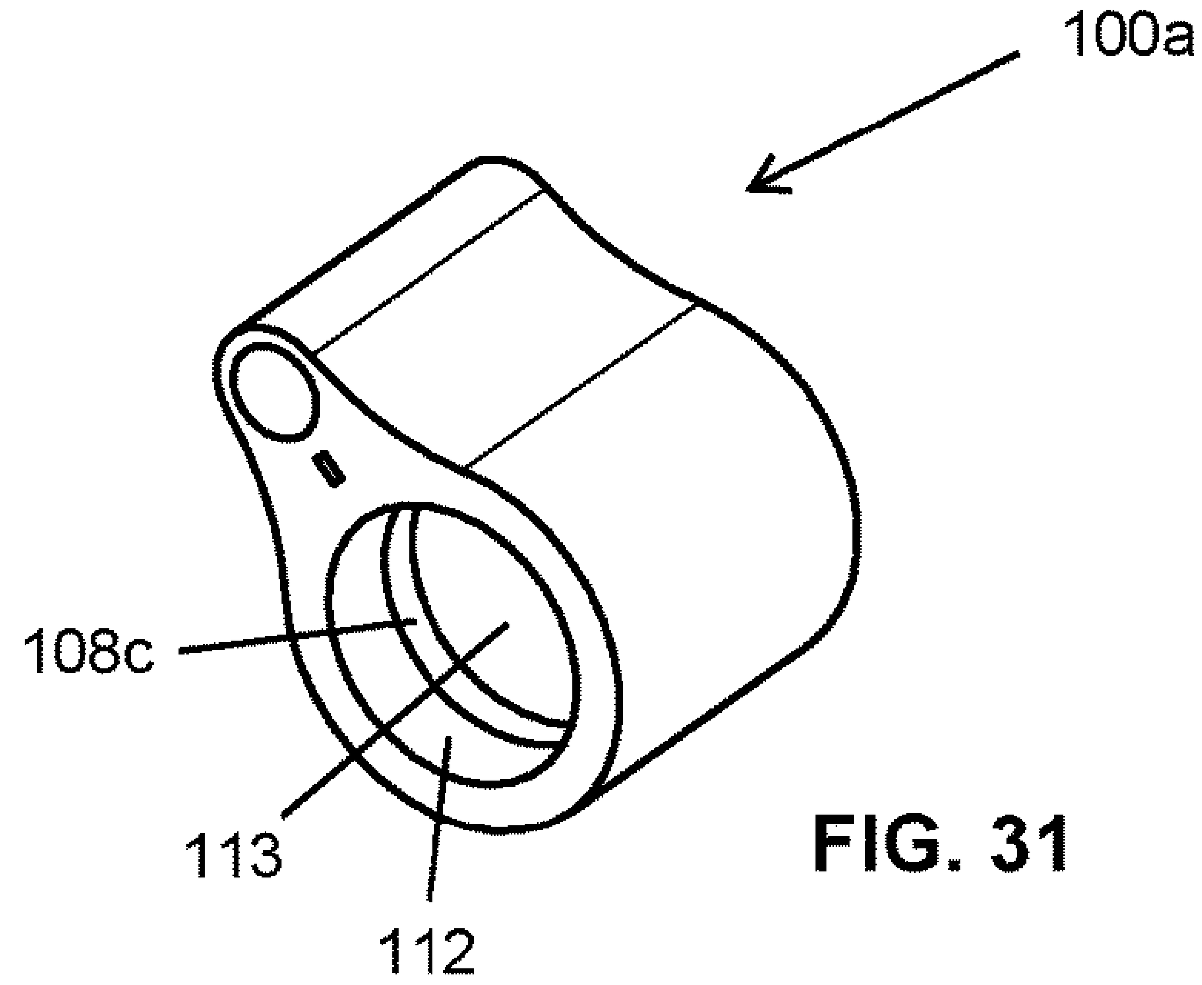

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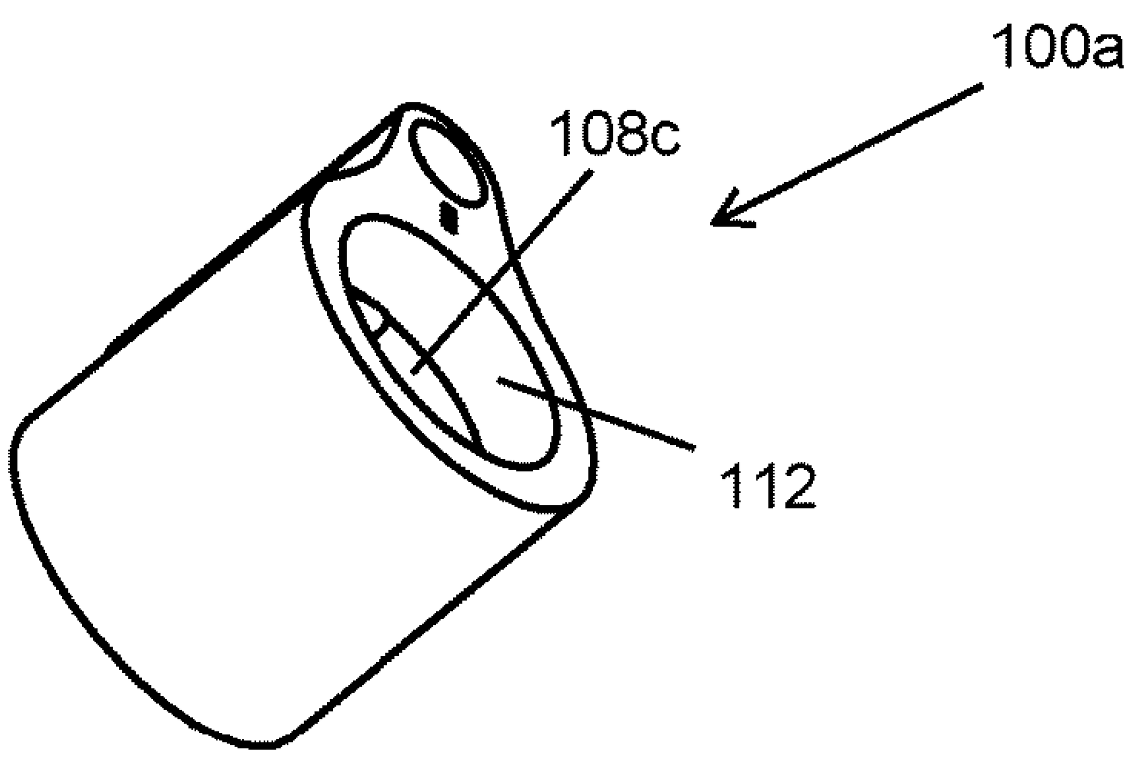

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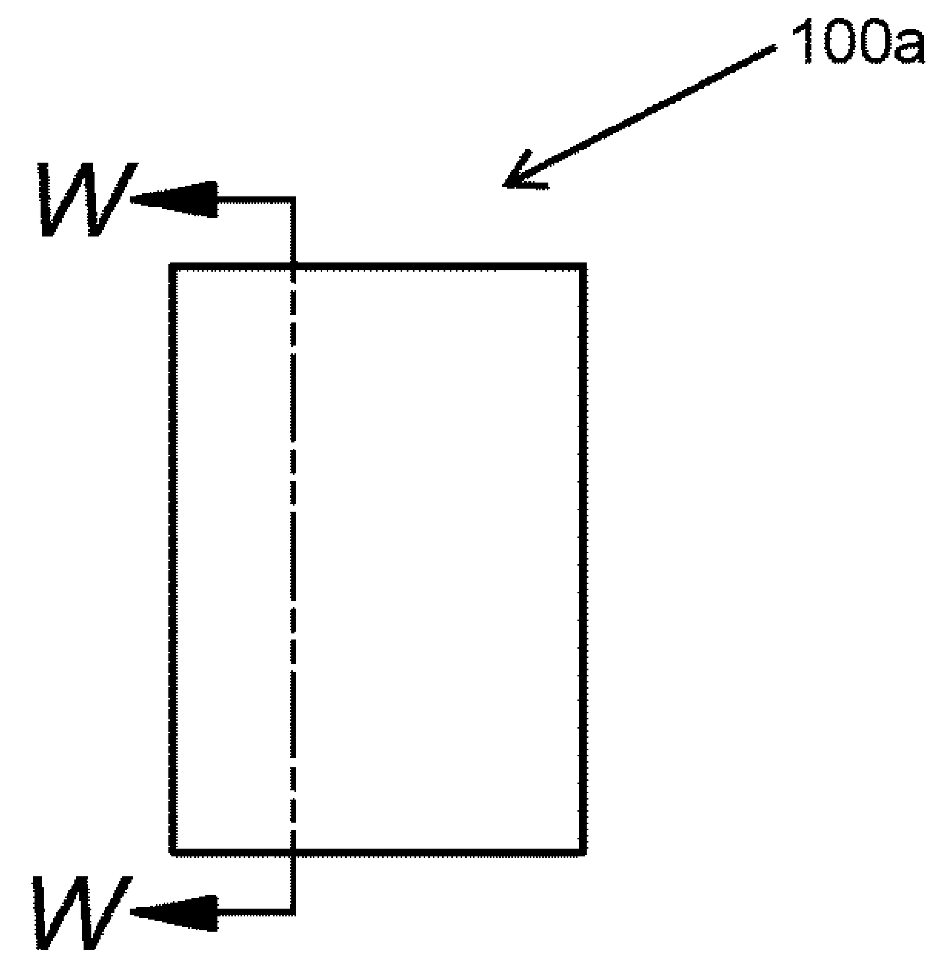

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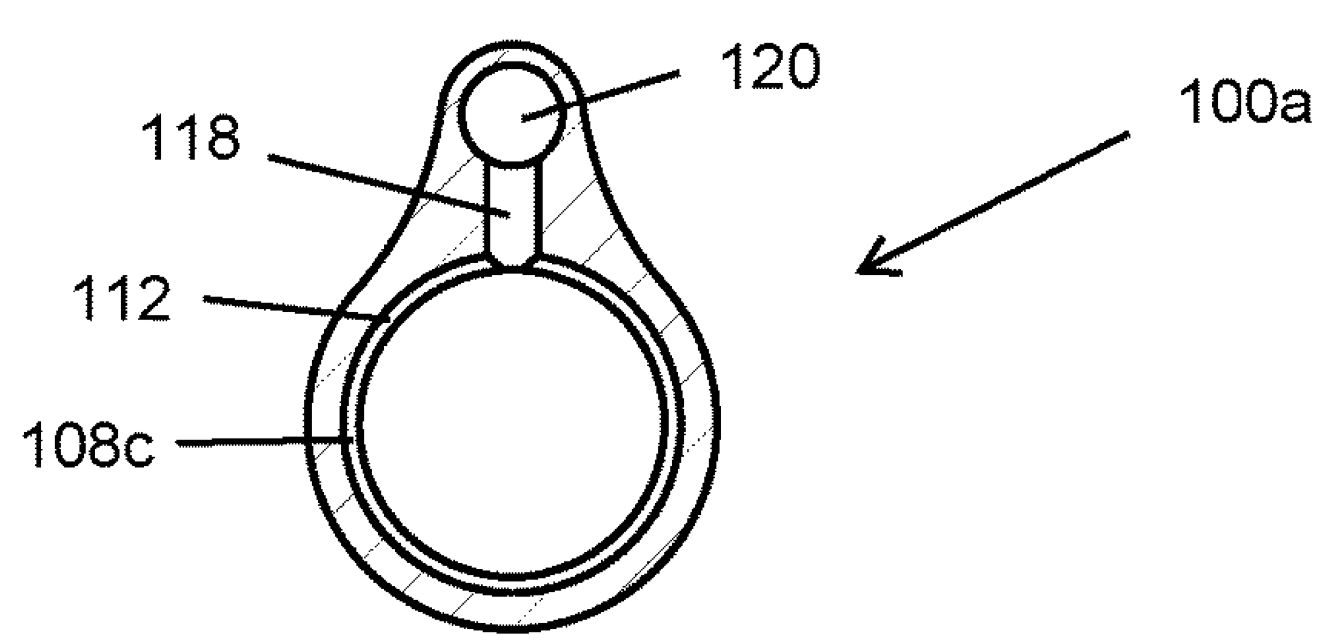

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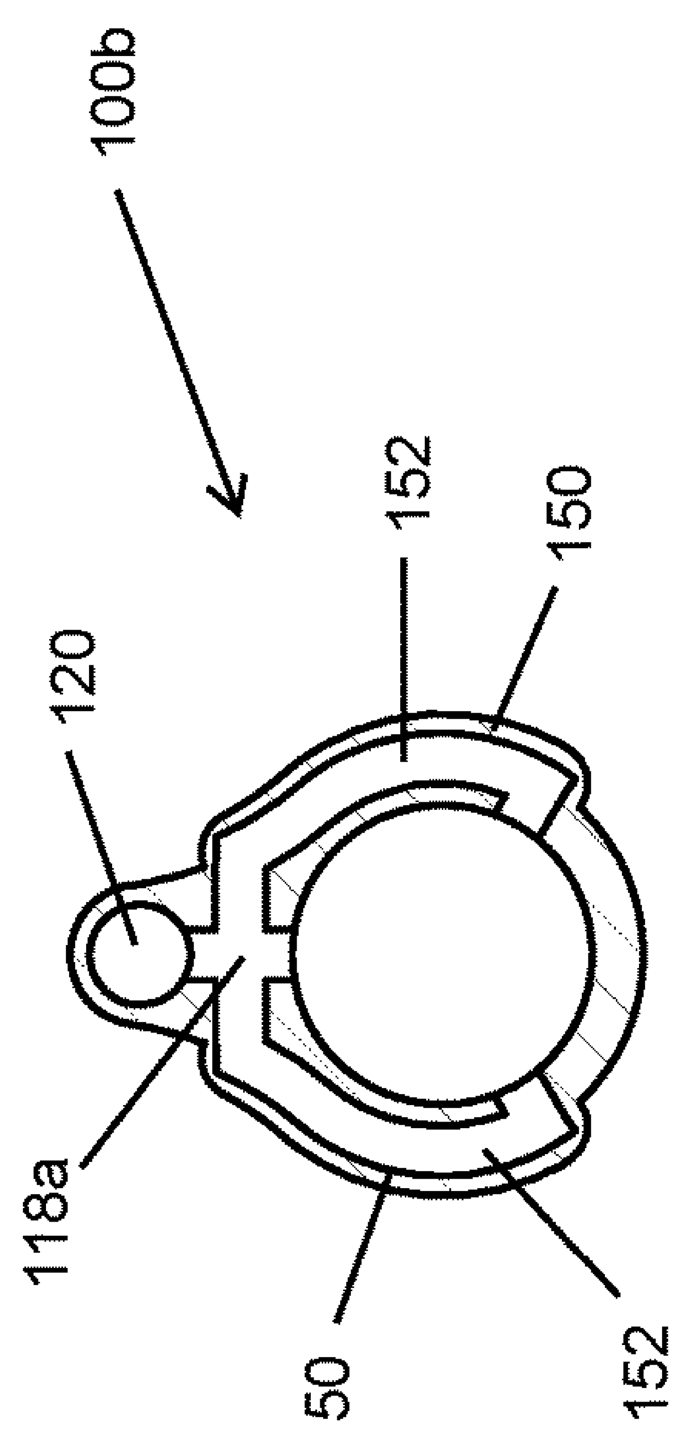

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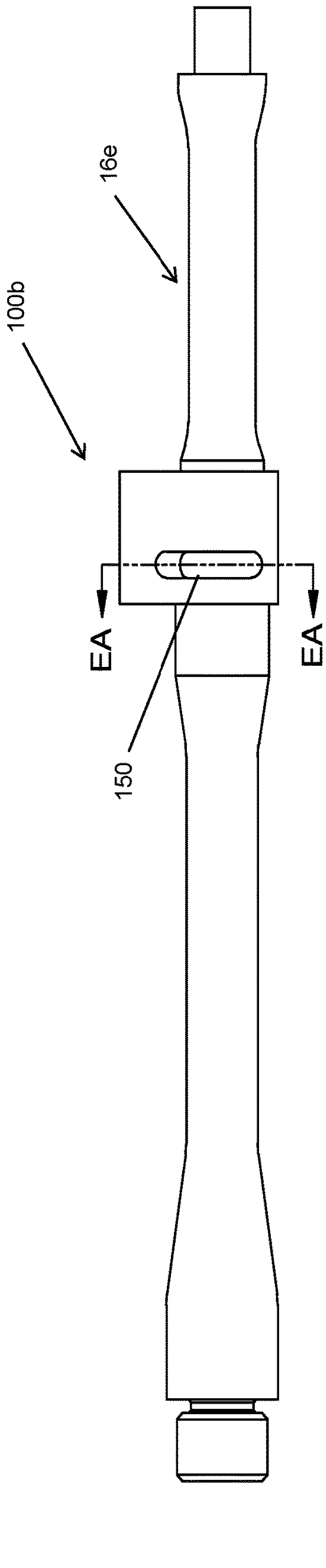

