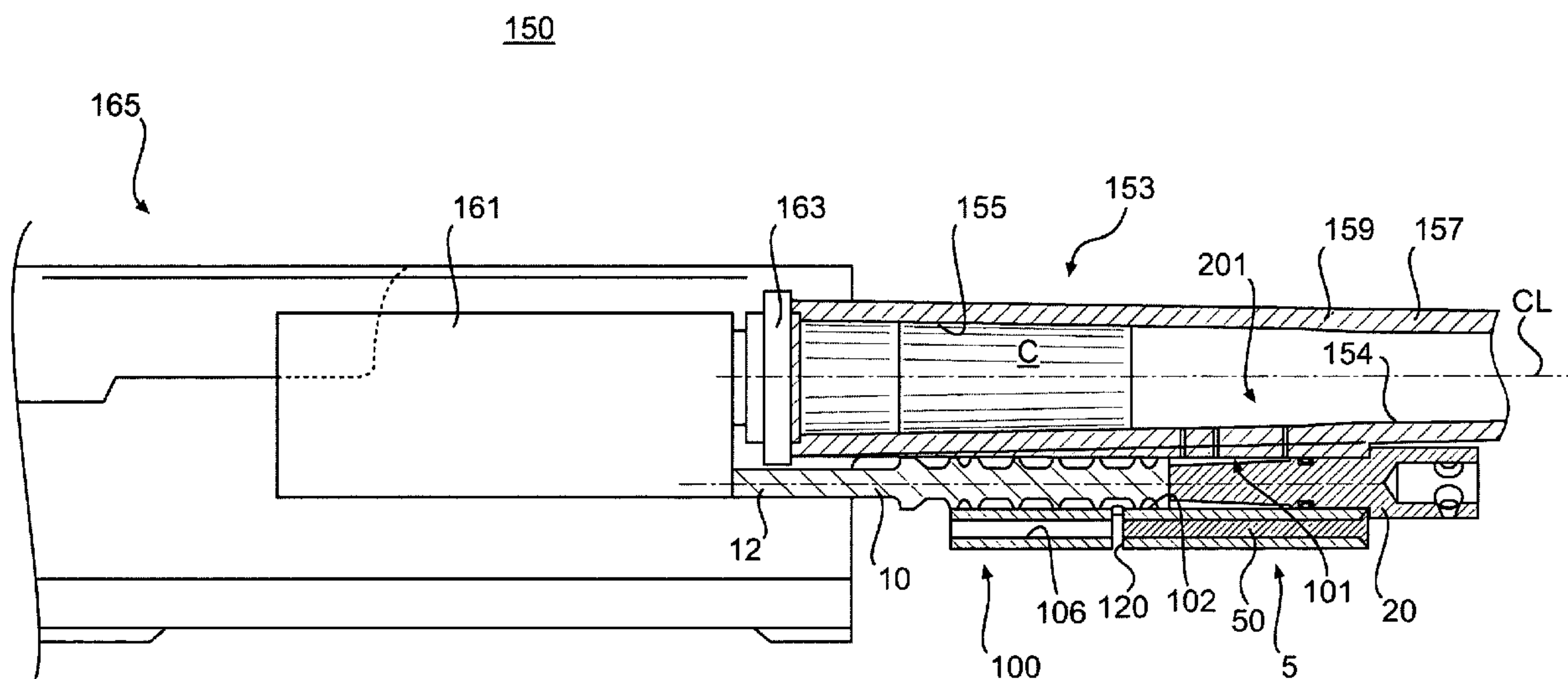




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(57) Abrégé/Abstract:

A gas operating system (5) for a firearm renders the firearm capable of firing a wide range of shot loads by passively and/or automatically compensating for different shot loads. The firearm includes a plurality of ports (210, 212, 214, 230, 232, 234) formed in the firearm barrel, and corresponding ports (110, 112, 114, 130, 132, 134) formed in a gas cylinder (100) of the gas operating system. The ports tap gases generated during firing which are used to cycle the firearm. When firing different cartridge loads, differing combinations of the ports are selectively at least partially blocked or otherwise obstructed by the cartridge casing according to the size of the cartridge.





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(57) Abstract: A gas operating system (5) for a firearm renders the firearm capable of firing a wide range of shot loads by passively and/or automatically compensating for different shot loads. The firearm includes a plurality of ports (210, 212, 214, 230, 232, 234) formed in the firearm barrel, and corresponding ports (110, 112, 114, 130, 132, 134) formed in a gas cylinder (100) of the gas operating system. The ports tap gases generated during firing which are used to cycle the firearm. When firing different cartridge loads, differing combinations of the ports are selectively at least partially blocked or otherwise obstructed by the cartridge casing according to the size of the cartridge.

GAS-OPERATED FIREARM

BACKGROUND

Technical Field

[0001] The present invention generally relates to a gas operating system for firearms that allows firing of different cartridge loads for a given shell caliber or gauge.

Related Art

[0002] Automatic and semiautomatic shotguns having user-adjustable gas systems are known. Adjustable gas systems allow a user to control the amount of gas entering into and/or vented from the system, which allows a wider range of cartridge loads to be fired from a single firearm. However, if an adjustable gas system is set for heavy loads and the weapon is used to fire light loads, the firearm may not fully cycle, which may require the user to manually cycle the bolt in order to load the next round. If the adjustable gas system is set for light loads and the weapon is used to fire a heavy load, the bolt velocity after firing may result in improper cycling and the weapon may suffer reduced part life for certain components.

[0003] Firearms such as the Remington M/1187 have self-compensating gas systems. Self-compensating gas systems allow a wider range of loads to be fired without requiring adjustment of the gas system. However, the wide range of available cartridge loads may not be sufficiently compensated by conventional self-compensating systems. For example, 12 gauge loads have a wide spread from light 2-3/4" loads to heavy 3-1/2" loads. As a result, some self-compensating designs may not reliably operate light loads under all

conditions, and may suffer undesirably high bolt velocities when firing heavy magnum loads.

SUMMARY

[0004] According to a first example embodiment of the invention, a gas-operated firearm comprises a receiver, a firing mechanism, a barrel having a firing chamber, a plurality of ports extending through the barrel and opening into the firing chamber, a bolt having a locking position in which the bolt is adjacent a first, chamber end of the barrel, and a gas operating system comprising a gas cylinder. The gas cylinder has at least one piston bore in fluid communication with the barrel through the plurality of ports in the barrel. The bores in the barrel can be arranged as single ports or as groups of ports located at different distances from the chamber end of the barrel.

[0005] According to one aspect of the present invention, the firearm is capable of firing different cartridge loads, which generally correspond to different cartridge lengths. The ports in the barrel can be arranged so that when shorter, lighter load cartridges are fired, the cartridge casing is short enough so that it does not interfere with, or render “inactive” any of the ports in the barrel. The gases from firing therefore pass unimpeded to the gas operating system and provide the energy needed to perpetuate the action of the firearm. As longer cartridges corresponding to heavier loads are fired, the cartridge case may extend to a sufficient length within the chamber so that one or more of the ports in the barrel are at least partially blocked, obscured, or otherwise rendered “inactive” by the cartridge case. In general, the heavier the cartridge load, the longer the cartridge, and accordingly a greater number of ports are rendered inactive during firing of longer cartridges. The larger the number of inactive ports, the smaller the percentage of firing gases that are used to cycle the firearm. Heavier load cartridges are therefore compensated for because the

greater the cartridge load, the smaller the percentage of the firing gases that is passed to the gas operating system to cycle the firearm.

[0006] According to another aspect of the invention, the firearm is capable of firing a wide range of shot loads without requiring active adjustment of the firearm. The gases transmitted for cycling the firearm are instead passively or automatically adjusted for according to the length of the shell casing.

[0007] According to yet another aspect of the invention, any number and/or combination of ports may be formed in the barrel, and corresponding ports formed in the gas cylinder, in order to accommodate firing of a wide variety of cartridge loads.

[0008] Other aspects, features, and details of embodiments of the present invention can be more completely understood by reference to the following detailed description of preferred embodiments, taken in conjunction with the drawings figures and from the appended claims.