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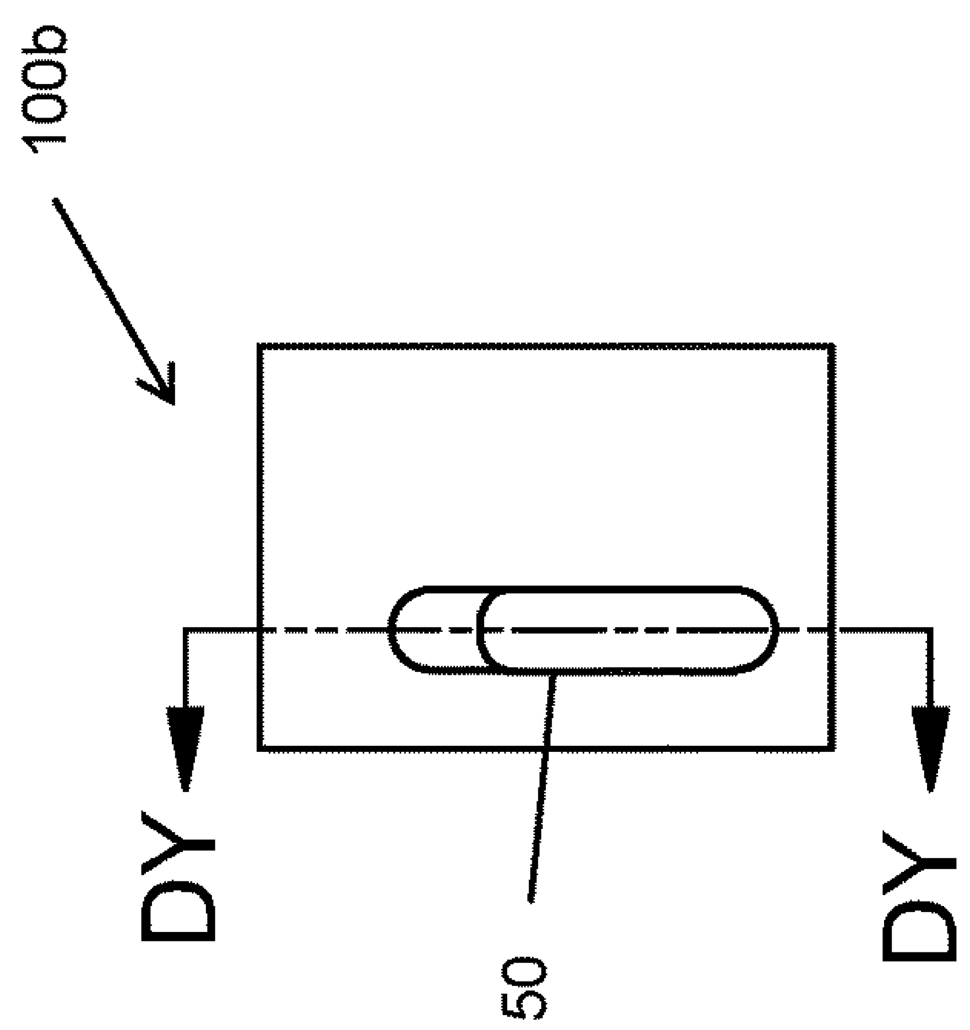

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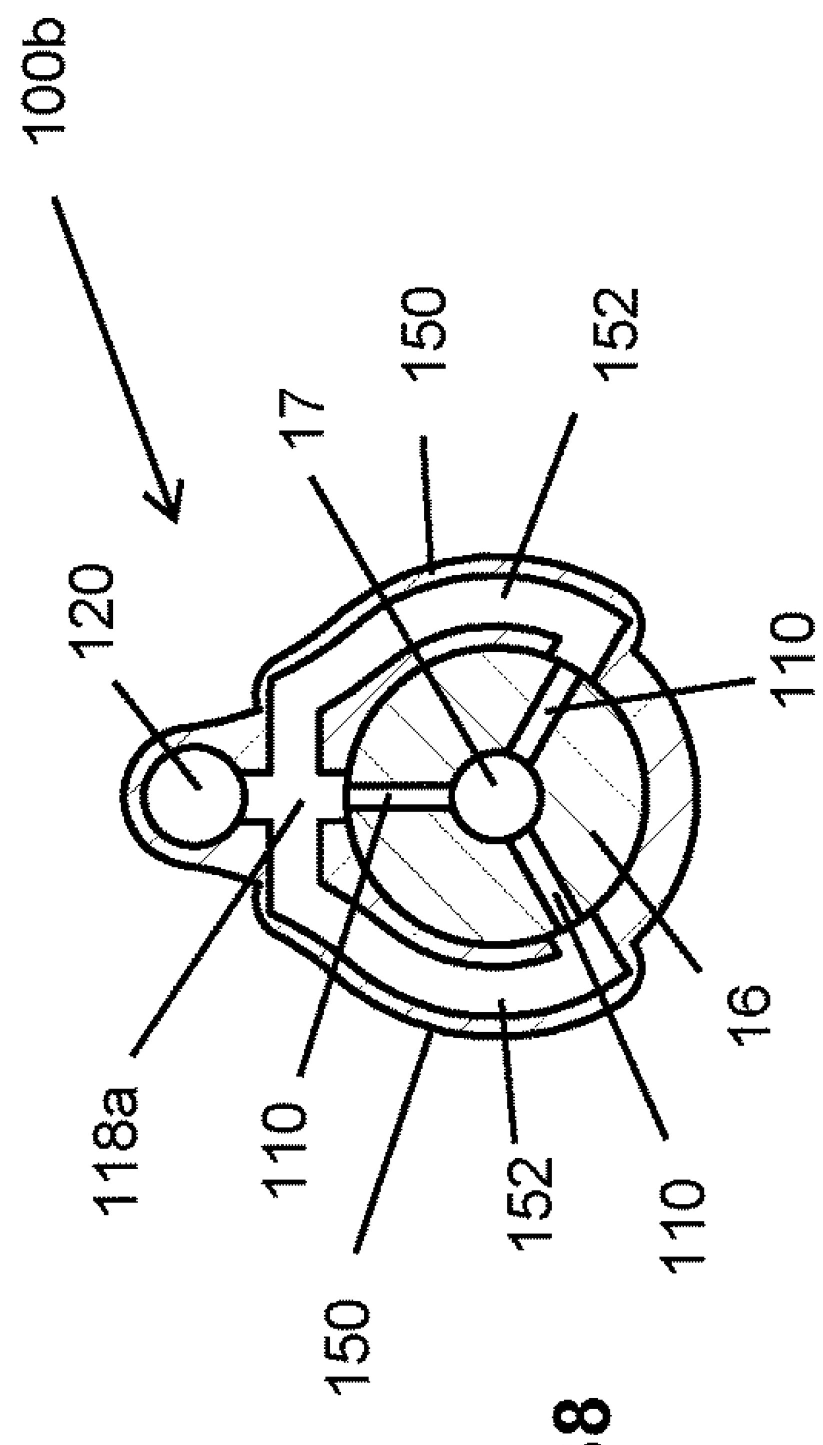

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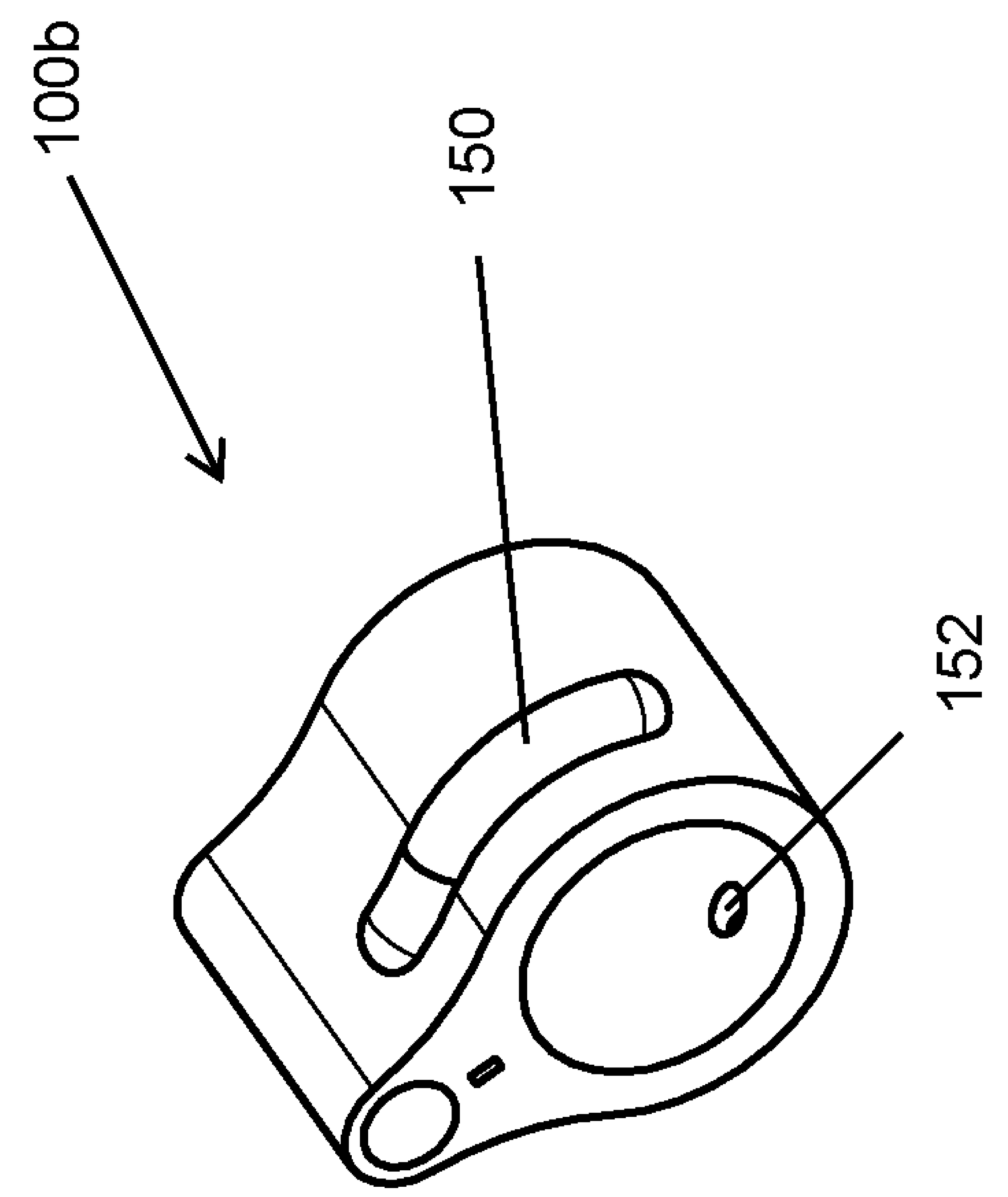

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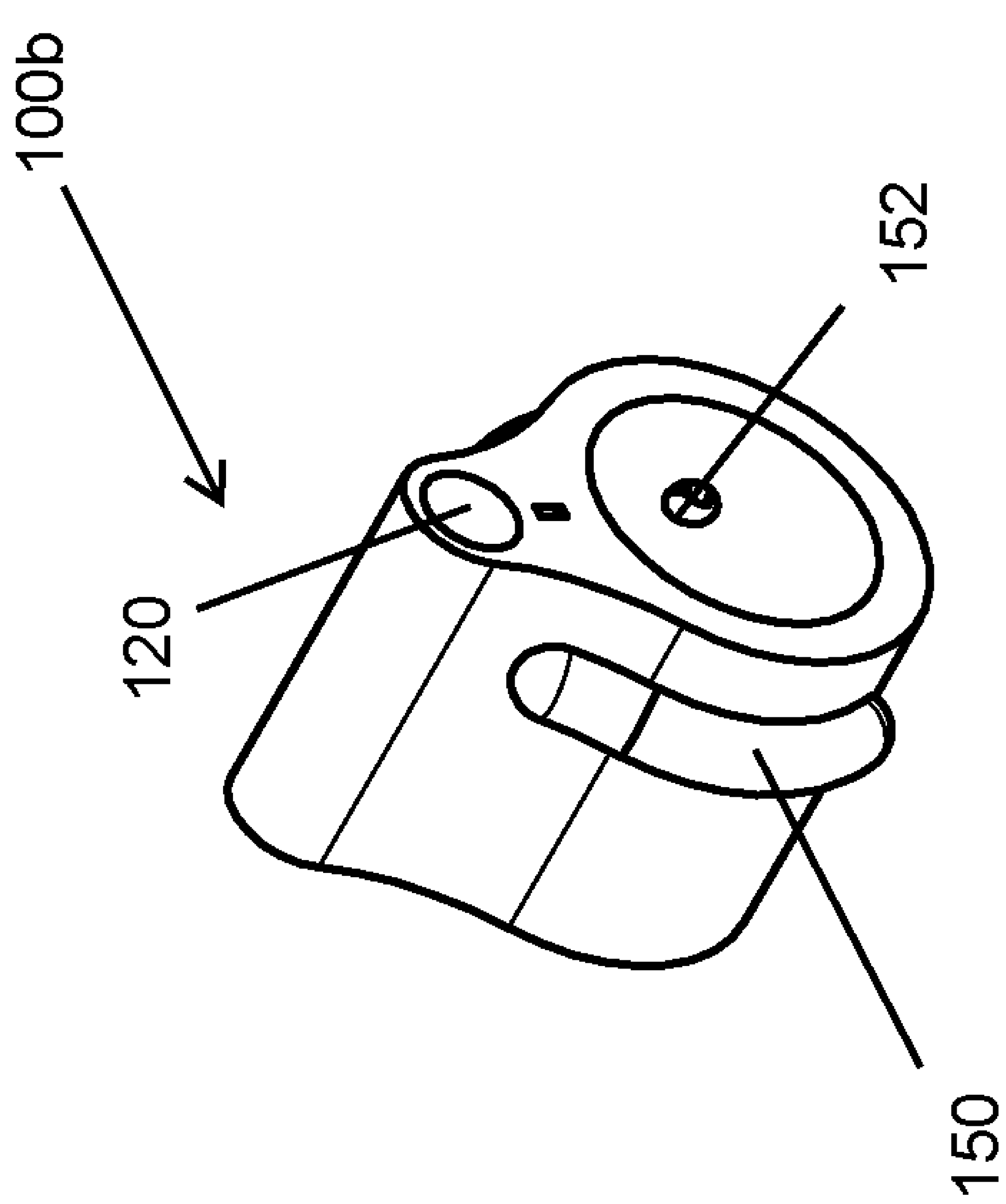

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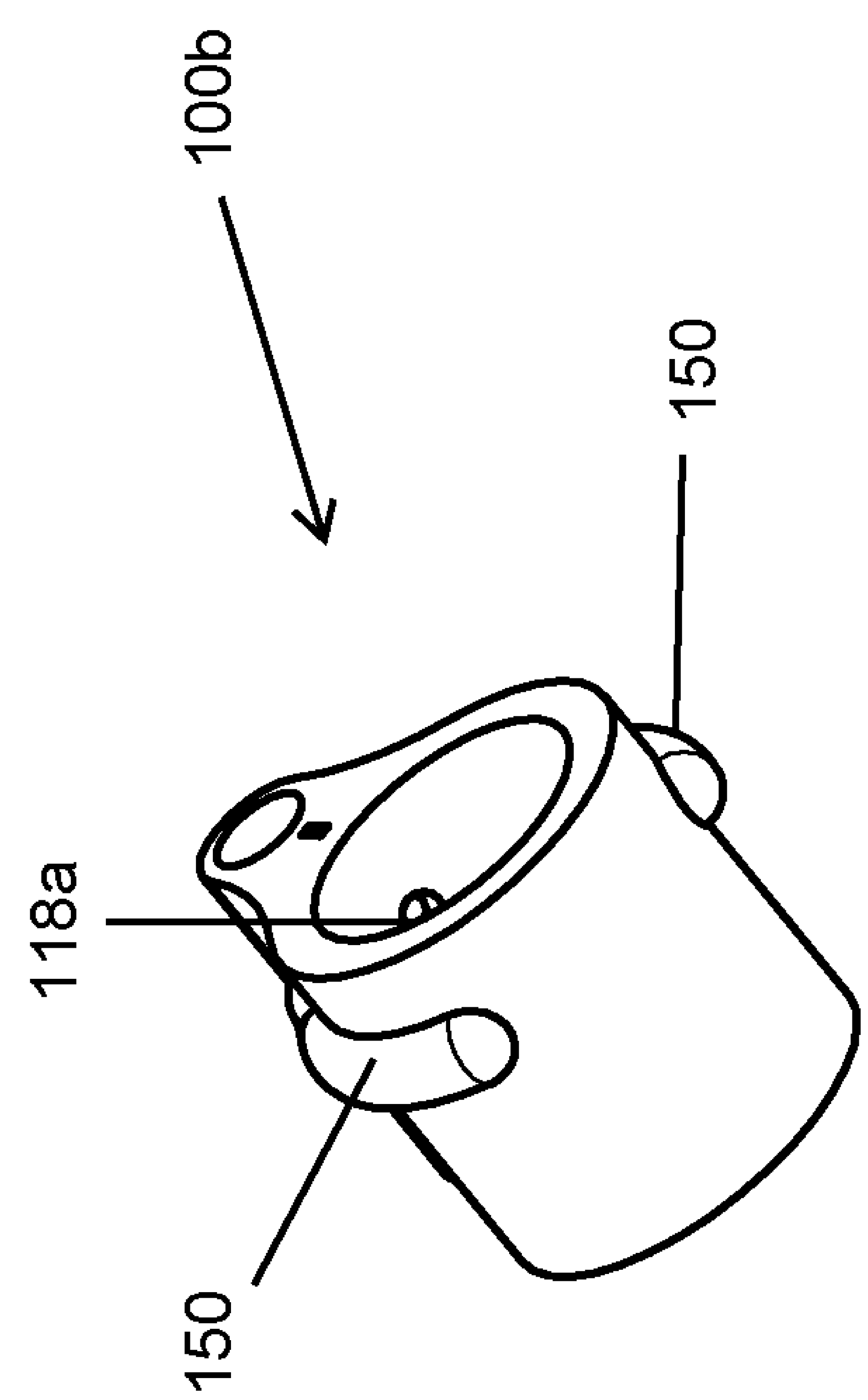