[0009] According to common practice, the various features of the drawings discussed below are not necessarily drawn to scale. Dimensions of various features and elements in the drawings may be expanded or reduced to more clearly illustrate the embodiments of the invention.

[0009a] In accordance with one aspect of the present invention, there is provided a firearm, comprising: a receiver; a firing mechanism; a barrel having a firing chamber for accommodating cartridges of different lengths; a plurality of ports extending through the barrel and opening into the firing chamber; a bolt having a locking position in which the bolt is adjacent to a first end of the barrel; and a gas operating system, wherein the gas operating system comprises a gas cylinder having at least one piston bore in fluid communication with the barrel through the plurality of ports in the barrel, and wherein the plurality of ports are selectively positioned at different distances along the length of the firing chamber from the first end of the barrel whereby the length of a cartridge determines which, if any, of the plurality of ports are

covered and thereby controls flow of gas from the firing chamber to the at least one piston bore.

[0009b] In accordance with a further aspect of the present invention, there is provided a firearm, comprising: a receiver; a firing mechanism; a barrel having a firing chamber at a first end of the barrel; two or more ports extending through the barrel; a gas operating system comprising a gas cylinder in communication with the barrel through the two or more ports in the barrel, wherein at least a first port of the two or more ports is located along the barrel at a first distance from the first end of the barrel, and at least a second port is located along the barrel at a second distance from the first end of the barrel, wherein the second distance is greater than the first distance wherein cartridges of different lengths can be used, whereby the length of the cartridge determines which, if any, of the two or more ports are covered to vary flows of gases transmitted to the gas cylinder of the gas operating system.

[0009c] In accordance with a further aspect of the present invention, there is provided a method of operating a firearm, comprising: providing a firearm comprising: a receiver; a firing mechanism; a barrel having a firing chamber; a plurality of ports extending through the barrel and opening into the firing chamber; and a gas operating system; providing a cartridge having a case; chambering the cartridge in the firing chamber; actuating the firing mechanism to fire the cartridge, wherein as the cartridge is fired, the case extends axially in the firing chamber, and at least partially prevents part of the gases generated from firing to pass through at least one of the plurality of ports in the barrel.

[0009d] In accordance with one aspect of the present invention, there is provided a method of operating a firearm, comprising: providing a firearm comprising: a receiver; a firing mechanism; a barrel having a firing chamber at a first end of the barrel; a plurality of ports extending through the barrel, the plurality of ports comprising a first port at a first distance from the first end of the barrel, a second port at a second distance from the first end of the barrel that is greater than the first distance, and a third port at a third distance from the first end of the barrel that is greater than the second distance; providing a cartridge having a case; chambering the cartridge in the firing chamber;

actuating the firing mechanism to fire the cartridge, wherein as the cartridge is fired, the case extends axially in the firing chamber, whereby the length of the cartridge determines which, if any, of the plurality of ports are covered to control flow of the gases generated from firing to pass through the plurality of ports.

[0009e] In accordance with a further aspect of the present invention, there is provided a method of manufacturing a barrel component for a firearm, comprising: providing a barrel having a firing chamber, a muzzle end, a cylindrical portion, and a constriction between the firing chamber and the cylindrical portion; providing a gas cylinder; securing the gas cylinder to the barrel; and forming at least one aperture through the gas cylinder and the barrel, wherein a first end of the at least one aperture opens into the firing chamber.

[0009f] In accordance with a further aspect of the present invention, there is provided a method of operating a firearm, comprising: providing a firearm comprising: a receiver; a firing mechanism; a barrel having a firing chamber for accommodating cartridges of different lengths; a plurality of ports extending through the barrel and opening into the firing chamber at selected different distances along the length of the firing chamber from a first end of the barrel; and a gas operating system in fluid communication with the plurality of ports; providing a cartridge having a case; chambering the cartridge in the firing chamber; actuating the firing mechanism to fire the cartridge, wherein as the cartridge is fired, the case extends axially in the firing chamber, and determines which, if any, of the plurality of ports are covered to restrict or prevent flow of gas to the gas operating system, thereby controlling flow of gas to the gas operating system.

[0009g] In accordance with one aspect of the present invention, there is provided a method of manufacturing a barrel component for a firearm, comprising: providing a barrel having a firing chamber, a muzzle end, a cylindrical portion, and a constriction between the firing chamber and the cylindrical portion; providing a gas cylinder; securing the gas cylinder to the barrel; and forming a plurality of apertures through the gas cylinder and the

barrel, wherein a first end of each aperture of the plurality of apertures opens into the firing chamber at selected different distances along the length of the firing chamber from the muzzle end.

[0009h] In accordance with a further aspect of the present invention, there is provided a firearm, comprising: a receiver; a firing mechanism; a barrel having a firing chamber; a plurality of ports extending through the barrel and opening into the firing chamber; a bolt having a locking position in which the bolt is adjacent to a first end of the barrel; and a gas operating system, wherein the gas operating system comprises a gas cylinder having at least one piston bore in fluid communication with the barrel through at least one port of the plurality of ports in the barrel; wherein the plurality of ports in the barrel are arranged at varying locations along the length of the barrel from the firing chamber such that cartridges of different lengths can at least partially obscure one or more ports of the plurality of ports to vary flows of gases transmitted to the gas cylinder of the gas operating system.

[0009i] In accordance with a further aspect of the present invention, there is provided a method of operating a firearm, comprising: loading a firearm comprising: a receiver; a firing mechanism; a barrel having a firing chamber; a plurality of ports extending through the barrel and opening into the firing chamber; and a gas operating system, with a cartridge, the cartridge having a case of a predetermined length; chambering the cartridge in the firing chamber; actuating the firing mechanism to fire the cartridge, wherein as the cartridge is fired, the case extends axially in the firing chamber, and at least partially covers at least one of the plurality of ports so as to at least partially prevent a portion of gases generated from firing to pass through the at least one of the plurality of ports in the barrel to control operation of the gas operating system of the firearm.

[0009j] In accordance with one aspect of the present invention, there is provided a method of operating a firearm, comprising: loading a cartridge having a case within a firearm comprising: a receiver; a firing mechanism; a barrel having a firing chamber at a first end of the barrel; a plurality of ports extending through the barrel, the plurality of ports comprising a first port at a

first distance from the first end of the barrel, a second port at a second distance from the first end of the barrel that is greater than the first distance, and a third port at a third distance from the first end of the barrel that is greater than the second distance; chambering the cartridge in the firing chamber; actuating the firing mechanism to fire the cartridge, wherein as the cartridge is fired, the case extends axially along the firing chamber, and wherein a length of the case determines which, if any, of the plurality of ports are covered to restrict or prevent a flow of the gases generated from firing from passing therethrough and to the gas operating system.

[0009k] In accordance with a further aspect of the present invention, there is provided a method of manufacturing a barrel component for a firearm, comprising: providing a barrel having a firing chamber, a muzzle end, a cylindrical portion, and a constriction between the firing chamber and the cylindrical portion; providing a gas cylinder; securing the gas cylinder to the barrel; and forming two or more spaced apertures through the gas cylinder and the barrel at spaced locations therealong, with the two or more spaced apertures located along the barrel at different distances from the firing chamber of the barrel so as to be selectively closeable by a cartridge received within the firing chamber, and wherein a first end of each aperture of the two or more spaced apertures opens into the firing chamber.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

[0010] **FIG. 1** is a partial sectional schematic view of a firearm having a gas operating system according to a first embodiment of the invention.

[0011] **FIG. 2** is an exploded view of the gas operating system according to the first embodiment.

[0012] **FIG. 3A** is a perspective view of a gas cylinder of the gas operating system.

- [0013] **FIG. 3B** is a side elevational view of the gas cylinder.
- [0014] **FIG. 3C** is a top view of the gas cylinder.
- [0015] **FIG. 4** is a bottom view of the gas cylinder.
- [0016] **FIG. 4A** is a section view taken on line **A-A** in **FIG. 4**.
- [0017] **FIG. 4B** is a section view taken on line **B-B** in **FIG. 4**.
- [0018] **FIG. 4C** is a section view taken on line **C-C** in **FIG. 4**.
- [0019] **FIG. 4D** is a section view taken on line **D-D** in **FIG. 4**.
- [0020] **FIG. 4E** is a section view taken on line **E-E** in **FIG. 4**.
- [0021] **FIGS. 5A** and **5B** are section views illustrating operation of the gas operating system when firing a first cartridge type.
- [0022] **FIGS. 6A** and **6B** are section views illustrating operation of the gas operating system when firing a second cartridge type.
- [0023] **FIGS. 7A** and **7B** are section views illustrating operation of the gas operating system when firing a third cartridge type.

DETAILED DESCRIPTION

- [0024] The invention as exemplified by the embodiment discussed below is generally directed to a gas operating system for autoloading firearms. The gas operating system allows a user to fire different loads for a given shell caliber or gauge, while avoiding undesirably high bolt velocities caused by firing excessive loads, and also ensuring that the weapon cycles fully when firing lighter loads. The gas operating system controls the amount of gas tapped from the barrel used to operate the firearm action by controlling a number of “active” ports in the firing chamber. An “active” port may be generally defined as a gas

bleed port that is at least partially unobstructed by a cartridge case and therefore available to tap gases generated during firing. According to the present invention, the gas ports may be located back in the chamber area of the barrel. Cartridge cases of differing sizes and loads selectively cover and render gas ports inactive according to the lengths of the cartridge cases.

[0025] **FIG. 1** is a partial sectional schematic view of a gas-operated smoothbore shotgun firearm **150** incorporating a gas operating system **5** according to the first embodiment of the invention. The gas-operated shotgun **150** includes a barrel **153** having a longitudinal bore **154** with a longitudinal axis or centerline **CL**. The barrel **153** includes a cartridge firing chamber **155** that is connected with a cylindrical portion **157** of the barrel **153** by a frustoconical constriction portion **159**. The cylindrical portion **157** of the barrel **153** may extend to a muzzle end (not shown) of the barrel. An example cartridge **C** is chambered within the firing chamber **155**. A bolt **161** is actuated by gas from a plurality of gas ports, collectively indicated by the reference numbers **101** and **201**, in a manner described in further detail below. Each of the gas ports **101** of the gas operating system **5** is aligned with a corresponding one of the ports **201** in the barrel **153**. The ports **101**, **201** allow gases generated during firing to be tapped from the firing chamber **155** to cycle the firearm **150**. In the exemplary illustrated embodiment, the bolt **161** has a rotating head **163** which may be, for example, of the type described in U.S. Pat. No. 4,604,942. Other bolt types may be used, and for the sake of brevity, the operation of the bolt **161** is not repeated herein in detail.

[0026] **FIG. 1** is partially schematic in that several of the ports **101** and the corresponding ports **201** in the barrel **153** are visible in the section view of the cartridge firing chamber **155**. As shown in further detail in **FIGS. 4A-4E** and discussed below, the ports **101** are offset at different radial and longitudinal positions in the gas operating system **5**, and therefore all of the ports **101** would

not be visible in a single planar section view. Each of the ports **201** in the firing chamber **155** is aligned with one of the ports **101**, and multiple ports **201** also would not be visible in a single section view.

[0027] The gas operating system **5** includes a first and a second piston pusher rod **10** (only one piston pusher rod **10** is shown in **FIG. 1**), a first and a second gas diverter and cap **20** (only one is shown in **FIG. 1**), a first and a second gas stop **50** (only one is shown in **FIG. 1**), and a gas cylinder **100**. The gas cylinder **100** may be attached to or formed as a part of the firearm barrel **153**. In the exemplary embodiment shown in **FIG. 1**, the underside of the chamber **155** of the firearm **150** rests on an upper surface of the gas cylinder **100** and the gas cylinder **100** is brazed to the underside of the barrel **153**. Each of the gas ports **101** formed in the gas cylinder **100** is aligned with and in fluid communication with one of the gas ports **201** in the barrel **153**. The structure and operation of the gas system **5** is described in further detail below.

[0028] **FIG. 2** is an exploded perspective view of the components of the gas operating system **5**. The gas operating system **5** includes the first and second piston pusher rods **10** (only one piston pusher rod **10** is shown in **FIG. 2**), the first and a second gas diverters and caps **20** (only one is shown in **FIG. 2**), the first and second gas stops **50** (only one is shown in **FIG. 2**), and the gas cylinder **100**. The gas cylinder **100** is generally divided into first and second longitudinally extending sections **122**, **124**. In the exemplary firearm embodiment shown in **FIG. 1**, the chamber **155** of the firearm **150** rests on a cylindrical concave upper profile **118** of the cylinder **100** that conforms to the shape of the underside of the barrel **153**.

[0029] The piston pusher rods **10** each include an elongate cylindrical piston body **12** having a plurality of spaced annular cleaning ribs **14** and a head **16**. The first piston pusher rod **10** is receivable and longitudinally translatable within a rear end of a first longitudinal piston bore **102** disposed in the first

section **122** of the gas cylinder **100**. The second piston pusher rod **10** (not shown) of similar or identical construction to the first pusher rod **10** is receivable and translatable within a rear end of a second longitudinal piston bore **104** disposed in the second section **124** of the gas cylinder **100**.

[0030] The first gas diverter and cap **20** is receivable within a front end of the first longitudinal piston bore **102** and can be threadably engaged with the piston bore **102** at threads **25**. A frustoconical stem **22** extends from one end of the diverter and cap **20**, and is adjacent to an annular recess **23** that is sized to receive an O-ring **40**. The O-ring **40** provides a gas seal for the cap and diverter **20** when mounted in the first piston bore **102**. The cap **27** extends from a front end of the cap and diverter **20** and includes peripherally-spaced bores **31**. The peripheral bores **31** can be provided, for example, to allow insertion of a tool used to screw and unscrew the diverter and cap **20** from the piston bore **102**. A longitudinal lightening bore **29** may extend through the end of the cap and diverter **20**. The second gas diverter and cap **20** (not shown) of similar or identical construction is receivable and threadably engageable within a front end of the second longitudinal lightening bore **104**.

[0031] The first gas stop **50** is receivable within a front end of a first bleed bore **106** in the first longitudinal section **122** of the gas cylinder **100**. A gas bleed slot **120** (see **FIG. 1**) is formed in a side of the first section **122** of the gas cylinder **100**, and is in fluid communication with the first bleed bore **106**. The first gas stop **50** extends from the front end of the first bleed bore **106** and terminates short of the gas bleed slot **120**, as shown in **FIG. 1**. A second gas bleed slot **120** is formed in the second section **124** of the gas cylinder **100**, and is in fluid communication with a second bleed bore **108** in the second section **122**. The second gas stop **50** of similar or identical construction is received in the front end of the second bleed bore **108**. The gas stops **50** may be freely

translatable within their respective bores 106, 108, and are held in place by the cap and diverters 20 in the bores 102, 104 respectively.

[0032] According to one aspect of the invention, the plurality of gas ports 101 are formed in the gas cylinder 100, in fluid communication with the plurality of ports 201 in the barrel 153 (FIG. 1), and allow cartridge loads of different “strength” to be fired from the firearm 150. Three of the gas ports 101 are illustrated in FIG. 2, and are indicated by the reference numbers 110, 112, 114. Additional gas ports 130, 132, 134 of the plurality of ports 101 in the gas cylinder 100 are illustrated in FIGS. 3A-3C, and are discussed in detail below.

[0033] FIG. 3A is a perspective view of the upper surface of the gas cylinder 100 illustrating the arrangement of the gas ports 110, 112, 114, 130, 132, 134 in the gas cylinder. FIG. 3B is a side elevational view of the gas cylinder 100, and FIG. 3C is a top view of the gas cylinder. The gas ports 110, 112, 114, 130, 132, 134 are arranged along the length of the first and second sections 122, 124 of the gas cylinder 100, and generally extend through the cylinder from the upper surface to a lower surface of the gas cylinder 100. The upper ends of the gas ports 110, 112, 114, 130, 132, 134 are visible in FIGS. 3A and 3C.