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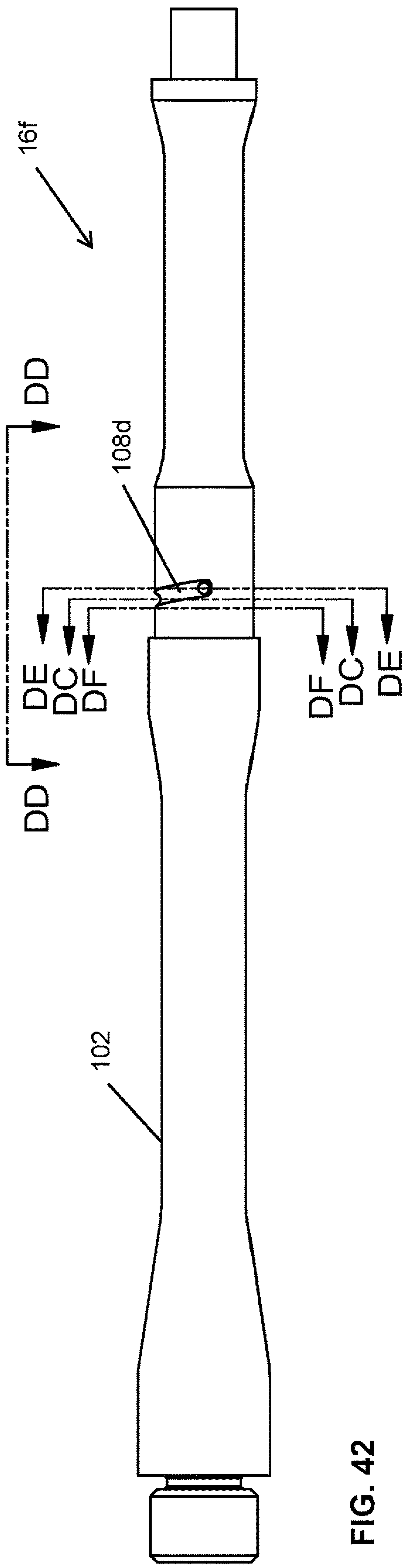

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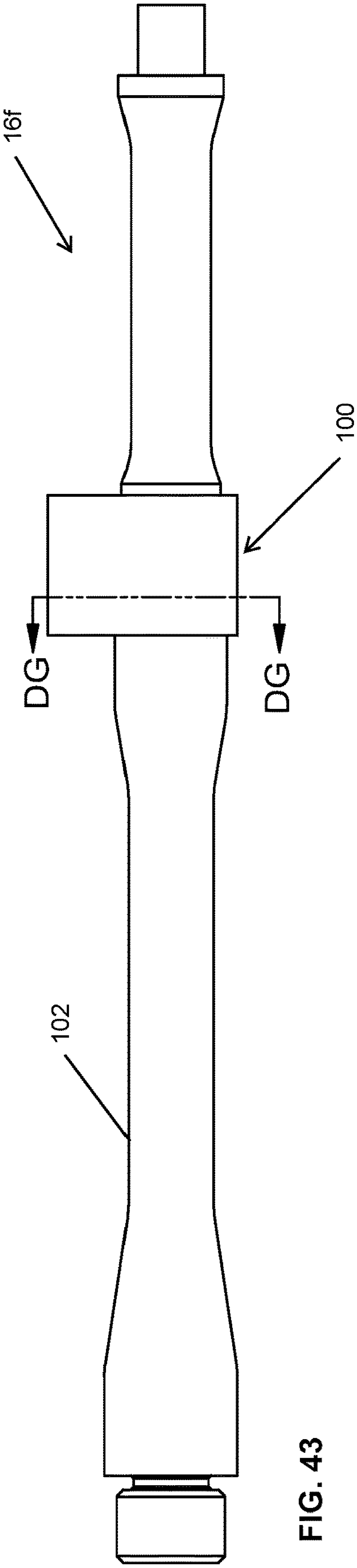

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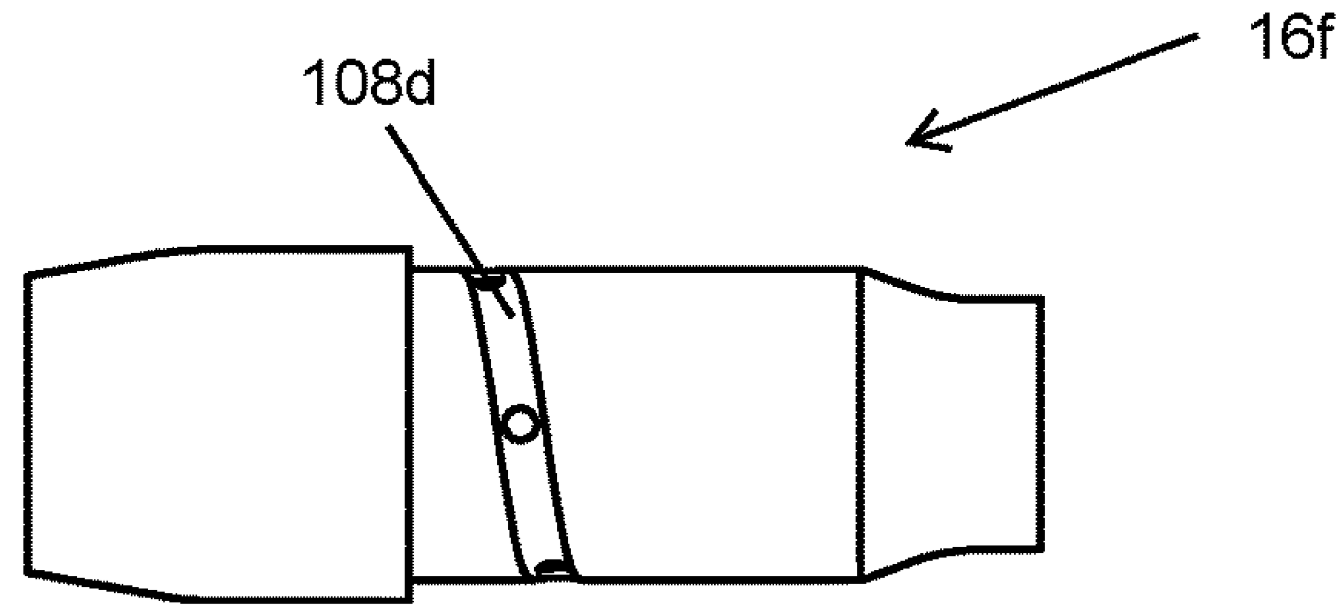

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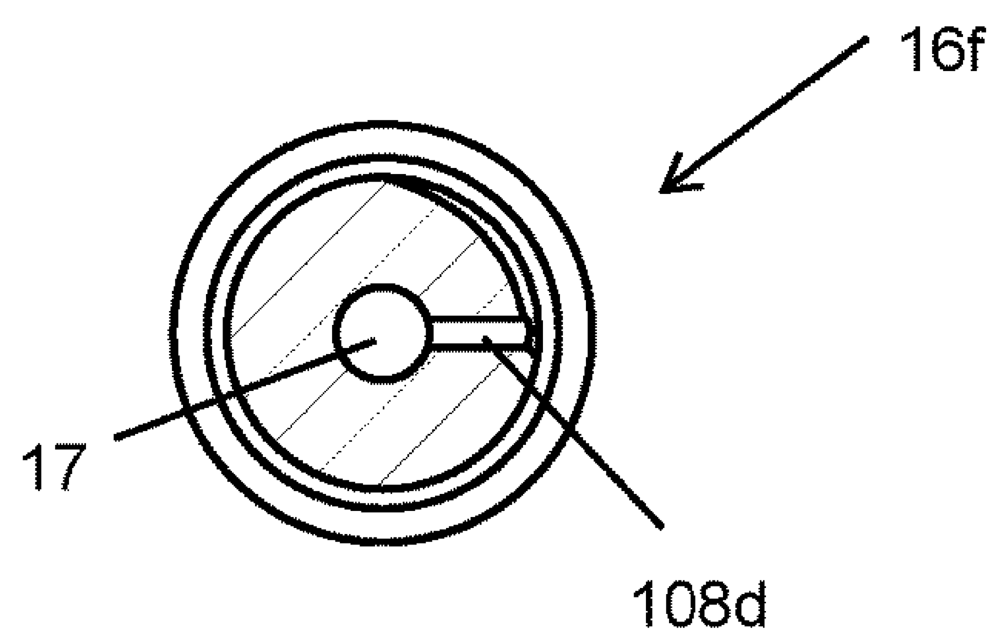

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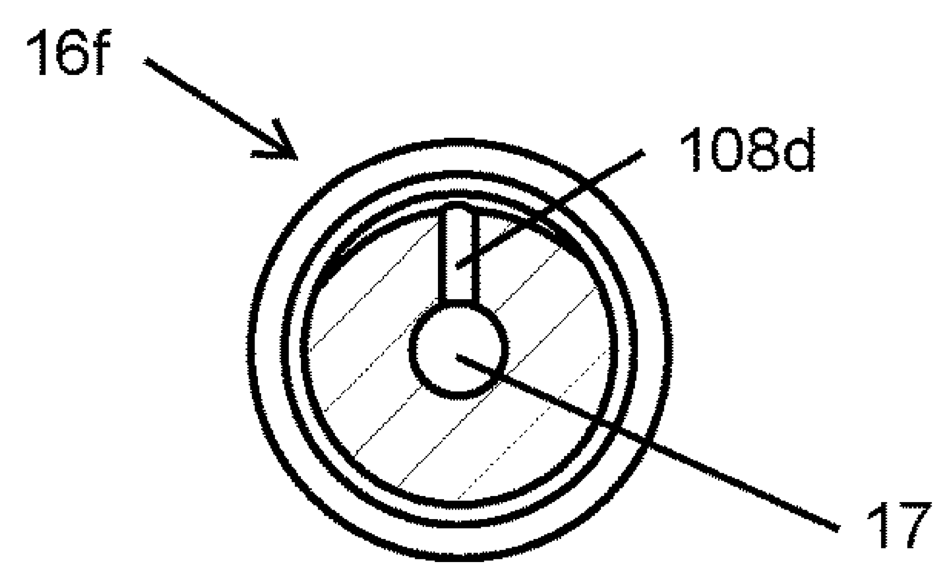

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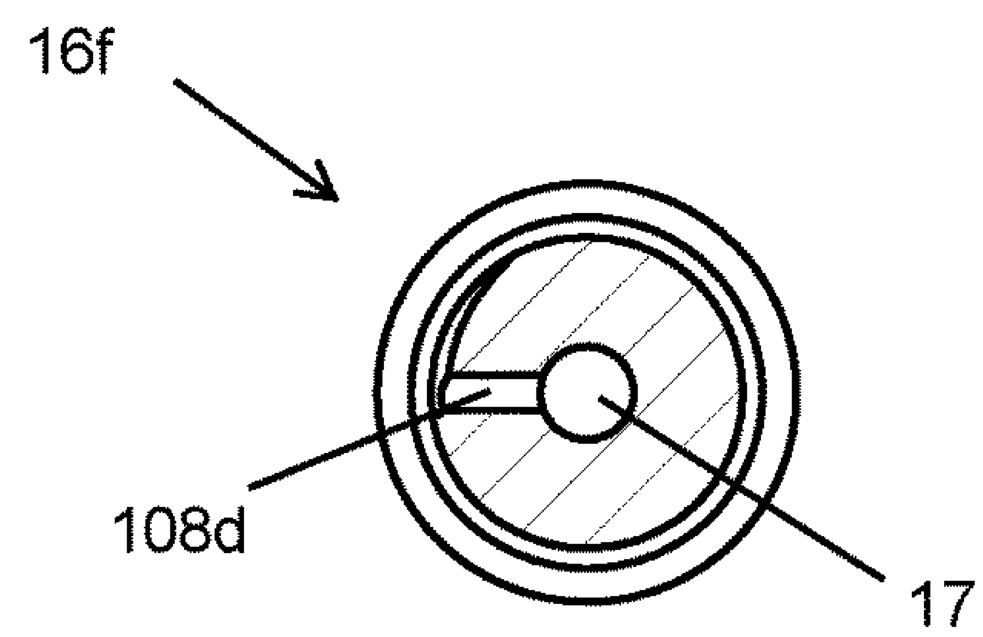

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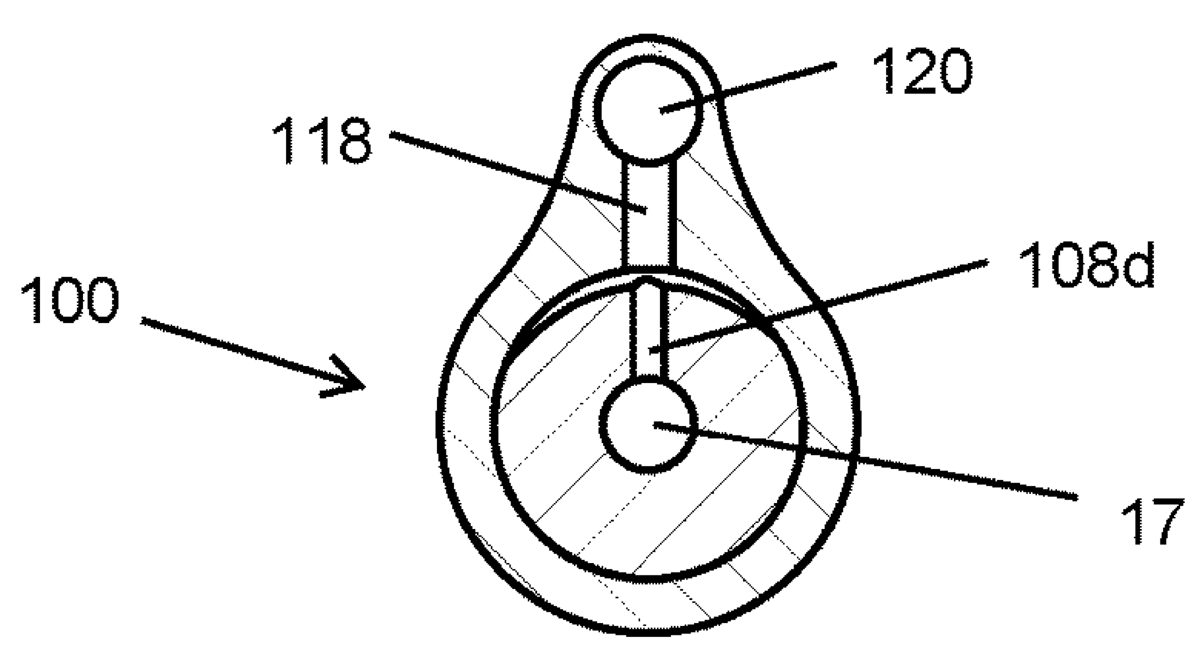

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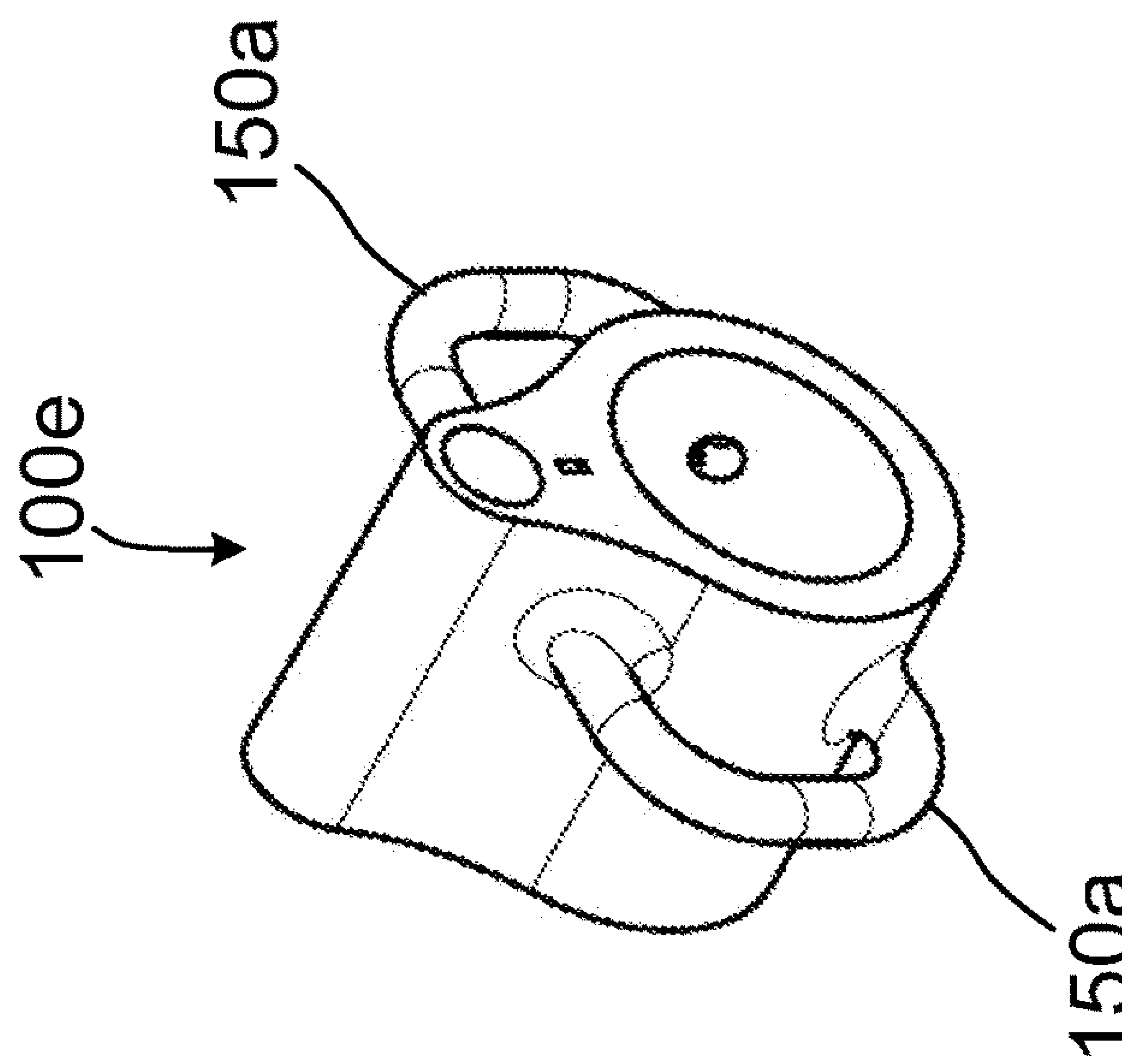