[0034] Referring to FIG. 3B, the gas bleed slots 120 in the sections 122, 124 are spaced a distance D_1 from a rear end of the gas cylinder 100. Referring to FIG. 3C, the gas ports 110, 112, 114, 130, 132, 134 are staggered at three exemplary distances D_2 , D_3 , D_4 from the rear of the gas cylinder 100. The ports 112, 114, which are formed in the first section 122, and the ports 132, 134, formed in the second section 124, are disposed at the distance D_2 from the rear of the gas cylinder 100. The port 110 is formed in the first section 122 and is located at the distance D_3 . The port 130 is formed in the second section 124 and is located at the distance D_4 . Cartridge shells of different lengths may be selected to wholly or partially block, close off, or otherwise cover one or more of the staggered gas ports 110, 112, 114, 132, 134, thereby rendering the closed

gas port “inactive.” An inactive gas port is either wholly or partially ineffective in transmitting gases generated during firing to the longitudinal piston bores 102, 104, and therefore do not fully contribute to the rearward forces on the piston pusher rods 10 (illustrated in FIG. 2) that force the bolt rearwardly.

[0035] FIG. 4 is a bottom view of the gas cylinder 100 and illustrates the bottom terminal ends of the gas ports 110, 112, 114, 130, 132, 134 in the gas cylinder. As shown in the sectional views 4A-4C, the ports 110, 112, 114, 130, 132, 134 may be formed in the gas cylinder 100 at various angular orientations.

[0036] FIG. 4A is a transverse section view taken on line A-A in FIG. 4 and illustrates the gas port 130 formed in the second section 124 and located at the distance D_4 from the rear end of the gas cylinder 100. The port 130 is oriented at an angle α with respect to a vertical reference line. FIG. 4B is a transverse section view taken on line B-B in FIG. 4 and illustrates the port 110 formed in the first section 122 at the distance D_3 . The port 110 is oriented at an angle β with respect to a vertical reference line. FIG. 4C is a transverse section view taken on line C-C in FIG. 4 and illustrates the ports 112, 114, 132, 134 formed at the distance D_2 . The ports 112, 132 are oriented at an angle γ in the respective sections 122, 124 with respect to a vertical reference line. The ports 114, 134 are oriented at an angle θ in the respective sections 122, 124 with respect to a vertical reference line.

[0037] FIG. 4D is a transverse section view of the gas cylinder 100 taken on line D-D in FIG. 4. FIG. 4E is a longitudinal section view of the gas cylinder 100 taken on line E-E in FIG. 4. FIGS. 4D and 4E illustrate the gas bleed slots 120 formed in the underside of the gas cylinder 100. The gas bleed slots 120 can be formed by, for example, milling the underside of the gas cylinder 100. Referring to FIG. 4D, the upper surface 118 of the gas cylinder 100 can be generally concave cylindrical.

[0038] Firing of different cartridges using the firearm 150 and the accompanying function of the gas operating system 5 is discussed below with reference to **FIGS. 1** and **5A-7B**. For simplicity of illustration, as in **FIG. 1**, **FIGS. 5A-7B** are partially schematic in that all of the ports 110, 112, 114, 130, 132, 134 in the gas cylinder 100 and the corresponding ports 201 in the barrel 153 are shown and/or indicated by a reference number in a single section view. As discussed above with reference to 3A-4C, the ports 110, 112, 114, 130, 132, 134 are located at different angular and longitudinal locations in the gas cylinder 100 and all would not be visible in a single longitudinal planar section view. In **FIGS. 5A-7B**, the ports 201 formed in the barrel 153 are numbered 210, 212, 214, 230, 232, 234 to correspond to the ports 110, 112, 114, 130, 132, 134, respectively, formed in the gas cylinder 100 with which they are aligned and in fluid communication.

[0039] **FIGS. 5A** and **5B** are sectional views illustrating operation of the gas operating system 5 with a first cartridge type C1. In this example, the cartridge C1 is relatively short in length, which generally corresponds to a lighter load shell. Because the cartridge C1 is of relatively light load, more of the gases generated during firing are made available to enter the gas cylinder 100 and thereby perpetuate the action of the firearm 150.

[0040] Referring to **FIGS. 1** and **5A**, a shell C1 is loaded into the chamber 155 and the bolt 161 is closed, chambering the shell C1. The bolt head 163 locks to the barrel 153 or a barrel extension, if present. Locking the bolt head 163 secures the cartridge C1 in the firing chamber 155 after the shell C1 is fired. In the illustrated example, the bolt design is a rotating design, but other bolt types can be used. Generally speaking, the shell C1 is fired by activating a firing mechanism, such as by pulling a trigger to release a striker, which in turn hits the cartridge primer (not shown). The primer is ignited and in turn ignites the main powder charge in the shell C1. As pressure builds in the cartridge

case and the chamber **155**, the wad and shot column travels down the barrel **153**.

[0041] As the shot column travels down the barrel **153**, a percentage of the high pressure firing gases in the barrel **153** is tapped and is introduced into the gas cylinder **100**. Referring to **FIG. 5B**, when the first cartridge type **C1** is fired, the case of the cartridge **C1** assumes the extended form **C1'** as the cartridge casing unrolls. In this example, the extended cartridge form **C1'** does not cover or otherwise at least partially obstruct any of the ports **210, 212, 214, 230, 232, 234** in the barrel **153**. All ports **210, 212, 214, 230, 232, 234** therefore remain active to transmit gases through their corresponding ports **110, 112, 114, 130, 132, 134**, respectively. Referring also to **FIG. 1**, gases transmitted through the ports **110, 112, 114** are transmitted into the first piston bore **102** and force the first pusher piston rod **10** rearwardly against the bolt **161** in the direction of the arrow. Gases transmitted through the ports **130, 132, 134** are transmitted to the second piston bore **104** (not shown in **FIG. 5B**) and force the second pusher piston rod **10** rearwardly against the bolt **161**. The gases generated during firing are therefore capable of transmission through all of the ports **110, 112, 114, 130, 132, 134** (i.e., all ports are active) to the first and second piston pusher rods **10** in the bores **102, 104**, which provides the energy to unlock the bolt **161** and to propel the bolt **161** rearwardly. As the pusher piston rods **10** move rearwardly and uncover the gas bleed slots **120**, the firing gases vent through the bores **106, 108** and the slots **120**.

[0042] As the bolt **161** travels rearwardly, the spent case **C1** is pulled from the chamber **155** and ejected from the firearm **150**. The bolt **161** travels to the rear of the receiver **201**, which also compresses the action spring (not shown). If no feeding shell is present in a magazine, the bolt **161** locks open. If a feeding shell is present, the bolt **161** is released from the rear position and is propelled forward by the stored energy in the action spring. As the bolt **161**

travels back toward the barrel **153**, a new shell is fed into the chamber **155** and the bolt head **163** locks to the barrel **153**. The cycle repeats when the trigger is again pulled.

[0043] **FIGS. 6A and 6B** are sectional views illustrating operation of the gas operating system **5** with a second cartridge type **C2**. In this example, the second cartridge type **C2** is longer than the first cartridge **C1**, which generally corresponds to a heavier load shell. Because the cartridge **C2** is of heavier load, a smaller portion of the gases generated during firing are communicated to the gas cylinder **100** to perpetuate the action of the firearm **150**.

[0044] The cartridge **C2** is fired in generally the same manner as the cartridge **C1**. Referring to **FIG. 6B**, as the cartridge **C2** is fired, the case of the cartridge **C2** extends as it unrolls and assumes the form **C2'**. The extended case **C2'** at least partially covers the ports **212, 214, 232, 234** in the barrel **153**, rendering them inactive. The gases generated during firing are therefore either wholly or partially blocked from passing into the gas cylinder **100** through the corresponding ports **112, 114, 132, 134** in the gas cylinder **100** with which the ports **212, 214, 232, 234** are in fluid communication. The other ports **210, 230** in the barrel **153** remain active, and the firing gases are allowed to pass through the corresponding ports **110, 130** and into the first and second piston bores **102, 104**, respectively. The gases transmitted to the first and second piston bores **102, 104** provide the energy required to force the pusher piston rods **10** rearwardly to cycle the firearm **150**, as discussed above.

[0045] **FIGS. 7A and 7B** are sectional views illustrating operation of the gas operating system **5** with a third cartridge type **C3**. In this example, the third cartridge **C3** is longer than the second cartridge **C2**, which generally corresponds to a heavy load shell. Because the cartridge **C3** is of heavy load, a relatively small portion of the high pressure gases generated during firing are

communicated to the gas cylinder 100 to perpetuate the action of the firearm 150.

[0046] The third cartridge type C3 is fired in generally the same manner as the cartridges C1 and C2 discussed above. Referring to FIG. 7B, as the cartridge C3 is fired, the case of the cartridge C3 extends as it unrolls and assumes the form C3'. The extended case C3' at least partially covers or otherwise obstructs the ports 212, 214, 232, 234, 210 in the barrel 153, rendering them inactive. The gases generated during firing are therefore either wholly or partially blocked from passing into the gas cylinder 100 through the corresponding ports 112, 114, 132, 134, 110 in the gas cylinder 100 with which the ports 212, 214, 232, 234, 210 are in fluid communication. Only the port 230 remains active, and gases are transmitted through the corresponding port 130 in the gas cylinder 100 and into the second piston bore 104. The gases transmitted to the second piston bore 104 act on the second pusher piston rod 10 to cycle the firearm 150 as discussed above. In this mode of operation, only one pusher piston rod 10 is used to cycle the firearm 150.

[0047] According to one aspect of the present invention, the gas operating system renders a firearm capable of firing a wide range of shot loads without requiring active adjustment of the firearm. The gases transmitted for cycling the firearm are instead passively or automatically adjusted for according to the length of the shell casing. Any number and/or combination of ports may be formed in the barrel, and corresponding ports formed in the gas cylinder, in order to accommodate firing of a wide variety of cartridge loads.

[0048] **EXAMPLE**

[0049] A firearm 150 is provided with a gas operating system 5 as illustrated in FIGS. 1-7B. The gas cylinder 100 has a length, measured from left to right in FIG. 4, of 77 mm. The distances illustrated in FIGS. 3B and 3C are: $D_1 =$

30.2 mm, $D_2 = 43$ mm, $D_3 = 49$ mm, and $D_4 = 62$ mm. The angles illustrated in FIGS. 4A-4C are: $\alpha = 25^\circ$, $\beta = 25^\circ$, $\gamma = 25^\circ$, and $\theta = 42^\circ$. Each of the ports 110, 112, 114, 130, 132, 134 are cylindrical bores having a diameter of 1.2 mm. The ports 210, 212, 214, 230, 232, 234 are also cylindrical bores. The piston bores 102, 104 are cylindrical bores having a diameter of 10.8 mm. The bleed bores 106, 108 are cylindrical bores having a diameter of 5 mm. The exemplary cartridge C1 illustrated in FIGS. 5A and 5B corresponds to 2-3/4 inch 12 gauge ammunition. The exemplary cartridge C2 illustrated in FIGS. 6A and 6B corresponds to 3 inch 12 gauge ammunition. The exemplary cartridge C3 illustrated in FIGS. 7A and 7B corresponds to 3-1/2 inch 12 gauge ammunition.

[0050] In the embodiment described above, the barrel 153 is illustrated as formed separately from the gas cylinder 100, and gases generated during firing are communicated from the chamber 155 through aligned sets of ports in the barrel 153 and the gas cylinder 100. In an alternative embodiment, the gas cylinder and the barrel may be of a one-piece construction, requiring only one set of ports.

[0051] The gas cylinder 100 described above is divided into two sections 122, 124, which house two separate piston pusher rods 10 in a “dual-tap” configuration. A “single-tap” system, using a single piston bore with a single piston pusher rod, is also within the scope of the present invention. In this embodiment, bores formed in the firearm barrel would each be in fluid communication with the single piston bore.

[0052] The components of the gas operating system 5 can be made from conventional durable, high strength materials including metals, such as hardened steel, composites, and other materials.

[0053] In the illustrated embodiment, the ports 110, 112, 114, 130, 132, 134 in the gas cylinder 100 and the corresponding port 210, 212, 214, 230, 232, 234 in the barrel 153 are straight along their lengths and circular in cross section. The ports may, however, take the form of other apertures, such as, for example, apertures of non-circular cross section.

[0054] The ports 110, 112, 114, 130, 132, 134 in the gas cylinder 100 and the corresponding ports 210, 212, 214, 230, 232, 234 in the barrel 153 can be formed by methods such as drilling, for example. In one exemplary method of manufacture, the gas cylinder can be brazed to the barrel before forming the gas tap ports. Each port in the gas cylinder (e.g. port 110) and its corresponding port in the barrel (e.g. port 210) can then be drilled in a single drilling operation. In order to facilitate drilling, slots or other locating features may be milled or otherwise formed at one or more locations on the underside of the gas cylinder so that a drill bit can be readily located on the exterior of the gas cylinder. When viewed from the perspective of FIG. 1, the ports 110, 112, 114, 130, 132, 134 in the gas cylinder 100 and the corresponding ports 210, 212, 214, 230, 232, 234 in the barrel 153 are illustrated as extending perpendicular or substantially perpendicular to the long axis CL of the barrel 153. The ports may, however, be oriented at other nonzero angles with respect to the long axis CL of the barrel.

[0055] The example embodiment of the gas operating system 5 is incorporated in a gas-actuated twelve-gauge shotgun. Other types of gas-actuated firearms may be equipped with a gas operating system as discussed herein without departing from the scope of the present invention.

[0056] The gas ports disclosed in this specification are described as formed by drilling. Any of the ports in this specification can be formed by alternative methods, such as, for example, electronic discharge machining (EDM).

[0057] The method of operating the firearm 150 is described in terms of a trigger-operated firing mechanism that releases a striker. Other types of firing mechanisms, such as, for example, electrical firing mechanisms, can also be incorporated in a firearm in accordance with the present invention.

[0058] The foregoing description of the invention illustrates and describes the present invention. Additionally, the disclosure shows and describes only selected embodiments of the invention, but it is to be understood that the invention is capable of use in various other combinations, modifications, and environments and is capable of changes or modifications within the scope of the inventive concept as expressed herein, commensurate with the above teachings, and/or within the skill or knowledge of the relevant art.

The embodiments of the present invention in which an exclusive property or privilege is claimed are defined as follows:

1. A firearm, comprising:
 - 5 a receiver;
 - a firing mechanism;
 - a barrel having a firing chamber for accommodating cartridges of different lengths;
 - a plurality of ports extending through the barrel and opening into the firing chamber;
 - a bolt having a locking position in which the bolt is adjacent to a first end of the
 - 10 barrel; and
 - a gas operating system, wherein the gas operating system comprises a gas cylinder having at least one piston bore in fluid communication with the barrel through the plurality of ports in the barrel,
 - 15 and wherein the plurality of ports are selectively positioned at different distances along the length of the firing chamber from the first end of the barrel whereby the length of a cartridge determines which, if any, of the plurality of ports are covered and thereby controls flow of gas from the firing chamber to the at least one piston bore.
2. The firearm of claim 1, wherein the positions of the plurality of ports opening into the firing chamber are selected to account for axial extension of the cartridge in the firing
- 20 chamber.
3. The firearm of claim 1 or 2, wherein the ports of the plurality of ports are respectively located at three separate distances from the first end of the barrel.
4. The firearm of claim 3, wherein multiple ports are located at one or more of the three separate distances.
- 25 5. The firearm of claim 4, wherein the multiple ports are circumferentially spaced having regard to a longitudinal axis along the firing chamber.