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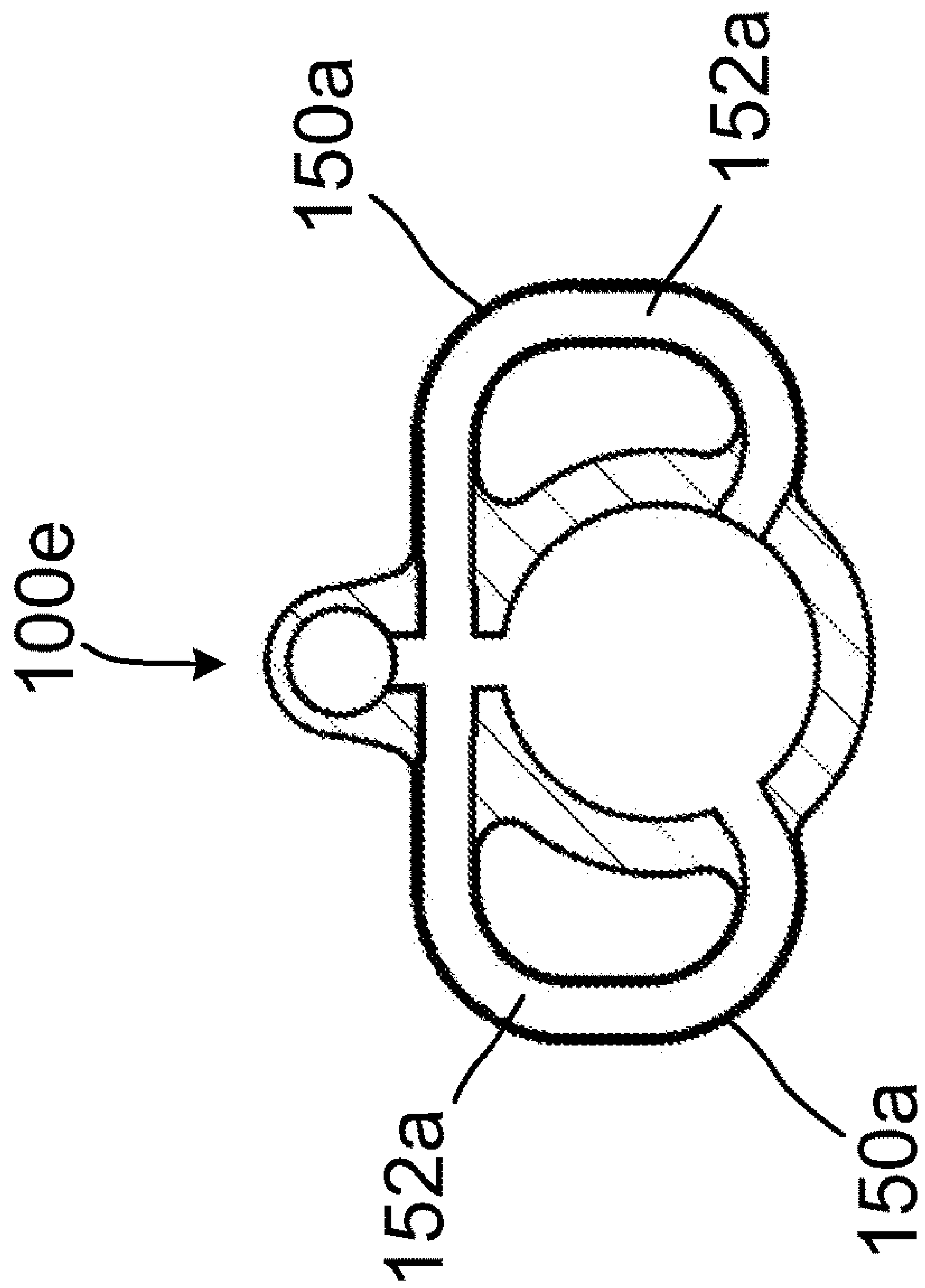

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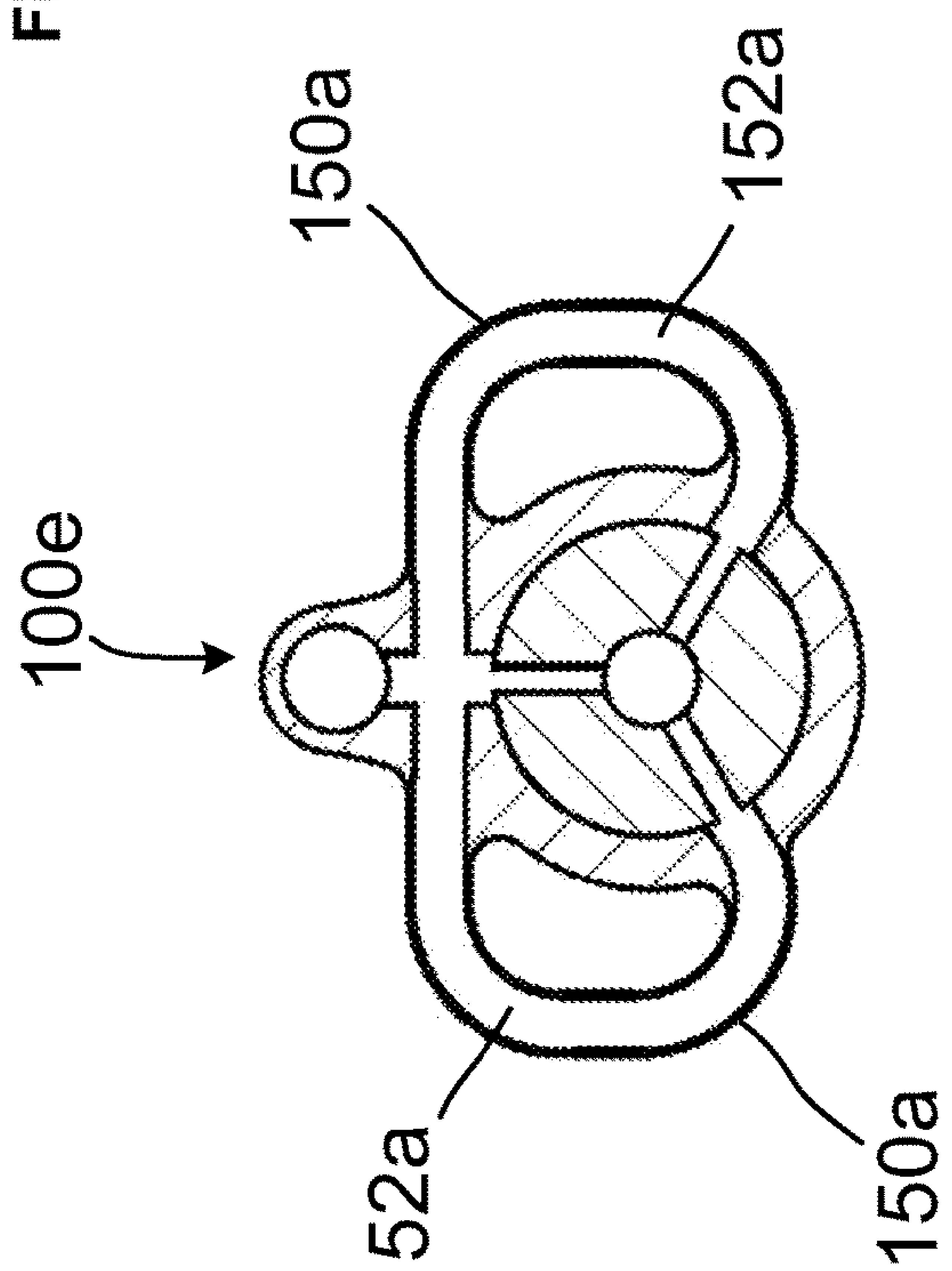
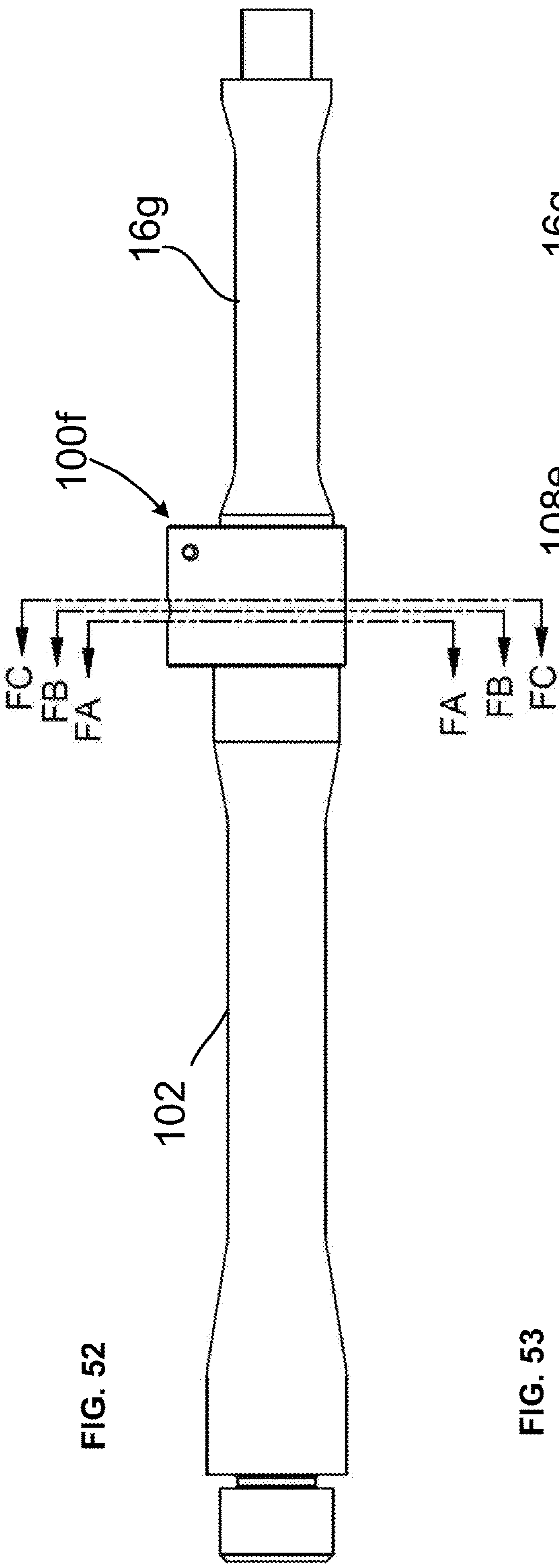


FIG. 51



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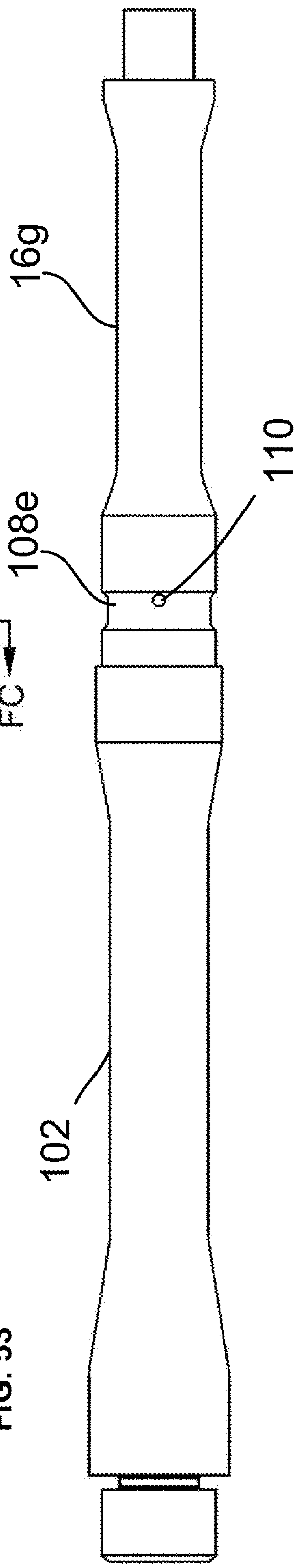

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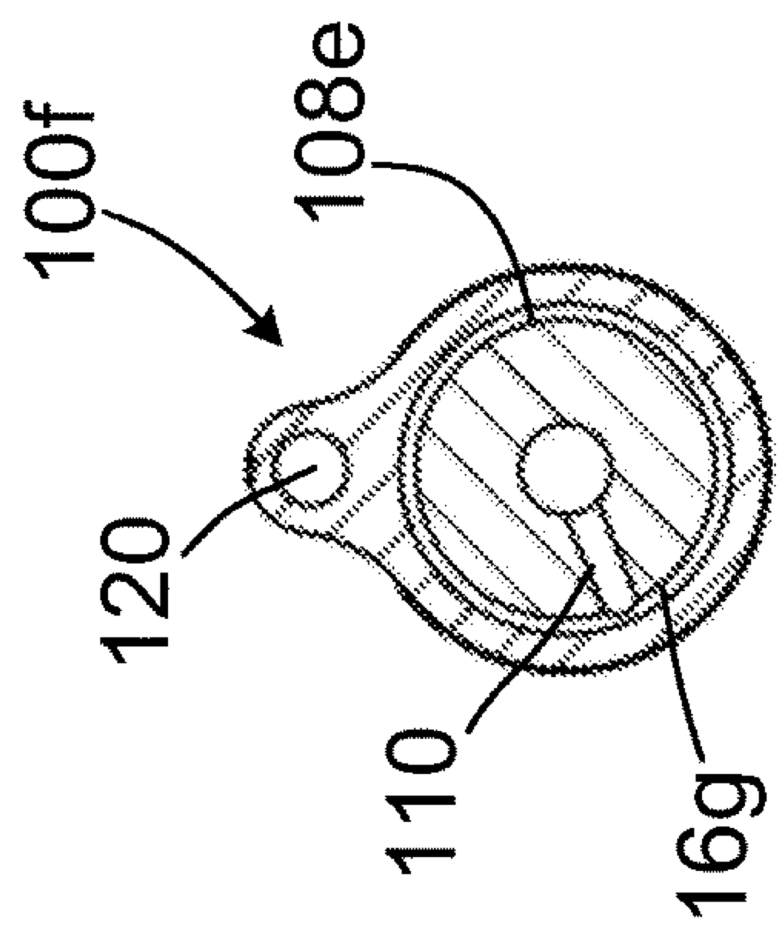
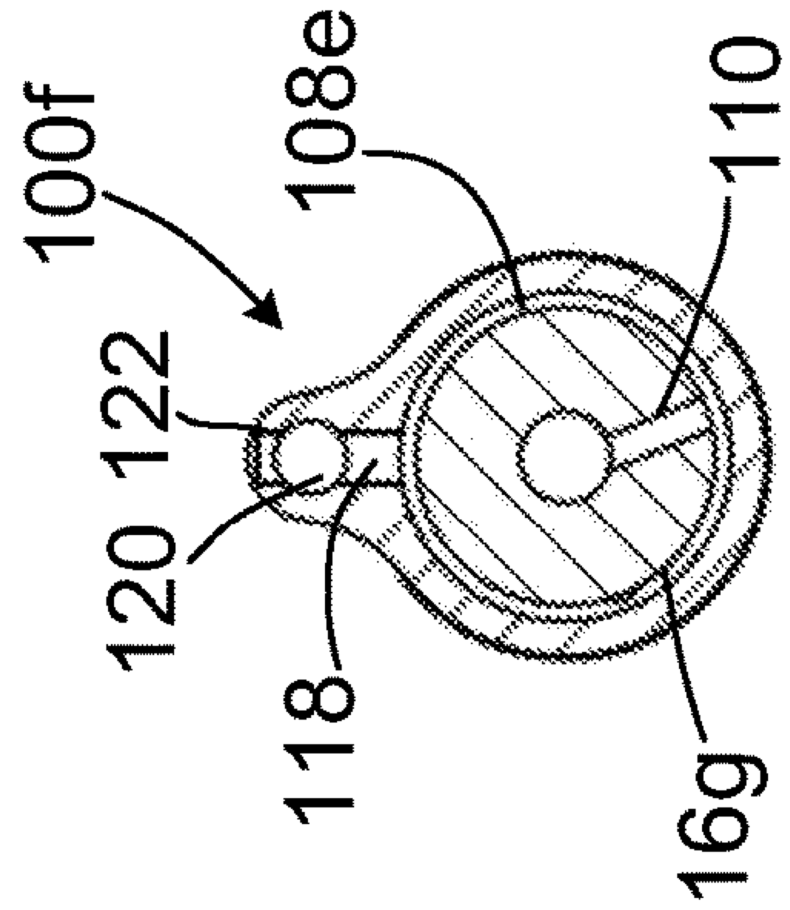