6. The firearm of claim 1, wherein at least a first port of the plurality of ports is at a first distance from the first end of the barrel, and at least at least a second port of the plurality of ports is at a second distance from the first end of the barrel that is greater than the first distance.
- 5 7. The firearm of claim 6, wherein at least a third port of the plurality of ports is at a third distance from the first end of the barrel that is greater than the second distance.
8. The firearm according to any one of claims 1 to 7, wherein the at least one piston bore comprises a first piston bore and a second piston bore.
9. The firearm according any one of claims 1 to 8, wherein the barrel comprises a
10 conical constriction between the plurality of ports and a second end of the barrel.
10. The firearm according to any one of claims 1 to 9, wherein the gas operating system further comprises at least one pusher piston rod axially translatable within the at least one piston bore.
11. The firearm according to any one of claims 1 to 10, wherein the gas cylinder is joined
15 to an underside of the barrel, and wherein the gas cylinder comprises a plurality of ports, one each of the plurality of ports in the gas cylinder being aligned with a corresponding one of the plurality of ports in the barrel.
12. The firearm according to any one of claims 1 to 11, wherein the plurality of ports in the barrel extend through the barrel at a nonzero angle with respect to a longitudinal axis of
20 the barrel.
13. A firearm, comprising:
 - a receiver;
 - a firing mechanism;
 - a barrel having a firing chamber at a first end of the barrel;
 - 25 two or more ports extending through the barrel;
 - a gas operating system comprising a gas cylinder in communication with the barrel through the two or more ports in the barrel, wherein at least a first port of the two or more

ports is located along the barrel at a first distance from the first end of the barrel, and at least a second port is located along the barrel at a second distance from the first end of the barrel, wherein the second distance is greater than the first distance wherein cartridges of different lengths can be used, whereby the length of the cartridge determines which, if any, of the two or more ports are covered to vary flows of gases transmitted to the gas cylinder of the gas operating system.

14. The firearm of claim 13, wherein at least a third port is at a third distance from the first end of the barrel that is greater than the second distance.

15. The firearm of claim 13 or 14, wherein the gas cylinder comprises a first piston bore and a second piston bore.

16. The firearm of claim 15, wherein the gas operating system further comprises a first pusher piston axially translatable within the first piston bore.

17. The firearm of any one of claims 13 to 16, wherein the barrel comprises a frustoconical constriction between the three or more ports and a second end of the barrel.

18. The firearm of any one of claims 13 to 17, wherein the gas cylinder is joined to an underside of the barrel, and wherein the gas cylinder comprises two or more ports, one each of the two or more ports in the gas cylinder being aligned with a corresponding one of the two or more ports in the barrel.

19. The firearm of any one of claims 11 to 18, wherein the two or more ports in the barrel extend through the barrel at a nonzero angle with respect to a longitudinal axis of the barrel.

20. A method of operating a firearm, comprising:

providing a firearm comprising: a receiver; a firing mechanism; a barrel having a firing chamber; a plurality of ports extending through the barrel and opening into the firing chamber; and a gas operating system;

25 providing a cartridge having a case;

chambering the cartridge in the firing chamber;

actuating the firing mechanism to fire the cartridge, wherein as the cartridge is fired, the case extends axially in the firing chamber, and at least partially prevents part of the gases generated from firing to pass through at least one of the plurality of ports in the barrel.

21. The method according to claim 20, wherein the plurality of ports in the barrel extend
5 through the barrel at a nonzero angle with respect to a longitudinal axis of the barrel.

22. A method of operating a firearm, comprising:

providing a firearm comprising: a receiver; a firing mechanism; a barrel having a firing chamber at a first end of the barrel; a plurality of ports extending through the barrel, the plurality of ports comprising a first port at a first distance from the first end of the barrel, a
10 second port at a second distance from the first end of the barrel that is greater than the first distance, and a third port at a third distance from the first end of the barrel that is greater than the second distance;

providing a cartridge having a case;

chambering the cartridge in the firing chamber;

15 actuating the firing mechanism to fire the cartridge, wherein as the cartridge is fired, the case extends axially in the firing chamber, whereby the length of the cartridge determines which, if any, of the plurality of ports are covered to control flow of the gases generated from firing to pass through the plurality of ports.

23. The method of claim 22, wherein as the case extends axially the case at least partially
20 prevents part of the gases generated from firing to pass through the second port.

24. The method according to claim 22 or 23, wherein the plurality of ports in the barrel extend through the barrel at a nonzero angle with respect to a longitudinal axis of the barrel.

25. A method of manufacturing a barrel component for a firearm, comprising:

providing a barrel having a firing chamber, a muzzle end, a cylindrical portion, and a
25 constriction between the firing chamber and the cylindrical portion;

providing a gas cylinder;

securing the gas cylinder to the barrel; and

forming at least one aperture through the gas cylinder and the barrel, wherein a first end of the at least one aperture opens into the firing chamber.

26. The method according to claim 25, wherein the at least one aperture is oriented at a nonzero angle with respect to a longitudinal axis of the barrel.

5 27. A method of operating a firearm, comprising:

providing a firearm comprising: a receiver; a firing mechanism; a barrel having a firing chamber for accommodating cartridges of different lengths; a plurality of ports extending through the barrel and opening into the firing chamber at selected different distances along the length of the firing chamber from a first end of the barrel; and a gas
10 operating system in fluid communication with the plurality of ports;

providing a cartridge having a case;

chambering the cartridge in the firing chamber;

actuating the firing mechanism to fire the cartridge, wherein as the cartridge is fired, the case extends axially in the firing chamber, and determines which, if any, of the plurality of
15 ports are covered to restrict or prevent flow of gas to the gas operating system, thereby controlling flow of gas to the gas operating system.

28. The method according to claim 27, wherein the plurality of ports in the barrel extend through the barrel at a nonzero angle with respect to a longitudinal axis of the barrel.

29. A method of manufacturing a barrel component for a firearm, comprising:

20 providing a barrel having a firing chamber, a muzzle end, a cylindrical portion, and a constriction between the firing chamber and the cylindrical portion;

providing a gas cylinder;

securing the gas cylinder to the barrel; and

forming a plurality of apertures through the gas cylinder and the barrel, wherein a
25 first end of each aperture of the plurality of apertures opens into the firing chamber at selected different distances along the length of the firing chamber from the muzzle end.

30. The method according to claim 29, wherein the plurality of apertures are oriented at a nonzero angle with respect to a longitudinal axis of the barrel.
31. A firearm, comprising:
- a receiver;
 - 5 a firing mechanism;
 - a barrel having a firing chamber;
 - a plurality of ports extending through the barrel and opening into the firing chamber;
 - a bolt having a locking position in which the bolt is adjacent to a first end of the barrel; and
 - 10 a gas operating system, wherein the gas operating system comprises a gas cylinder having at least one piston bore in fluid communication with the barrel through at least one port of the plurality of ports in the barrel; wherein the plurality of ports in the barrel are arranged at varying locations along the length of the barrel from the firing chamber such that cartridges of different lengths can at least partially obscure one or more ports of the plurality
 - 15 of ports to vary flows of gases transmitted to the gas cylinder of the gas operating system.
32. The firearm of claim 31, wherein at least a first port of the plurality of ports is at a first distance from the first end of the barrel, and at least a second port of the plurality of ports is at a second distance from the first end of the barrel that is greater than the first distance.
33. The firearm of claim 31 or 32, wherein at least a third port of the plurality of ports is
- 20 at a third distance from the first end of the barrel that is greater than the second distance.
34. The firearm of any one of claims 31 to 33, wherein the at least one piston bore comprises a first piston bore and a second piston bore.
35. The firearm of any one of claims 31 to 34, wherein the barrel comprises a frustoconical constriction between the three or more ports and a second end of the barrel.
- 25 36. The firearm of any one of claims 31 to 35, wherein the gas operating system further comprises at least one pusher piston rod axially translatable within the at least one piston bore.

37. The firearm of any one of claims 31 to 36, wherein the gas cylinder is joined to an underside of the barrel, and wherein the gas cylinder comprises a plurality of ports, one each of the plurality of ports in the gas cylinder being aligned with a corresponding one of the plurality of ports in the barrel.

5 38. The firearm of any one of claims 31 to 37, wherein the plurality of ports in the barrel extend through the barrel at a nonzero angle with respect to a longitudinal axis of the barrel.

39. A method of operating a firearm, comprising:

loading a firearm comprising: a receiver; a firing mechanism; a barrel having a firing
chamber; a plurality of ports extending through the barrel and opening into the firing
10 chamber; and a gas operating system, with a cartridge, the cartridge having a case of a
predetermined length;

chambering the cartridge in the firing chamber;

actuating the firing mechanism to fire the cartridge, wherein as the cartridge is fired,
the case extends axially in the firing chamber, and at least partially covers at least one of the
15 plurality of ports so as to at least partially prevent a portion of gases generated from firing to
pass through the at least one of the plurality of ports in the barrel to control operation of the
gas operating system of the firearm.

40. The method of claim 39, wherein the plurality of ports in the barrel extend through
the barrel at a nonzero angle with respect to a longitudinal axis of the barrel.