FIG. 54



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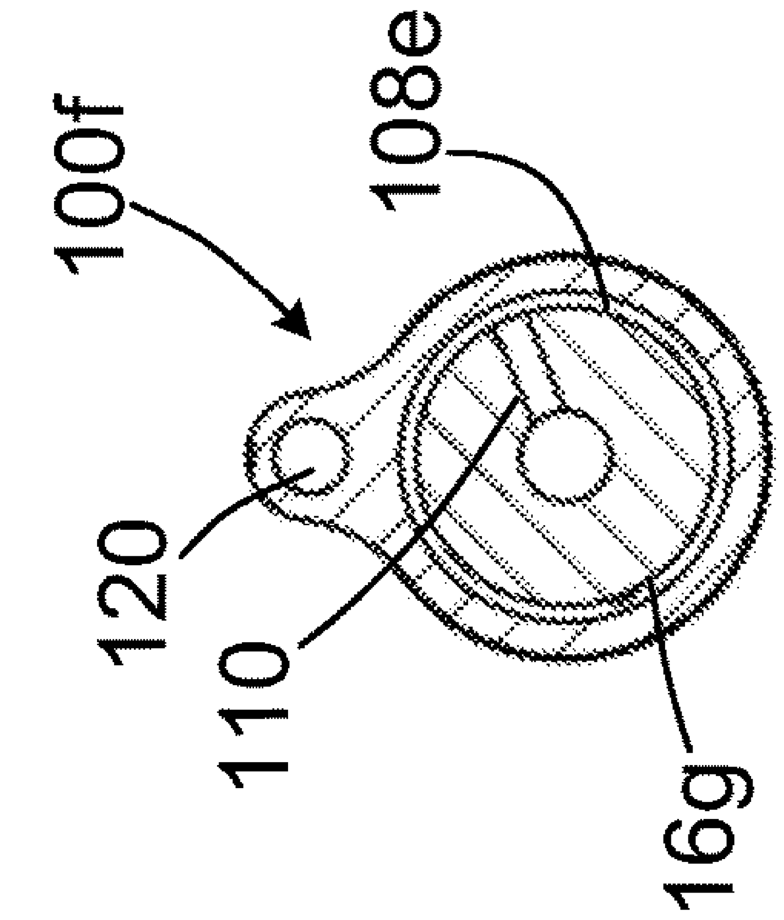
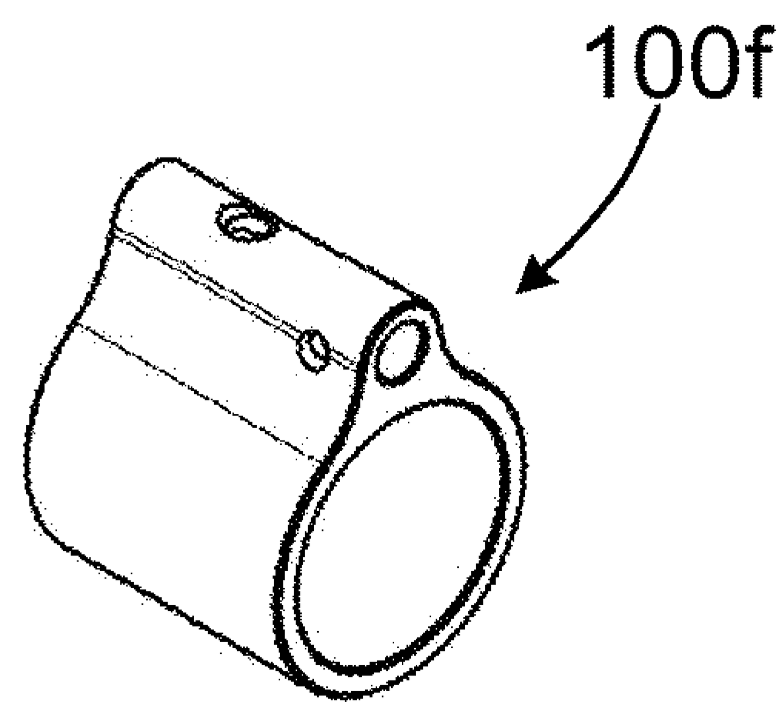


FIG. 56

FIG. 57



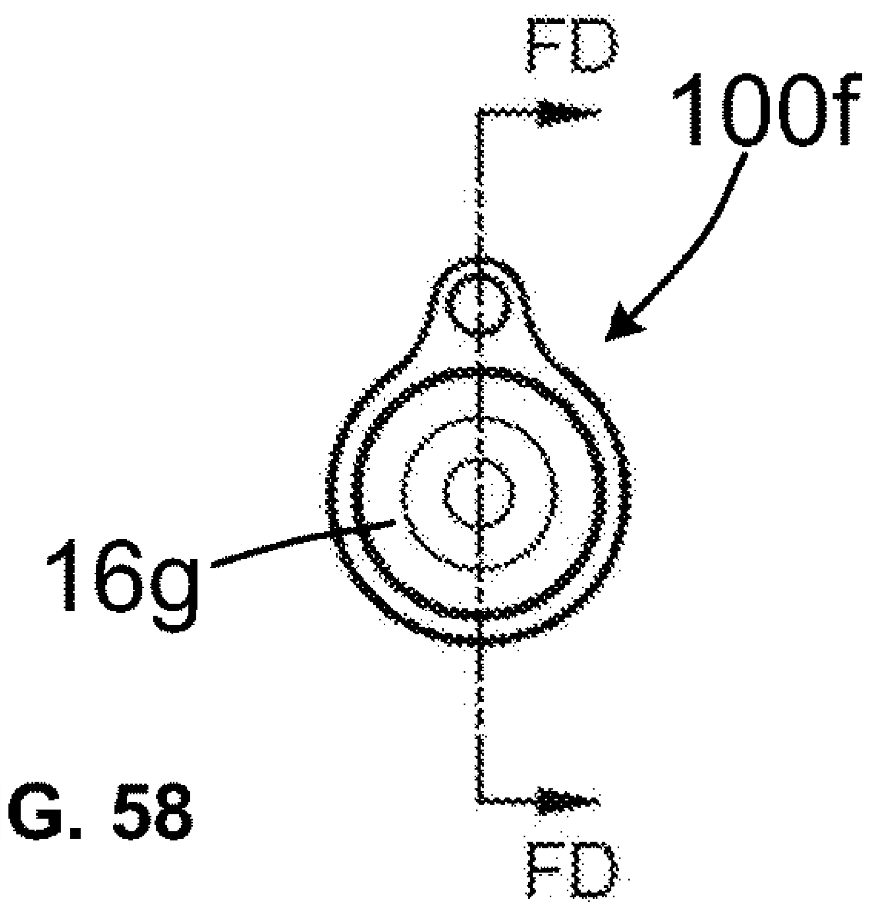


FIG. 58

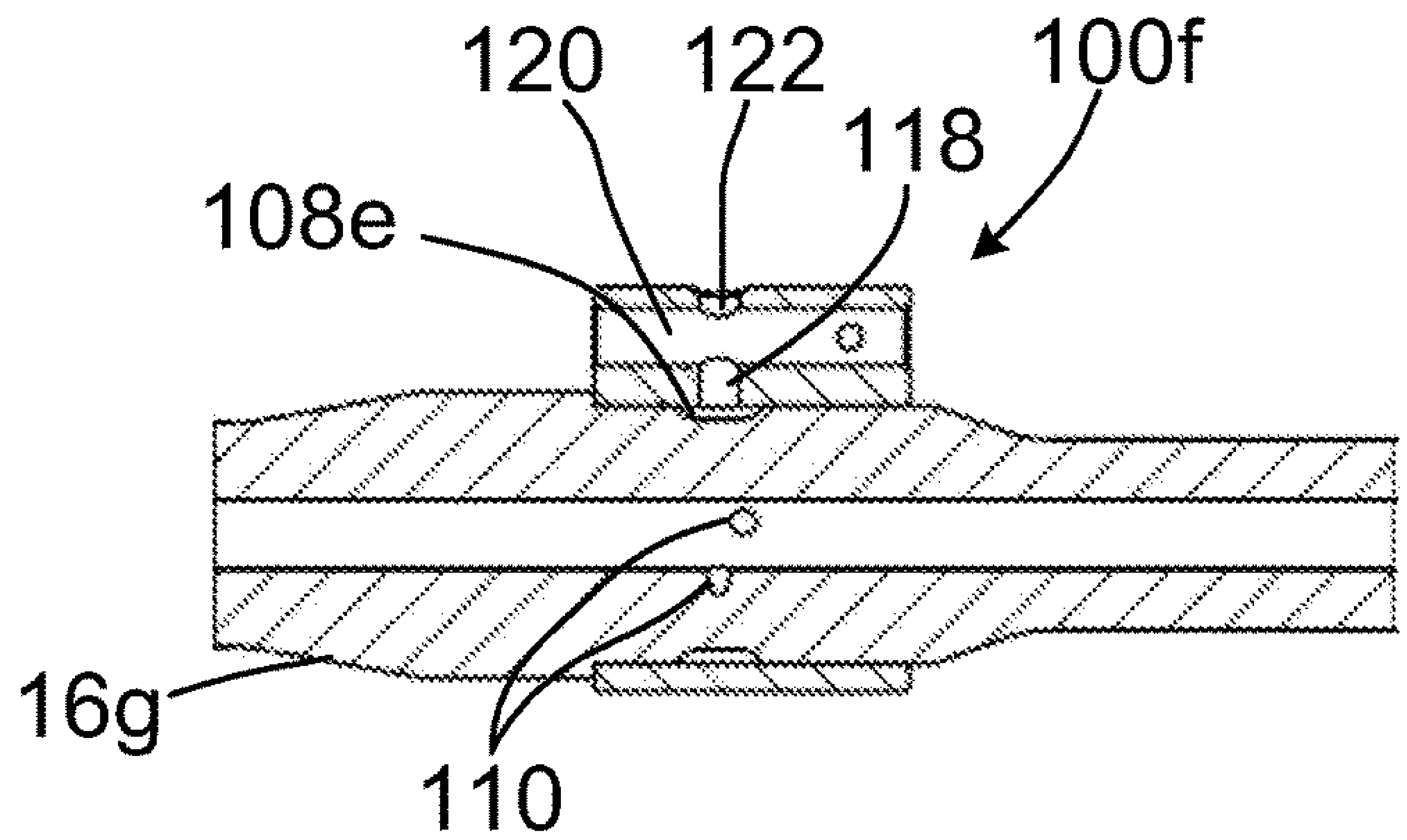


FIG. 59

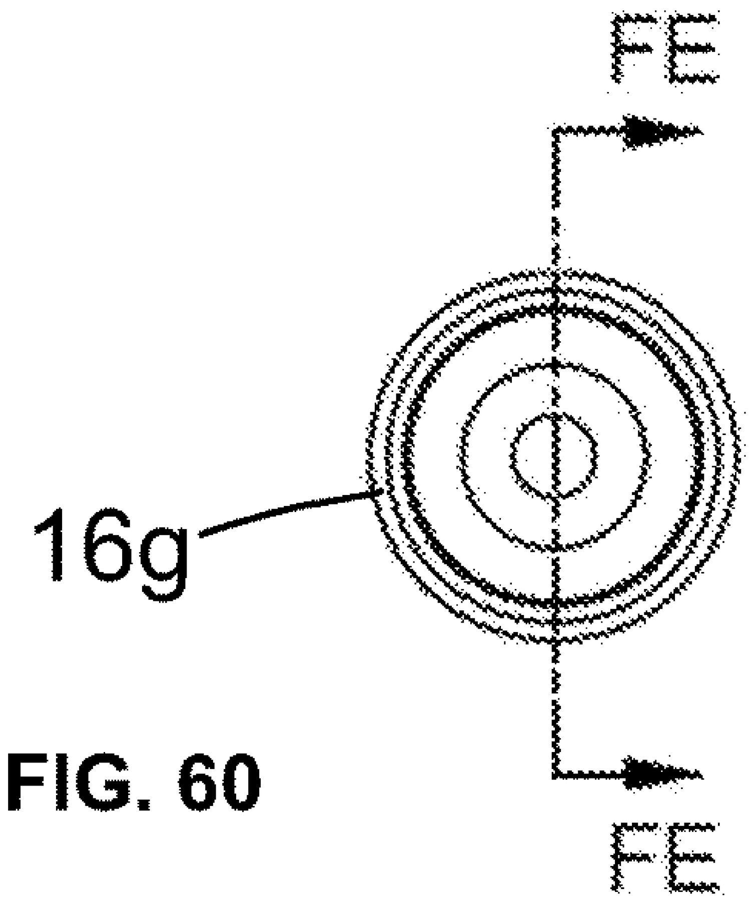


FIG. 60

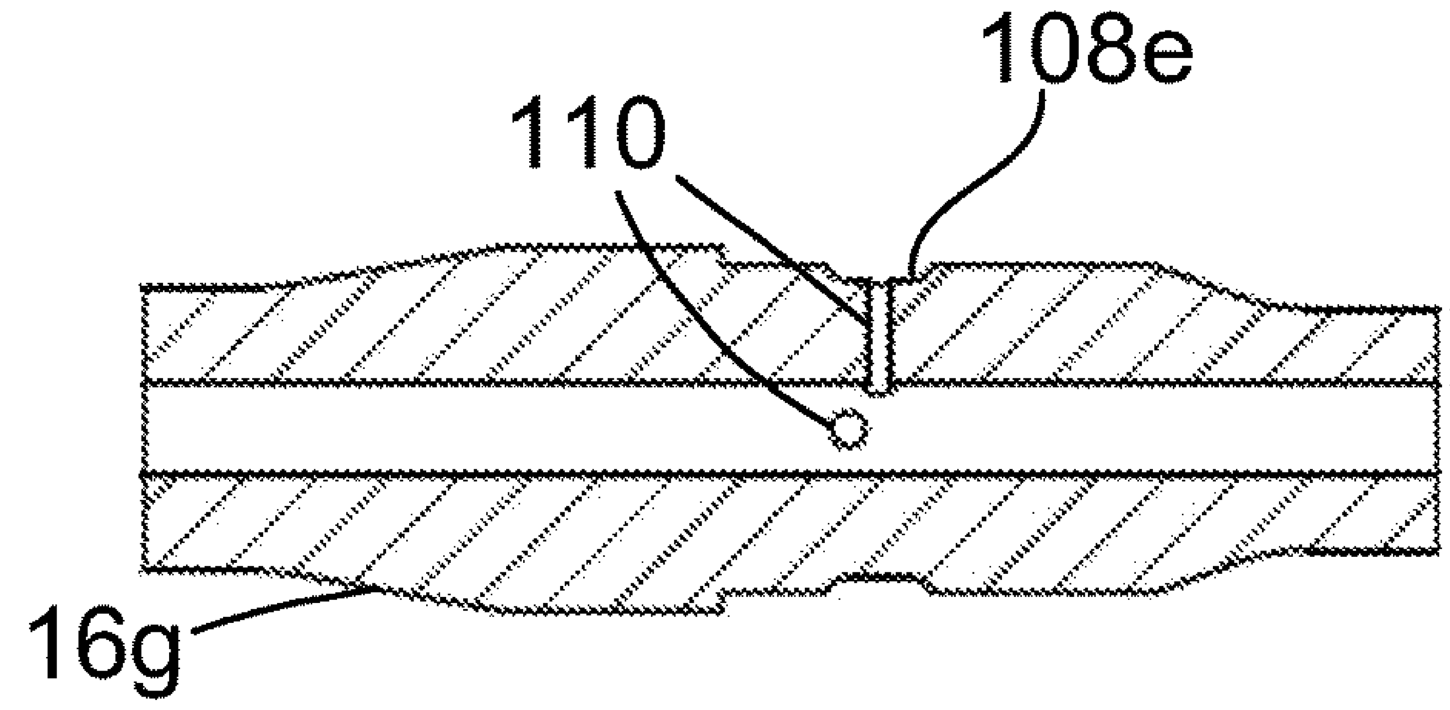


FIG. 61

FIREARM ASSEMBLIES WITH MULTIPLE GAS PORTS

FIELD

The inventive concepts disclosed herein relate to assemblies for gas-actuated firearms in which propellant gas generated by the discharge of the firearm is used to actuate an internal mechanism that automatically reloads the firearm, and firearms that include such assemblies.

BACKGROUND

Tactical rifles and other types of firearms commonly are equipped with a gas system configured to capture energy, in the form of high-pressure gas, generated by the discharge of the firearm. The energy is used to activate and cycle a mechanism, or action, that automatically reloads the firearm. Gas-actuated firearms may include a single gas port in the barrel to cause pressurized gas to operate portions of the action of the firearm.

When a cartridge (also referred to as a round of ammunition) is discharged within a firearm, a projectile of the cartridge is propelled through the bore by high-pressure gas generated by the ignition of propellant within the cartridge case. When the propellant gas reaches the barrel gas port, a portion of the propellant gas enters that port. The pressurized propellant gas then energizes the action of the firearm to eject from the firearm the now-empty case of the fired cartridge; cock the firing mechanism of the firearm; strip an unfired cartridge from a magazine of the firearm; and load the unfired cartridge into a chamber of the barrel.

In general, the surface of the barrel that defines the barrel gas port is susceptible to erosion as the hot, high-pressure propellant gas, which includes abrasive combustion byproducts, passes through the barrel gas port at high velocity. Over time, the erosion can enlarge and alter the shape of the barrel gas port, which can increase the pressure of the propellant gas within the gas system, potentially resulting in premature wear and failure of the action and other components of the firearm.

Also, a projectile traveling down the barrel immediately after discharge can expand against the adjacent interior surface of the barrel as a result of the pressure of the expanding gas behind it. When the projectile passes the barrel gas port, this expansion will push some of the projectile into the gas port, which in turn will shave off material from the projectile. The resulting imbalance in the projectile can reduce the gyroscopic stability of the projectile, causing the projectile to deviate from its intended flight path, thereby reducing shooting accuracy. Thus, a need exists for an improved firearm gas system.

SUMMARY

The present disclosure generally relates to multi-port gas block assemblies for firearms. In one aspect, the disclosed technology relates to an assembly for directing propellant gas to an action of a firearm, including: a barrel defining a bore configured to guide a projectile as the projectile is propelled through the bore by pressurized gas, the barrel having a plurality of barrel gas ports formed therein, each of the barrel gas ports being in fluid communication with the bore; and at least one gas block configured to align with an axial location of the barrel gas ports, the at least one gas block having a gas block gas port formed therein, wherein at least one of the barrel and the at least one gas block define

a passage configured to direct the pressurized gas from the barrel gas ports to the gas block gas port. In one embodiment, the passage is in fluid communication with the barrel gas ports and the gas block gas port. In another embodiment, at least one of an outer surface of the barrel and an inner surface of the at least one gas block has a groove formed therein; the groove is in fluid communication with the barrel gas ports; and the groove at least partly defines the passage. In another embodiment, the groove extends along an entire circumference of the outer surface of the barrel or an entire circumference of the inner surface of the at least one gas block. In some embodiments, the barrel and the at least one gas block are rotationally agnostic relative to each other, such that the barrel and the at least one gas block are configured direct the pressurized gas from the plurality of barrel gas ports to the gas block gas port in at least two relative rotational positions between the barrel and the at least one gas block. In some embodiments, the groove extends along an entire circumference of the outer surface of the barrel, an exit of one of the plurality of gas ports is disposed in the groove at a first location along a length of the barrel, and an exit of a second one of the plurality of barrel gas ports is positioned in the groove at a second location along the length of the barrel different than the first location. In another embodiment, the groove extends along not more than a portion of a circumference of the outer surface of the barrel or a portion of a circumference of the inner surface of the at least one gas block. In another embodiment, the barrel has an inner surface that defines the bore; each of the barrel gas ports has an entrance defined by the inner surface of the barrel; and the entrances of the barrel gas ports are spaced apart along a circumference of the inner surface barrel by substantially equal angular distances. In some embodiments, two or more of the gas ports may be arranged linearly at a same angular position and different axial positions along the length of the barrel.

In another embodiment, the barrel has an inner surface that defines the bore; each of the barrel gas ports has an entrance defined by the inner surface of the barrel, the entrance of one of the barrel gas ports is positioned at a first location along a length of the barrel; and the entrance of a second one of the barrel gas ports is positioned at a second location along the length of the barrel. In another embodiment, the groove extends in a curvilinear path along the outer surface of the barrel or along the inner surface of the at least one gas block. In another embodiment, the groove extends in a linear path along the outer surface of the barrel or along the inner surface of the at least one gas block. In another embodiment, the barrel has three barrel gas ports formed therein. In another embodiment, the at least one gas block has a gas tube receiving passage formed therein and configured to receive an end of a gas tube, wherein the gas tube receiving passage is in fluid communication with the at least one gas block gas port. In another embodiment, the groove is formed in the outer surface of the barrel; and the passage is defined by the groove and an adjacent portion of the inner surface of the at least one gas block. In another embodiment, an exit of each of the barrel gas ports is located at least partly within the groove. In another embodiment, the groove is formed in the inner surface of the at least one gas block; and the passage is defined by the groove and an adjacent portion of the outer surface of the barrel.

In some embodiments, the gas block may be configured to be mounted on the barrel. In some embodiments, the gas block and the barrel may define a single integral piece.

In another embodiment, the barrel gas ports extend radially in relation to a longitudinal axis of the barrel. In another

embodiment, the groove has a semi-circular cross section. In another embodiment, the passage and the barrel gas ports form a manifold operable to supply a stream of the pressurized gas to the gas block gas port from the barrel gas ports.

In another aspect, the disclosed technology relates to an assembly for directing propellant gas to an action of a firearm, including: a barrel defining a bore configured to guide a projectile as the projectile is propelled through the bore by pressurized gas, the barrel having a plurality of gas ports formed therein, each of the gas ports being in fluid communication with the bore; and at least one gas block configured align with an axial location of the plurality of barrel gas ports, wherein: the at least one gas block has a gas port formed therein; the at least one gas block includes a conduit having an entrance and an exit; and the conduit is configured so that the entrance to the conduit aligns with, and is in fluid communication with one of the barrel gas ports, and the exit aligns with, and is in fluid communication with the gas block gas port. In one embodiment, the at least one gas block is configured so that the gas block gas port aligns with and is in fluid communication with another one of the barrel gas ports. In another aspect, the disclosed technology relates to a firearm, including any of the assemblies disclosed herein.

In some embodiments, a barrel for a firearm is provided, including: an inner surface defining a bore configured to guide a projectile as the projectile is propelled through the bore by pressurized gas, wherein the barrel has a plurality of barrel gas ports formed therein, wherein each of the barrel gas ports has an entrance defined by the inner surface of the barrel, and wherein each of the barrel gas ports is configured to simultaneously fluidically connect to a passage for directing the pressurized gas to an action of the firearm. In some embodiments, an outer surface of the barrel has a groove formed therein, wherein the groove is in fluid communication with the barrel gas ports, and wherein the groove at least partly defines the passage. In some embodiments, at least two of the plurality of barrel gas ports may be defined at different axial locations along a length of the barrel. In some embodiments, each of the plurality of barrel gas ports may be defined at a same axial location along a length of the barrel. The plurality of barrel gas ports may be spaced circumferentially about the barrel. As used herein, terms such as “axial location” refer to a position relative to the stated parameter without regard to other parameters (e.g., a position measured with respect to the axis of the length of the barrel without regard to the corresponding radial position unless stated otherwise).

In another embodiment, an assembly for directing gas to an action of a firearm may be provided, including: a barrel having an interior surface, the interior surface defining a plurality of entrance openings configured to receive pressurized gas therethrough; and means for directing the pressurized gas from each of the plurality of entrance openings to the action of the firearm. In some embodiments, at least two of the plurality of barrel gas ports may be defined at different axial locations along a length of the barrel. In some embodiments, each of the plurality of entrance openings is defined at a same axial location along a length of the barrel. In some embodiments, the plurality of entrance openings are spaced circumferentially about the barrel. In some embodiments, the means for directing the pressurized gas from each of the plurality of entrance openings to the action of the firearm may include a means for combining portions of the pressurized gas associated with each of the plurality of entrance openings into a single flow upstream of the action.

A variety of additional aspects will be set forth in the description that follows. The aspects can relate to individual features and to combinations of features. It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the broad inventive concepts upon which the embodiments disclosed herein are based.

BRIEF DESCRIPTION OF THE DRAWINGS

The following drawings are illustrative of particular embodiments of the present disclosure and do not limit the scope of the present disclosure. The drawings are not to scale and are intended for use in conjunction with the explanations provided herein. Embodiments of the present disclosure will hereinafter be described in conjunction with the appended drawings.

FIG. **1** is a cross-sectional, schematic side view of an exemplary firearm equipped with a barrel and gas block assembly as described herein.

FIG. **2** is a magnified view of the area designated “A” in FIG. **1**.

FIG. **3** is a partially exploded view of an action of the firearm shown in FIGS. **1** and **2**.

FIG. **4** is a front perspective view of a barrel of the firearm shown in FIGS. **1-3**.

FIG. **5** is a front perspective view of the barrel shown in FIG. **4**, with a gas block mounted thereon.

FIG. **6** is a side view of the barrel shown in FIGS. **4** and **5**.

FIG. **7** is a side view of the barrel and gas block shown in FIGS. **4-6**.

FIG. **8** is a cross-sectional view taken through the line “A-A” of FIG. **6**.

FIG. **9** is a cross-sectional view taken through the line “B-B” of FIG. **7**.

FIG. **10** is a front view of the barrel shown in FIGS. **4-9**.

FIG. **11** is a cross-sectional view taken through the line “C-C” of FIG. **10**.

FIG. **12** is a front view of the barrel and gas block shown in FIGS. **4-11**.

FIG. **13** is a cross-sectional view taken through the line “D-D” of FIG. **12**.

FIG. **14** is a side view of an alternative embodiment of the barrel shown in FIGS. **4-13**.

FIG. **15** is a side view of the barrel shown in FIG. **14**, with the gas block shown in FIGS. **5**, **7**, **9**, and **12** mounted thereon.

FIG. **16** is a cross-sectional view taken through the line “G-G” of FIG. **14**.

FIG. **17** is a cross-sectional view taken through the line “H-H” of FIG. **15**.

FIG. **18** is a side view of another alternative embodiment of the barrel shown in FIGS. **4-13**.

FIG. **19** is a top view of the area denoted “K-K” in FIG. **18**.

FIG. **20** is a cross-sectional view taken through the line “CH-CH” of FIG. **18**.

FIG. **21** is a cross-sectional view taken through the line “CJ-CJ” of FIG. **18**.

FIG. **22** is a side view of another alternative embodiment of the barrel shown in FIGS. **4-13**.

FIG. **23** is a cross-sectional view taken through the line “AW-AW” of FIG. **22**.

FIG. **24** is a side view of another alternative embodiment of the barrel shown in FIGS. **4-13**.

FIG. **25** is a cross-sectional view taken through the line "BC-BC" of FIG. **24**.

FIG. **26** is a side view of another alternative embodiment of the barrel shown in FIGS. **4-13**, and an alternative embodiment of the gas block shown in FIGS. **5**, **7**, **9**, **12**, **15**, and **17** mounted thereon.

FIG. **27** is a side view of the barrel shown in FIG. **26**.

FIG. **28** is a cross-sectional view taken through the line "V-V" of FIG. **26**.

FIG. **29** is a cross-sectional view taken through the line "BH-BH" of FIG. **27**.

FIG. **30** is a top-right perspective view of the gas block shown in FIGS. **26** and **28**.

FIG. **31** is a bottom-right perspective view of the gas block shown in FIGS. **26**, **28**, and **30**.

FIG. **32** is a bottom-front perspective view of the gas block shown in FIGS. **26**, **28**, **30**, and **31**.

FIG. **33** is a front view of the gas block shown in FIGS. **26**, **28**, and **30-32**.

FIG. **34** is a cross-sectional view taken through the line "W-W" of FIG. **33**.

FIG. **35** is a side view of another alternative embodiment of the gas block shown in FIGS. **5**, **7**, **9**, **12**, **13**, **15**, and **17**.

FIG. **36** is a cross-sectional view taken through the line "DY-DY" of FIG. **35**.

FIG. **37** is a side view of the barrel shown in FIGS. **26-29**, with the gas block shown in FIGS. **35** and **36** mounted thereon.

FIG. **38** is a cross-sectional view taken through the line "EA-EA" of FIG. **37**.

FIG. **39** is a top-right perspective view of the gas block shown in FIGS. **35-38**.

FIG. **40** is a front-left perspective view of the gas block shown in FIGS. **35-39**.

FIG. **41** is a bottom-front perspective view of the gas block shown in FIGS. **35-40**.

FIG. **42** is a side view of another alternative embodiment of the barrel shown in FIGS. **4-13**.

FIG. **43** is a side view of the barrel shown in FIG. **42**, with the gas block shown in FIGS. **5**, **7**, **9**, **12**, **13**, **15**, and **17**.

FIG. **44** is a top view of the area designated "DD-DD" in FIG. **42**.

FIG. **45** is a cross-sectional view taken through the line "DF-DF" of FIG. **42**.

FIG. **46** is a cross-sectional view taken through the line "DC-DC" of FIG. **42**.

FIG. **47** is a cross-sectional view taken through the line "DE-DE" of FIG. **42**.

FIG. **48** is a cross-sectional view taken through the line "DG-DG" of FIG. **43**.

FIG. **49** is a perspective view of another embodiment of the gas block shown in FIGS. **35-41**.

FIG. **50** is a cross-sectional view of the gas block of FIG. **49**.

FIG. **51** is a cross-sectional view of the gas block of FIG. **49** mounted on a barrel.

FIG. **52** is a side view of another embodiment of the barrel shown in FIGS. **4-13** with another embodiment of the gas block shown in FIGS. **5**, **7**, **9**, **12**, **13**, **15**, and **17**.

FIG. **53** is a side view of the barrel of FIG. **52**.

FIG. **54** is a cross-sectional view taken through the line "FA-FA" of FIG. **52**.

FIG. **55** is a cross-sectional view taken through the line "FB-FB" of FIG. **52**.

FIG. **56** is a cross-sectional view taken through the line "FC-FC" of FIG. **52**.

FIG. **57** is a perspective view of the gas block of FIG. **52**.

FIG. **58** is a front view of the barrel and gas block of FIG. **52**.

FIG. **59** is a cross-sectional view taken through the line "FD-FD" of FIG. **58**.

FIG. **60** is a front view of the barrel of FIG. **52**.

FIG. **61** is a cross-sectional view taken through the line "FE-FE" of FIG. **60**.

DETAILED DESCRIPTION

The inventive concepts are described with reference to the attached figures, wherein like reference numerals represent like parts and assemblies throughout the several views. The figures are not drawn to scale and are provided merely to illustrate the instant inventive concepts. The figures do not limit the scope of the present disclosure or the appended claims. Several aspects of the inventive concepts are described below with reference to example applications for illustration. It should be understood that numerous specific details, relationships, and methods are set forth to provide a full understanding of the inventive concepts. One having ordinary skill in the relevant art, however, will readily recognize that the inventive concepts can be practiced without one or more of the specific details or with other methods. In other instances, well-known structures or operation are not shown in detail to avoid obscuring the inventive concepts.

Embodiments of the present disclosure may include a firearm having a barrel with multiple flow paths defined in the bore of the barrel through which pressurized gas may flow. These multiple flow paths may be combined and directed to the action to energize various functions of the firearm action, such as ejecting a spent casing, loading a new cartridge, and cocking a trigger mechanism. In various embodiments the flow paths may include a plurality of barrel gas ports defined in the barrel, which are fluidically combined into a single passage or conduit at or before the action. The barrel gas ports may be simultaneously fluidically coupled with at least a portion of the action to allow pressurized gas to travel to the action via any of the barrel gas ports. In some embodiments, each of the barrel gas ports may be continuously fluidically connected with the action between a point at or upstream of an inner surface of the barrel to the action.

FIGS. **1** and **2** schematically depict a gas-operated firearm **10** according to various embodiments discussed herein. The firearm **10** may be a semi-automatic firearm (e.g., a rifle) that fires a projectile **30** (e.g., bullet). The firearm **10** is equipped with a gas system **18** configured to capture energy generated by the firing of the projectile **30**, and to use the captured energy to cycle a mechanism that automatically reloads and cock the hammer of the firearm **10**. Specific details of the firearm **10** are presented for exemplary purposes only. The inventive principles disclosed herein can be applied to other types of firearms, including but not limited to other types of rifles, including automatic rifles, shotguns, and pistols.

In the depicted embodiment, the firearm **10** includes a receiver **12**, a barrel **16**, and a magazine **19** that holds unfired rounds of ammunition or cartridges **32**. Each cartridge **32** may include a case **31** with a projectile **30**, a primer (not shown), and a propellant (also not shown) all housed within the case **31**. The barrel **16** may include a chamber **33** that receives and houses an individual cartridge **32** immediately prior to firing, as shown in FIG. **2**. The barrel **16** need not be a single integral piece. Prior to firing, the cartridge **32** may be held in the chamber **33** by a bolt (e.g., bolt member **132** shown in FIG. **3**) of the receiver **12**.

The depicted receiver **12** includes a trigger mechanism and an action **22**. The trigger mechanism includes a trigger **23** that is pulled by the user, or shooter, in order to initiate the firing sequence of the firearm **10**. Prior to firing, the trigger mechanism may hold a spring-loaded hammer (not shown) in a cocked position. The trigger mechanism may prevent the hammer from moving until the trigger **23** is pulled, and may release the hammer when the trigger **23** is pulled. Upon release, the hammer may strikes a firing end of the cartridge **32**, via a firing pin assembly, causing the primer within the cartridge **32** to ignite the propellant. Once ignited, the propellant forms a high-pressure propellant gas G that propels the projectile **30** through a lengthwise bore **17** formed in the barrel **16**, until the projectile **30** exits the end, or muzzle **39** of the barrel **16** at high velocity. The projectile **30** may at least partially seal the bore **17** to cause the buildup of propellant gas G pressure behind the projectile for both driving the projectile and, once the projectile passes a gas port in the barrel **16** associated with the gas system **18**, for driving the action **22**.

The action **22** ejects the spent case **31** from the firearm **10** after firing, reloads an unfired, or pre-firing, cartridge **32** into the chamber **33** from the magazine **19**, and cocks the hammer of the trigger mechanism. The action **22** is gas-actuated, i.e., the action **22** may receive energy from the gas system **18** in the form of at least a portion of the high-pressure propellant gas G generated by the burning propellant of the cartridges **32**, and the energy may cause the action **22** to eject the spent case **31**, to reload an unfired cartridge **32**, and cock the trigger mechanism.