20 41. A method of operating a firearm, comprising:

loading a cartridge having a case within a firearm comprising: a receiver; a firing
mechanism; a barrel having a firing chamber at a first end of the barrel; a plurality of ports
extending through the barrel, the plurality of ports comprising a first port at a first distance
from the first end of the barrel, a second port at a second distance from the first end of the
25 barrel that is greater than the first distance, and a third port at a third distance from the first
end of the barrel that is greater than the second distance;

chambering the cartridge in the firing chamber;

actuating the firing mechanism to fire the cartridge, wherein as the cartridge is fired, the case extends axially along the firing chamber, and wherein a length of the case determines which, if any, of the plurality of ports are covered to restrict or prevent a flow of the gases generated from firing from passing therethrough and to the gas operating system.

5 42. The method of claim 41, wherein as the case extends axially the case at least partially prevents part of the gases generated from firing to pass through the second port.

43. The method of claim 41 or 42, wherein the plurality of ports in the barrel extend through the barrel at a nonzero angle with respect to a longitudinal axis of the barrel.

44. A method of manufacturing a barrel component for a firearm, comprising:

10 providing a barrel having a firing chamber, a muzzle end, a cylindrical portion, and a constriction between the firing chamber and the cylindrical portion;

 providing a gas cylinder;

 securing the gas cylinder to the barrel; and

 forming two or more spaced apertures through the gas cylinder and the barrel at
15 spaced locations therealong, with the two or more spaced apertures located along the barrel at different distances from the firing chamber of the barrel so as to be selectively closeable by a cartridge received within the firing chamber, and wherein a first end of each aperture of the two or more spaced apertures opens into the firing chamber.

45. The method of claim 44, wherein the two or more spaced apertures are oriented at a
20 nonzero angle with respect to a longitudinal axis of the barrel.