The depicted gas system **18** is a direct-impingement gas system in which the propellant gas G acts directly on the action **22**. However, the technology disclosed herein can be used in connection with other types of gas systems, such as gas piston systems, including any gas system that directly or indirectly transfers energy of the propellant gas G from the bore **17** to drive the action **22**. In such embodiments, the action may be said to include such pistons or other energy transfer mechanisms. Additionally, the depicted action **22** is a bolt carrier group, but other types of actions can be used in the alternative. The operation of such actions and other receiver components and trigger mechanisms in response to the inventive gas systems, methods, and assemblies disclosed herein would be understood by one of ordinary skill in the art in light of the present disclosure.

As shown in FIG. **3**, an example embodiment of the action **22** includes a bolt carrier **130** and a bolt member **132**. The bolt carrier **130** defines a bolt chamber **134**. A rearward portion of the bolt member **132** is positioned within the bolt chamber **134**, and can move both linearly and rotationally within the bolt chamber **134**. The bolt member **132** may include gas seal rings **136** that form a movable seal between the bolt member **132** and the adjacent surface of the bolt carrier **130** within the bolt chamber **134**. A volume between an internal wall of the bolt carrier **130** and the rear portion of the bolt member **132** forms a gas actuation chamber that receives the propellant gas G.

With continued reference to FIG. **3**, in the depicted embodiment, the bolt carrier **130** receives the propellant gas G from the barrel **16** and gas system **18** (examples of which are shown in FIGS. **1**-**2**). In particular, the gas system **18** may direct the propellant gas G into a gas key **27** attached to the bolt carrier **130**, and the gas key **27** may direct the gas into a gas inlet port **140** on the bolt carrier **130**. The gas inlet port may fluidically connect to the gas actuation chamber defined between the inner wall of the bolt carrier **130** and the rear portion of the bolt member **132**, such that, unless otherwise obstructed by the moving elements described herein, the bore **17** of the barrel **16** is configured to be fluidically connected to the gas actuation chamber within the bolt carrier **130** via the gas system **18** (e.g., via gas tube receiving passage **120** shown in FIG. **9**). As would be appreciated by one skilled in the art in light of the present disclosure, the action **22** may include a firing pin **162**, a firing pin retainer pin **142**, and/or a bolt cam pin **144**. The bolt member **132** may include an extractor **158**, extractor spring assembly **160** and/or, an extractor pin **146**. The bolt member **132** may include an ejector **156**, ejector spring **154**, and/or an ejector roll pin **148**.

During firing of the depicted embodiment, when the trigger **23** is pulled and before any movement of the bolt carrier **130**, a head portion of the bolt member **132** may be locked with the barrel **16** to prevent the bolt member **132** from being forced rearward by the initial inertia of the projectile case during combustion of the propellant. In some embodiments, once the propellant gas G passes through the gas system **18** and enters the bolt carrier **130**, the pressure of the propellant gas G acts on (1) the surface of the bolt member **132** and on the gas seal rings **136** of the bolt member **132** on the one hand and (2) on the rear, interior surfaces of the bolt carrier **130** on the other hand. Because the bolt member **132** cannot move forward, due to being in contact with the barrel **16**, the resulting pressure of the propellant gas G in the gas actuation chamber causes the bolt carrier **130** to move rearward, in a linear direction, within the receiver **12**.

In one embodiment, as the bolt carrier **130** is initially retracted rearward under the pressure of the propellant gas G, the bolt member **132** is rotated sufficiently (e.g., via camming surfaces (not shown) between the bolt carrier **130** and bolt member **132**) to unlock its head portion from a locking receptacle (not shown) of the barrel **16**. The bolt member **132** then retracts along with the bolt carrier **130** as the inertia of the bolt carrier **130** continues rearward. As the bolt member **132** is retracted, it extracts a spent cartridge case **31** from the chamber **33** of the barrel **16**, and ejects the spent case **31** through a cartridge port, or breech (not shown), formed in the receiver **12**. The rearward movement of the bolt carrier **130** may also cause cocking of the trigger mechanism.

In some embodiments, the bolt carrier **130** compresses a recoil spring (not shown) as the bolt carrier **130** and bolt member **132** translate rearward. The recoil spring may drive the bolt carrier **130** and the bolt member **132** forward when the pressure exerted by the propellant gas G has decreased sufficiently so as to be overcome by the force of the recoil spring. As the bolt carrier **130** and bolt member **132** subsequently are driven forward by the force of the recoil spring, the head portion of the bolt member strips an unfired cartridge **32** from the magazine **19**, and feeds the cartridge **32** into the chamber **33** of the barrel **16** in preparation for subsequent firing. The bolt member **132** may again be axially rotated (e.g., by camming surfaces between the bolt carrier **130** and bolt member **132**) to lock the head portion of the bolt member **132** with the barrel **16** when the cartridge is **32** inserted in the chamber **33**. In some embodiments, the gas system **18** includes a gas block **100** configured for mounting on the barrel **16**. In some embodiments, the gas block **100** and barrel **16** may be one integral piece made of a single block of material, separately formed components that are then attached (e.g., welded, screwed, adhered, or the like) during assembly, or any other manner of producing the described structures as a whole. In some embodiments, multiple gas blocks may be used, with one or more ports being defined in two different blocks, with the multiple gas blocks operating as described herein with respect to any embodiment of a gas block. Unless stated otherwise, reference to a "gas block" and a "barrel" does not imply or require the two named elements to comprise a single integral piece or multiple pieces. Unless stated otherwise, two or more components that are not required to move relative to one another during firing may be manufactured as a single piece or multiple pieces without departing from the spirit of the present disclosure, and two or more components that are not required to move relative to one another during firing but for which the use of either a single piece or multiple pieces is otherwise preferred (e.g., for manufacturability, maintainability, or other reasons) may be considered equivalent to the non-preferred single piece or multiple piece embodiments. The barrel **16** and the gas block **100** together form an assembly for directing propellant gas to the action **22** of the firearm **10** with or without one or more intermediate conduits.

The barrel **16** has an outer surface **102**; and an inner surface **104** that defines the bore **17**. The inner surface **104** can have rifling to impart spin to the projectile **30** as it travels through the barrel **16** during discharge of the firearm **10**. In one embodiment in which the gas block **100** is attached to the barrel **16**, the outer surface **102** has a smooth and/or constant-diameter surface portion **106**, as shown in FIGS. **4**, **6**, and **11**, for engaging with the gas block **100**. In some embodiments, a continuous indentation or groove **108** is formed in the surface portion **106**, and extends along the entire outer circumference of the surface portion **106**. The groove **108** can have a semi-circular cross section, as can be seen in FIGS. **6**, **11**, and **13**; the cross-section of the groove **108** can have other shapes, such as square or rectangular, in alternative embodiments. In embodiments having a single-piece gas block and barrel, the groove may be equivalently described as a passage within the combined gas block and barrel.

In some embodiments, the barrel **16** may include a plurality of gas ports **110** terminating at the bore **107** of the barrel **16**, such that the propellant gas G may have multiple flow paths out of the bore **17**. With reference to FIGS. **4-29**, **36-38**, and **42-48**, the depicted barrels **16** (including barrels **16***a*-**16***f*) have three gas ports **110** formed therein. The barrel gas ports **110** are shown as having a cylindrical shape in FIGS. **8**, **9**, **11**, and **13**. In some embodiments, each barrel gas port **110** extends through the wall of the barrel **16**, between the inner surface **104** and the groove **108**.

In some embodiments, one or more barrel gas ports **110** may fluidically connect within the barrel **16**, such that the barrel includes multiple entrance openings at the surface of the bore **17** and one or more fewer outlet openings downstream of the bore. In some embodiments, each barrel gas port **110** forms a flow path that extends in a direction substantially perpendicular to the lengthwise (longitudinal) direction of the bore **17**; and these flow paths place the bore **17** in fluid communication with the groove **108** so that the high-pressure propellant gas G within the bore **17** can reach the groove **108**.

Referring to FIGS. **8** and **9**, the depicted embodiment shows each barrel gas port **110** angularly spaced from the adjacent barrel gas ports **110** by about 120 degrees. More specifically, each of the barrel gas ports **110** of the depicted barrel **16** has an entrance defined by the inner surface **104** of the bore **107** of the barrel **16**; and the entrances of adjacent ones of the barrel gas ports **110** are spaced apart along a circumference of the inner surface **104** by substantially equal (i.e., equal or approximately equal) angular distances. In some embodiments, the barrel gas ports **110** may each be disposed at the same axial position relative to a length of the barrel **16**.

The barrel **16** can include a plurality of barrel gas ports **110**—i.e., more or less than three gas ports **110**, such as 2, 3, 4, 5, 6, 7 or more barrel gas ports **110**. Additionally, adjacent barrel gas ports **110** can be angularly spaced, evenly or unevenly from each other by more or less than 120 degrees, such as 45, 60, 75, 90, 105, 135, 150, 165, or 180 degrees.

Each barrel gas port **110** has a diameter of, for example, about 0.068 inches in an example embodiment using three ports. In an example embodiment using one port, the port may have a diameter of, for example, about 0.089 inches. In some embodiments, the number of ports may be inversely proportional to the size of each port. In some embodiments, the diameter of each port may be determined as the minimum diameter required to actuate the firearm without malfunctioning. In some embodiments using multiple ports, each port may have a different diameter. As used herein, the term "about" in reference to a numerical value means plus or minus 15 percent of the numerical value of the number with which it is being used. Also, specific dimensions are presented herein for exemplary purposes only, and unless expressly stated otherwise are not intended to limit the scope of the appended claims; alternative embodiments can have dimensions other than those specified herein.

In some embodiments in which the gas block **100** attached to the barrel **16**, the gas block **100** has an inner surface **112** that defines a cylindrical barrel receiving passage **113** within the gas block **100**. The inner surface **112** is depicted in FIGS. **9**, **13**, and **30-32**. As shown in FIG. **13**, the barrel receiving passage **113** has a diameter that approximately matches the outer diameter of the barrel **16** at the location of the barrel gas ports **110** (e.g., the outer surface portion **106** described herein), so that the gas block **100** fits snugly over the barrel **16** with minimal clearance.

The groove **108** in outer surface portion **106** of barrel **16** and the overlying portion of the inner surface **112** of the gas block **100** may define a closed flow path or passage **114**, as depicted in FIG. **9**—e.g., the groove **108** and the outer surface portion **106** each partly define the passage **114**. The passage **114** directs the high-pressure propellant gas G from the groove **108** into the gas block **100**. The minimal clearance between the gas block **100** and the barrel **16** discourages leakage of propellant gas from the passage **114**. In some embodiments, the passage **114** may be defined by either or both of the gas block **100** and the barrel **16**.

In some embodiments, the gas block **100** can be secured to the barrel **16** by, for example, two set screws (not shown) that are accommodated by threaded holes **116** formed in the gas block **100**. An example of holes **116** is shown in FIG. **13**. In some embodiments, the gas block **100** is configured to abut a larger-diameter surface portion **38** (labeled in FIG. **6**) of the outer surface **102** of the barrel **16**, wherein surface portion **38** has a larger diameter than surface portion **106**, when the gas block **100** is properly positioned on the barrel **16**, as can be seen in FIGS. **4-7**. This feature can help ensure that the gas block **100** is installed at its proper longitudinal position along the length of the barrel **16**. Other features, such as dimples (not shown) formed in the outer surface **102** of the barrel **16** for receiving the ends of the set screws, can be used to help ensure that the gas block **100** is positioned at its proper angular orientation in relation to the barrel **16**.

The depicted gas block **100** has a gas port **118**, shown as having a cylindrical shape, and a gas tube receiving passage **120** formed therein. Example embodiments of the gas block gas port **118** and the gas tube receiving passage **120** are shown in FIGS. **9** and **13**. The gas port **118** and gas tube receiving passage **120** may facilitate communication of the propellant gas G from the barrel gas ports **110** and the passage **114** to the action **22**.

The gas block gas port **118** may extend in a direction substantially perpendicular to the lengthwise direction the barrel receiving passage **113** and the barrel **16**. The gas block gas port **118** can have other orientations in alternative embodiments. The gas block gas port **118** has a diameter of, for example, about 0.068 inches. The gas tube receiving passage **120** extends substantially parallel to the lengthwise direction of the barrel receiving passage **113**, and the longitudinal axis of the barrel **16**. In some embodiments one or more intermediate gas tubes (e.g., the conduit shown in FIGS. **1-2**) may extend from the gas tube receiving passage **120** to the gas key **27** (shown in FIG. **3**). The aforementioned gas tube(s) may be separate tubes or may be conduits formed in or on any other portion of the firearm. In some embodiments, the gas block may include multiple gas tube receiving passages, each connected to at least one of the plurality of gas ports and each connected to at least one of a plurality of gas tubes that extend to the action.

The gas block **100** may be configured so that the gas block gas port **118** and/or a channel or other passage connected thereto aligns with the groove **108** in the outer surface portion **106** of the barrel **16**, as shown in FIG. **13**. As can be seen, the inner end of the gas port **118** faces, and is open to the groove **108**, so that the propellant gas in the passage **114** can enter the gas block **100** by way of the gas port **118**. In some embodiments, the diameter of the end portion of the gas block gas port **118** that is open to and abuts the groove **108** is equal to or larger than the diameter of the groove **108**. In instances in which multiple ports and/or one or more grooves are formed in the gas block, these ports and/or groove(s) may likewise serve as a portion of the passage to guide propellant gas G from the multiple barrel gas ports **110** opening into the bore **107** to the gas block gas port **118**.

The gas tube receiving passage **120** receives the propellant gas G from the gas block gas port **118**, and directs the propellant gas G to a gas tube (not shown) of the gas system **18**. An example of a gas tube is shown in US 2020/0033085, which is hereby incorporated by reference. A forward end of the gas tube is positioned in the gas tube receiving passage **120**. The diameter of the gas tube receiving passage **120** is sized so that the gas tube fits within the gas tube receiving passage **120** with minimal clearance, to discourage leakage of the propellant gas G entering the gas tube. The forward end of the gas tube is secured to the gas block **100** by a pin. As used herein, "pin" refers to a round pin, screw, square pin, flat pin, solid cylindrical pin, tapered pin, groove pin, spring pin, or any other shaped component or structure that would serve the same purpose described herein. The pin is accommodated by a pair of diametrically-opposed holes **124** (visible in FIG. **7**) formed in the gas block **100**, on opposite sides of the gas tube receiving passage **120**; and by a correspondingly aligned pair of diametrically-opposed holes formed in the gas tube.

The rearward end of the gas tube is connected to a gas key **27** (shown in FIG. **3**) of the gas system **18**. The gas key **27** receives the propellant gas G from the gas tube, and directs the propellant gas to the action **22** of the firearm **10** as described herein. In embodiments utilizing other gas-driven mechanisms, such as but not limited to a short- or long-stroke piston, the gas tube may likewise receive and/or be connected to such gas-driven components as would be appreciated in light of the present disclosure. In the depicted embodiment, the gas port **118** and gas tube receiving passage **120** define a single gas conduit connected to the action, such that the flow paths from the barrel gas ports **110** are combined upstream of the gas port **118** and gas tube receiving passage **120**. In some embodiments, any one or more ports and passages that collectively define a fluidic connection between the barrel gas ports **110** and the action **22** as described herein may be utilized.

In the depicted embodiments, the barrel gas ports **110**, passage **114**, gas block gas port **118**, gas tube receiving passage **120**, gas tube, and gas key **27** form a flow path that directs the high-pressure propellant gas G from the bore **17** to the action **22**. In particular, the propellant gas G generated by the burning propellant of the cartridge **32** travels behind the projectile **30**, and propels the projectile **30** through the bore **17** of the barrel **16**, as indicated by the arrows in FIG. **2**. As the propellant gas G reaches the barrel gas ports **110** in the barrel **16**, a portion of the propellant gas G enters, and travels through the barrel gas ports **110**. A passage **114** may then rejoin the propellant gas G traveling through each of the barrel gas ports **110**, which propellant gas G may be channeled to the action to drive reloading and cocking the firearm. For example, in some embodiments, the propellant gas G exits the barrel gas ports **110** and enters the passage **114** defined by the groove **108** and the inner surface **112** of the gas block **100**. The relatively high pressure within the bore **17** immediately after the firearm **10** is discharged may push the propellant gas G through the passage **114** and toward the gas block gas port **118** in the gas block **100**.

In some embodiments, the propellant gas G enters the gas block **100** via the gas block gas port **118**, and is directed to the gas tube by way of the gas block gas port **118** and the adjoining gas tube receiving passage **120**. The propellant gas G then travels through gas tube, and enters the action **22** by way of the gas key.

The multiple barrel gas ports **110** and the passage **114** may act as a manifold in which propellant gas G is taken from multiple locations within the barrel **16**, combined into a single flow, and then directed to the action **22**. As described herein in various embodiments, the barrel gas ports **110**, passage **114**, and any additional channels, conduits, or the like may be configured as one or more pieces. This arrangement permits the barrel gas ports **110** to be sized smaller than otherwise would be possible. More specifically, the multiple barrel gas ports **110** each can have a smaller diameter than a single gas port through which all of the propellant gas G is directed, while maintaining an aggregate flow rate of propellant gas G equal to the flow rate through a single, larger-diameter gas port for a given model of firearm. In some embodiments, the size of the gas ports may be determined experimentally by choosing the smallest opening which permits the action to cycle.

In various embodiments, the use of smaller-diameter gas ports such as the barrel gas ports **110** can provide significant advantages. For example, the smaller-diameter barrel gas ports **110** are believed to be less susceptible to erosion. As discussed above, the surface that defines a barrel gas port, in general, is susceptible to erosion as the hot, high-pressure propellant gas, which includes abrasive combustion byproducts, passes through the barrel gas port at high velocity. For a given cross-sectional flow area (e.g., assuming a single, large port is replaced by a plurality of smaller ports having the same cumulative cross-sectional flow area), the cumulative circumference of the smaller openings in the bore will be greater than the circumference of the larger opening. It is believed that this greater "length" of the opening circumferences will resist erosion better than a smaller-circumference opening. Thus, when multiple barrel gas ports are used, the erosive effects of the propellant flow are spread out over a greater opening edge length, potentially reducing erosion of the gas edge port surfaces. Moreover, when multiple gas ports are used, the interior of the barrel gas ports **110** may likewise define a greater combined interior surface area than the interior surface area of a single barrel gas port while providing a comparable flowrate. In some embodiments, multi-port designs may define a greater cumulative area than the equivalent area of a one port design.

Also, it is believed that the smaller gas ports cause less damage to the projectile **30**, providing an additional benefit to projectile stability and accuracy. As discussed above, a discharged projectile, such as the projectile **30** traveling, down a bore **17** expands against the adjacent inner surface of the barrel **16** as a result of the pressure of the expanding gas behind it. When the projectile **30** passes a barrel gas port, this expansion will push some of the projectile **30** into the gas port, which in turn will shave off material from the projectile **30**. By obdurating the bullet into the ports, a deformation or recess may be cut into the bullet for each port, which may cause multiple ports to have the potential for greater accuracy since the deformations may be spaced, and in some instances, evenly spaced. In contrast, for a barrel having a single gas port, this shaving action may remove material from one side of the projectile **30**, shifting the center of mass from the projectile's axis of rotation and causing an imbalance. The resulting imbalance in the projectile **30** can reduce the gyroscopic stability of the projectile **30**, causing the projectile **30** to deviate from its intended path, and thereby reducing shooting accuracy.

It is believed that the use of smaller barrel gas ports such as the barrel gas ports **110** can reduce the amount of material shaved off the projectile **30** and thus reduce the degree of the imbalance. Also, by spacing the multiple barrel gas ports **110** from each other, preferably in equal angular increments, the material loss associated with any one barrel gas port **110** can be offset or counter-balanced by the material losses associated with the other barrel gas ports **110**, which may maintain the center of mass along the axis of rotation of the projectile **30**. Thus, any net imbalance and loss of stability in the projectile **30** caused by the localized material loss can be minimized or substantially eliminated. It is noted that this result also can be achieved through the placement of holes extending outward from inner surface **104** of the barrel **16** (i.e., penetrating through the barrel body). In some embodiments, such holes, along with a single gas port, may be spaced apart in equal angular increments circumferentially about the barrel. The holes themselves may extend, for example, in a direction substantially perpendicular to the lengthwise direction of the barrel, or may extend at an angle of up to 30 degrees, up to 45 degrees, or up to 60 degrees from a direction substantially perpendicular to the lengthwise direction of the barrel. Additionally, these holes do not need to function as gas ports, and do not need to facilitate any gas flow whatsoever to achieve the aforementioned beneficial balancing effect. In some embodiments, multiple barrel gas ports need not be smaller than a single barrel gas port to achieve the beneficial balancing effect due.

In the following descriptions of alternative embodiments of the barrel **16** and gas block **100**, and in the accompanying figures, identical reference characters are used to denote components of the alternative embodiments that are substantially identical to components of the barrel **16** and the gas block **100**. As described herein, in various embodiments, any groove(s), channel(s), or equivalent passage(s), formed from one or more structural elements, that combine and connect the barrel gas ports **110** with the action **22** may be used.

FIGS. **14-17** depict an alternative embodiment of the barrel **16** in the form of a barrel **16***a*. The barrel **16***a* is substantially identical to the barrel **16**, with the exception that the barrel **16***a* has a groove **108***a* that extends along only a portion of the circumference of the outer surface **102** of the barrel **16**. More specifically, as shown in FIGS. **16** and **17**, the groove **108***a* extends along the three depicted barrel gas ports **110**, but does not extend between the two lowermost depicted barrel gas ports **110**.

FIGS. **18-21** depict another alternative embodiment of the barrel **16** in the form of a barrel **16***b*. The barrel **16***b* is substantially identical to the barrel **16***a*, with the exception that the barrel gas ports **110** are not all located at the same lengthwise or axial position along the barrel **16***b*. The barrel **16***b* has a groove **108***b* that extends along the outer surface **102** of the barrel **16***b* in a curvilinear manner, as shown in FIG. **19**, so that the position of the groove **108***b* in the axial direction of the barrel **16** constantly changes along the length of the groove **108***b*. This arrangement permits the groove **108***b* to align with each of the barrel gas ports **110** located at different axial positions along the barrel **16**. In this particular embodiment, two of the barrel gas ports **110** are located at the same axial position, as can be seen in FIG. **21**. The respective axial positions of the barrel gas ports **110** can be different, and the groove **108***b* can have a shape other than curvilinear in variants of the barrel **16***b*. In the depicted embodiment, the propellant gas enters the lower, rearmost two barrel gas ports **110** simultaneously and the top, frontmost gas port **110** after the other two. In some embodiments, axially offsetting two or more of the gas ports produces a softer push of the action, which is believed to be caused by the offset timing of the gas passing through the ports. This softer push may improve operation of at least some firearms.

For example FIGS. **42-48** depict a variant of the barrel **16***b* in the form of a barrel **16***f*. The barrel **16***f* has three barrel gas ports **110** each located at a different axial position along the barrel **16***f*. The barrel **16***f* has a groove **108***d* that extends along the outer surface **102** of the barrel **16***f* in a linear, i.e., substantially straight, manner from the perspective of the surface of the barrel **16***f* shown in FIG. **44**, so that the position of the groove **108***d* in the axial direction of the barrel **16***f* constantly changes along the length of the groove **108***d*, allowing the groove **108***d* to align with each of the barrel gas ports **110** located at different axial positions along the barrel **16**, such that the propellant gas enters each of the barrel gas ports **110** sequentially.

In other variants of the barrel **16***b*, the groove **108** can be widened to accommodate barrel gas ports **110** in different axial positions on the barrel **16**, without the groove **108** itself changing its axial position on the barrel **16**, i.e., without the groove **108***b* extending forward or rearward on the barrel.

FIGS. **22** and **23** depict another alternative embodiment of the barrel **16** in the form of a barrel **16***c*. The barrel **16***c* is substantially identical to the barrel **16***a*, with the exception that the barrel gas ports **110***a* of the barrel **16***c* do not extend radially in relation to the axial centerline of the barrel **16***c*, i.e., barrel the gas ports **110***a* do not extend in a direction perpendicular to the axial centerline of the barrel **16**, from the perspective of FIG. **23**. Instead, the barrel gas ports **110***a* have an angular offset in relation to the radial direction, as can be seen in FIG. **23**. As depicted, groove **108***a* extends along only a portion of the circumference of the outer surface **102** of the barrel **16**.

In some embodiments, the groove **108** may be FIGS. **24** and **25** depict another alternative embodiment of the barrel **16** in the form of a barrel **16***d*. The barrel **16***d* is substantially identical to the barrel **16***a*, with the exception that the angular spacing between adjacent gas ports **110** is not equal.

FIGS. **26-34** depict another alternative embodiment of the barrel **16** in the form of a barrel **16***e*, and an alternative embodiment of the gas block **100** in the form of a gas block **100***a*. In these embodiments, a groove **108***c*, similar to the groove **108**, is located on the inner surface **112** of the gas block **100***a*; and no groove is formed on the barrel **16***e*. The groove **108***c* and the adjacent portion of the outer surface **102** of the barrel **16***e* define a passage **114***a* similar to the passage **114** defined by the respective barrel **16** and gas block **100**. Propellant gas G from the bore **17** is directed to the passage **114***a* by the barrel gas ports **110**; and the passage **114***a* directs the propellant gas G to the gas block gas port **118** of the gas block **100***a* in a manner similar to the passage **114**. In some embodiments, both the gas block and the barrel may include at least a portion of the passage.

In the depicted embodiment, the groove **108***c* extends along the entire circumference of the inner surface **112** of the gas block **100***a*. In other alternative embodiments (not shown), the groove can extend along only a portion of the circumference of the inner surface **112**. In other alternative embodiments, the respective positions of the gas ports **110** in the axial direction of the barrel **16** can vary, and the groove can be curved (e.g., like the groove **108***a*) or linear and angled (e.g., like the groove **108***d*) so as to align with the various barrel gas ports **110**. In other alternative embodiments incorporating the groove located on the gas block **100***a*, the gas ports **110** can be offset from the radial direction like the barrel gas ports **110***a*; and the angular spacing between adjacent gas ports **110** can be non-equal as in the embodiment shown in FIGS. **24** and **25**.

FIGS. **35-41** depict another alternative embodiment of the gas block **100** in the form of a gas block **100***b*. The gas block **100***b* can be used with the barrel **16***e*, i.e., with the variant of the barrel **16** without any groove **108** formed therein. In some embodiments, the gas block **100***b* and barrel **16***e* may be integral as described herein. The gas block **100***b* may include one or more external conduits—e.g., 1, 2, 3, 4, or more external conduits. As depicted, gas block **100***b* includes two external conduits **150**. Each conduit **150** defines an enclosed passage **152**. An entrance to each passage **152** aligns with, and communicates with an associated one of the barrel gas ports **110** of the barrel **16**. An exit of each passage **152** adjoins a gas block gas port **118***a* of the gas block **100***b*. The passages **152** thus direct propellant gas from the two lower barrel gas ports **110** of the barrel **16** directly to the gas block gas port **118***a* of the gas block **100***b*. As can be seen in FIG. **38**, the gas block gas port **118***a* aligns with, and communicates directly with the uppermost barrel gas port **110**. Thus, this arrangement provides a manifold configuration similar to the barrel **16** and gas block **100**, and their variants, using external rather than internal flow passages. In some embodiments, the flow passages may each separately feed into the gas tube receiving passage **120** and/or gas tubes extending to the action.

FIGS. **49-51** depict an alternative embodiment of the gas block **100***b* in the form of a gas block **100***e*. In the embodiment of FIGS. **49-51**, the gas block **100***e* may be structured and may operate identically to the gas block **100***b* of FIGS. **35-41** except that the depicted conduits **150***a* and enclosed passages **152***a* extend outwardly from the gas block **100***e* with a gap between the conduits and the main body of the gas block.

In some embodiments, at least the barrel **16** may be rotationally agnostic, such that the relative rotation between the barrel and the gas block **100** does not affect fluidic coupling between the two. This may simplify assembly of the firearm because the user need not precisely align the barrel and gas block for operation. FIGS. **52-61** depict another example embodiment having a barrel **16***g* and gas block **100***f* which are rotationally agnostic relative to each other. The depicted gas block **100***f* includes a gas block gas port **118** and gas tube receiving passage **120** to receive the gas and direct the gas to the action as described in other embodiments herein. In some embodiments, an upper outlet **122** may be formed in the gas block **100***f* above the gas tube receiving passage **120** to enable machining of the gas block gas port **118**.

In the depicted embodiment, the barrel includes a plurality of barrel gas ports **110** spaced axially and rotationally from each other. Each of the barrel gas ports **110** is connected to groove **108***e*, which extends about the circumference of the barrel **16***g* and is sufficiently wide to encompass the outlets of each of the barrel gas ports **110**. In the depicted configuration, the pressurized gas may travel from the barrel to the action in the manner described with respect to any embodiment herein in instances in which the groove **108***e* aligns at some radial and axial position with the gas block gas port **118**. In this manner, the barrel **16***g* and gas block **100***f* may be said to be rotationally agnostic because, with reference to FIGS. **54-56**, none of the gas block ports **110** need align with any particular rotational position (e.g., the uppermost port **110** need not align with the gas block gas port **118**) because they each connect to the groove **108***e* which extends entirely around the circumference of the barrel **16***g*, which groove connects to the gas block gas port **118** in any rotational position and several axial positions. In some embodiments, the gas block **100***f* will define the gas tube receiving passage **120** at an uppermost side of the gas block relative to the firearm to align with the gas key.

Similarly, the structures shown in the remaining embodiments herein may be used with the embodiment of FIGS. **52-61**, such as including a groove on the interior of the gas block **100***f* in addition to or instead of the groove **108***e* on the barrel **16***g*. The gas block **100***f* and barrel **16***f* may also be made as a single, integral piece or as multiple pieces in accordance with any embodiment discussed herein. The remaining structures not detailed with respect to any embodiment discussed herein may be configured to operate in accordance with the structure and function of any other embodiment.

The various embodiments described above are provided by way of illustration only and should not be construed to limit the claims attached hereto. Those skilled in the art will readily recognize various modifications and changes that may be made without following the example embodiments and applications illustrated and described herein, and without departing from the true spirit and scope of the following claims.

I claim:

1. An assembly for directing gas to an action of a firearm, comprising:

a barrel defining a bore configured to guide a projectile as the projectile is propelled through the bore by pressurized gas, the barrel having a plurality of barrel gas ports formed therein, wherein the barrel gas ports are longitudinally displaced from one another along a longitudinal axis of the barrel, each of the plurality of barrel gas ports being in fluid communication with the bore; and a gas block configured to be mounted on and at least partially encircle the barrel, the gas block having a gas block gas port formed therein,

wherein at least one of the barrel and the gas block defines a groove as part of a passage configured to direct the pressurized gas from the plurality of barrel gas ports to the gas block gas port, wherein all of the plurality of the longitudinally displaced barrel gas ports are directly connected with the groove, and wherein the gas block gas port is directly connected with the groove, and wherein pressurized gas from the barrel is conducted through the plurality of barrel gas ports, through the groove, and into the gas block gas port.

2. The assembly of claim **1**, wherein an outer surface of the barrel has the groove formed therein.

3. The assembly of claim **2**, wherein the barrel has an inner surface that defines the bore; each of the plurality of barrel gas ports has an entrance defined by the inner surface of the barrel; the entrance of one of the plurality of barrel gas ports is positioned at a first location along a length of the barrel; and the entrance of a second one of the plurality of barrel gas ports is positioned at a second location along the length of the barrel different than the first location.

4. The assembly of claim **2**, wherein an exit of each of the plurality of barrel gas ports is located at least partly within the groove.

5. The assembly of claim **1**, wherein the groove extends along an entire circumference of the outer surface of the barrel or an entire circumference of the inner surface of the at least one gas block.

6. The assembly of claim **1**, wherein the groove extends along a portion of a circumference of the outer surface of the barrel or a portion of a circumference of the inner surface of the at least one gas block.

7. The assembly of claim **1**, wherein the barrel has an inner surface that defines the bore; each of the plurality of barrel gas ports has an entrance defined by the inner surface of the barrel; and the entrances of the plurality of barrel gas ports are spaced apart along a circumference of the inner surface barrel by substantially equal angular distances.

8. The assembly of claim **1**, wherein the at least one gas block has a gas tube receiving passage formed therein and configured to receive an end of a gas tube, wherein the gas tube receiving passage is in fluid communication with the gas block gas port.

9. The assembly of claim **1**, wherein the groove is formed in the outer surface of the barrel; and the passage is defined by the groove and an adjacent portion of the inner surface of the at least one gas block.

10. The assembly of claim **1**, wherein the groove is formed in the inner surface of the at least one gas block; and the passage is defined by the groove and an adjacent portion of the outer surface of the barrel.

11. The assembly of claim **1**, wherein the plurality of barrel gas ports extend radially in relation to a longitudinal axis of the barrel.

12. The assembly of claim **1**, wherein the groove and the plurality of barrel gas ports form a manifold operable to supply a stream of the pressurized gas to the gas block gas port from the plurality of barrel gas ports.

13. The assembly of claim **1**, wherein the at least one gas block and the barrel define a single integral piece.

14. A firearm, comprising the assembly of claim **1**.

15. The assembly of claim **1**, wherein the groove is defined within the gas block, and the groove at least partly defines the passage through the gas block.

16. The assembly of claim **15**, wherein the groove is configured to direct the pressurized gas from the plurality of barrel gas ports to the gas block port is further configured to direct the pressurized gas through the passage of the gas block to the action of the firearm.

17. The assembly of claim **16**, wherein the at least one gas block receives gas through the gas block gas port in a direction perpendicular to an axis along which the bore extends, and expels gas in a direction substantially parallel to the axis along which the bore extends, and wherein the barrel gas ports also extend perpendicular to the axis along which the bore extends.

18. A portion of a firearm comprising:

a barrel having an inner surface defining a bore configured to guide a projectile as the projectile is propelled through the bore by pressurized gas,

wherein the barrel has a plurality of barrel gas ports formed therein, the plurality of barrel gas ports displaced from one another along a longitudinal axis of the barrel,

wherein each of the plurality of barrel gas ports has an entrance defined by the inner surface of the barrel,

a gas block mounted on and at least partially encircling the barrel of the firearm at a position aligned with an axial location of the plurality of barrel gas ports defining at least one gas block gas port in fluid communication with the plurality of barrel gas ports;

wherein a groove is defined in at least one of the barrel and the gas block, wherein all of the plurality of barrel gas ports are directly connected with the groove, wherein the gas block gas port is directly connected with the groove, and

wherein all of the plurality of barrel gas ports are configured to conduct the pressurized gas from the barrel to the groove, through the at least one gas block gas port, and through a gas tube receiving path to act on, at least indirectly, an action of the firearm.

19. The barrel of claim **18**, wherein an outer surface of the barrel has the groove formed therein and wherein the groove at least partly defines a passage for directing the pressurized gas to the action of the firearm.

20. The barrel of claim **18**, wherein the plurality of barrel gas ports are spaced circumferentially about the barrel.

21. A firearm comprising the barrel of claim **18**.

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