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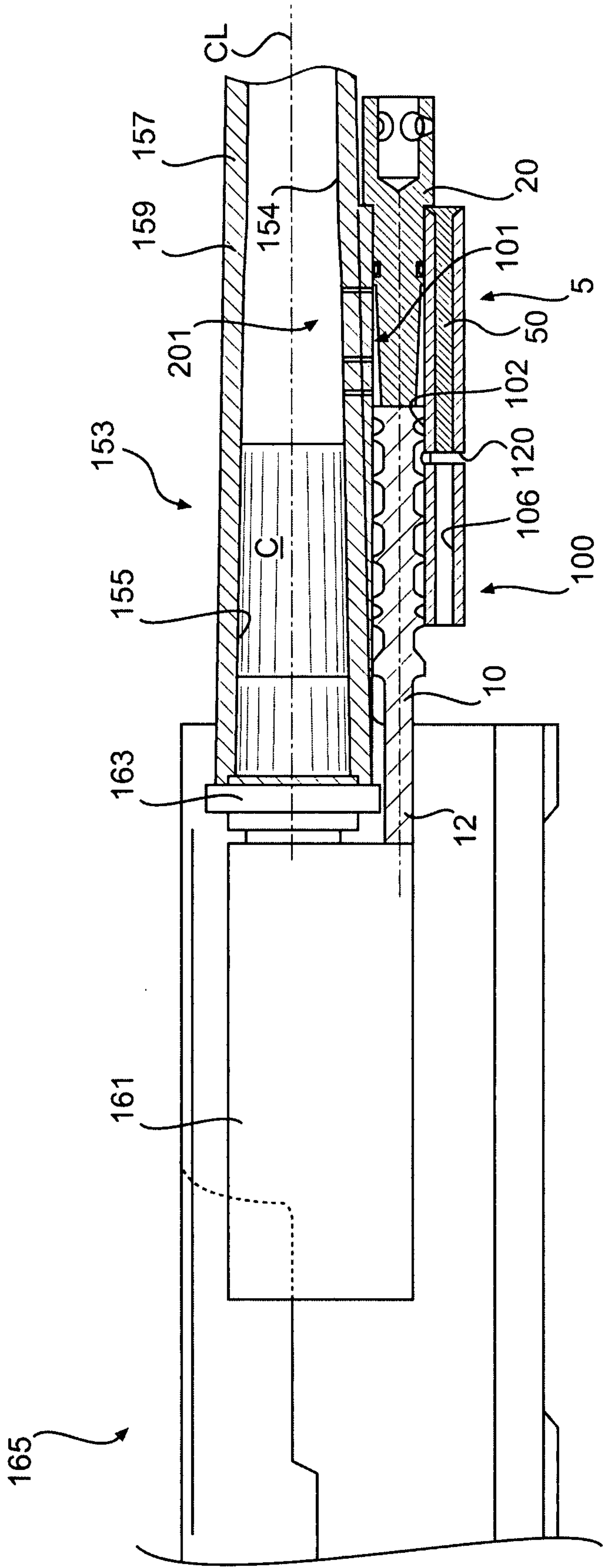
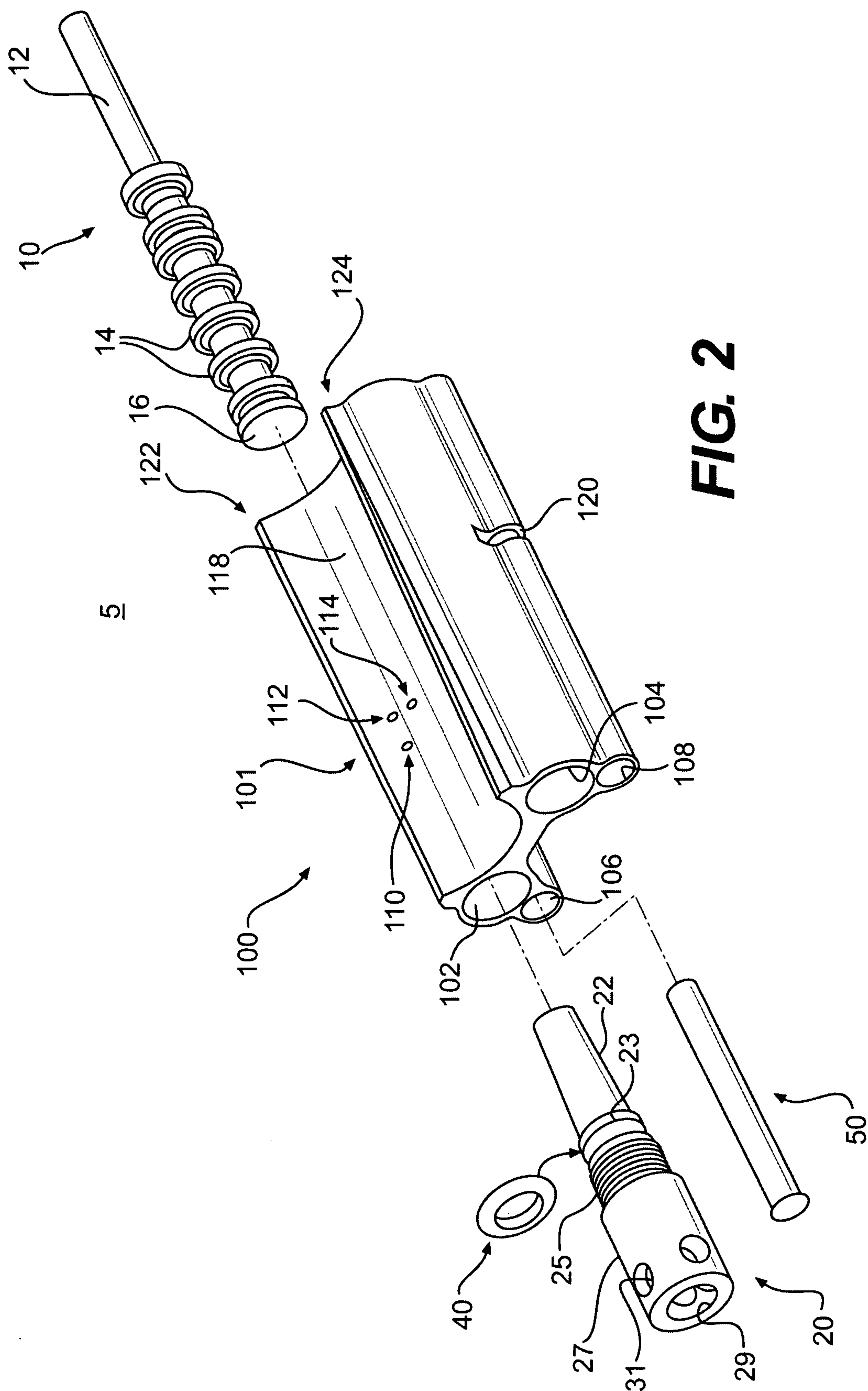
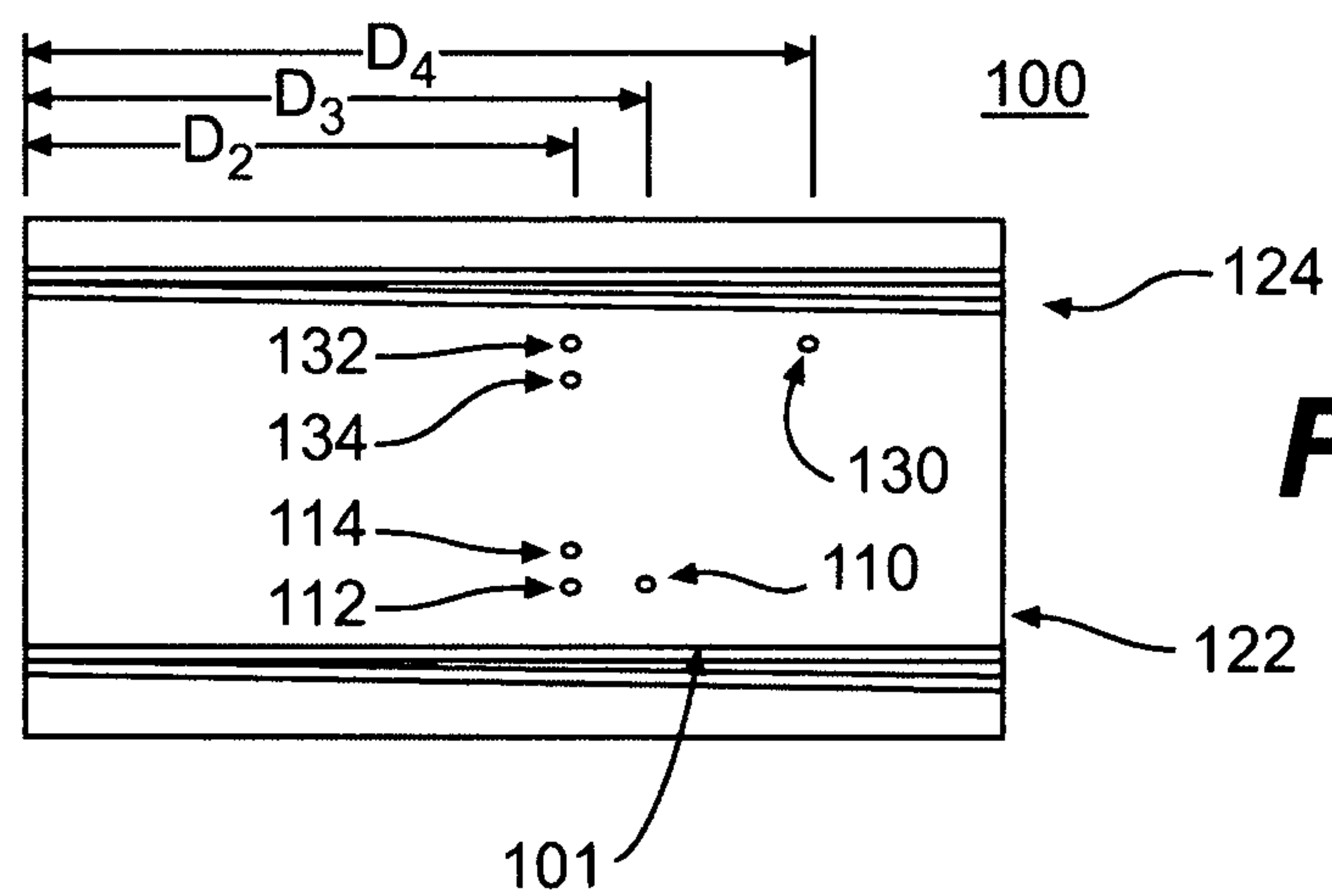
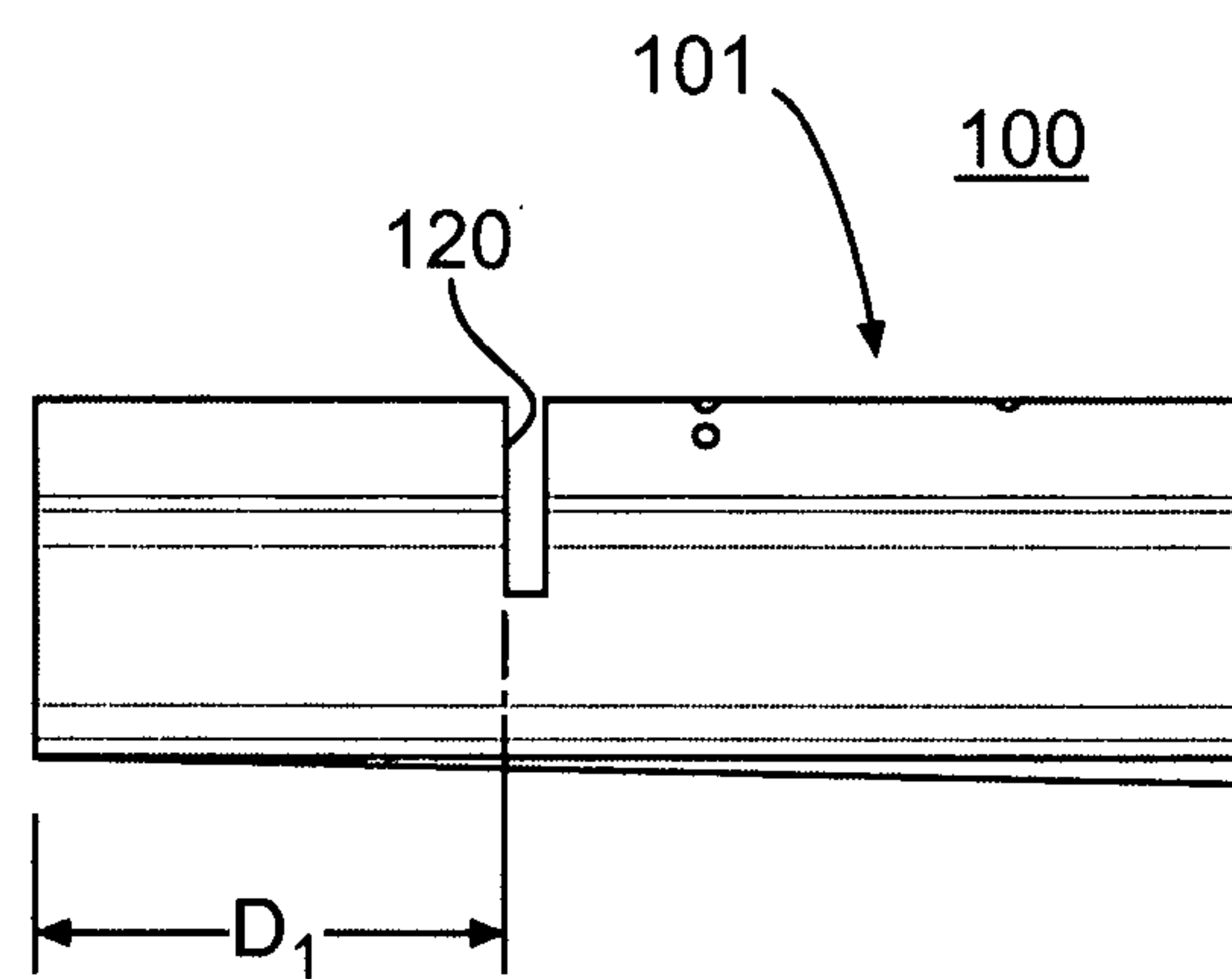
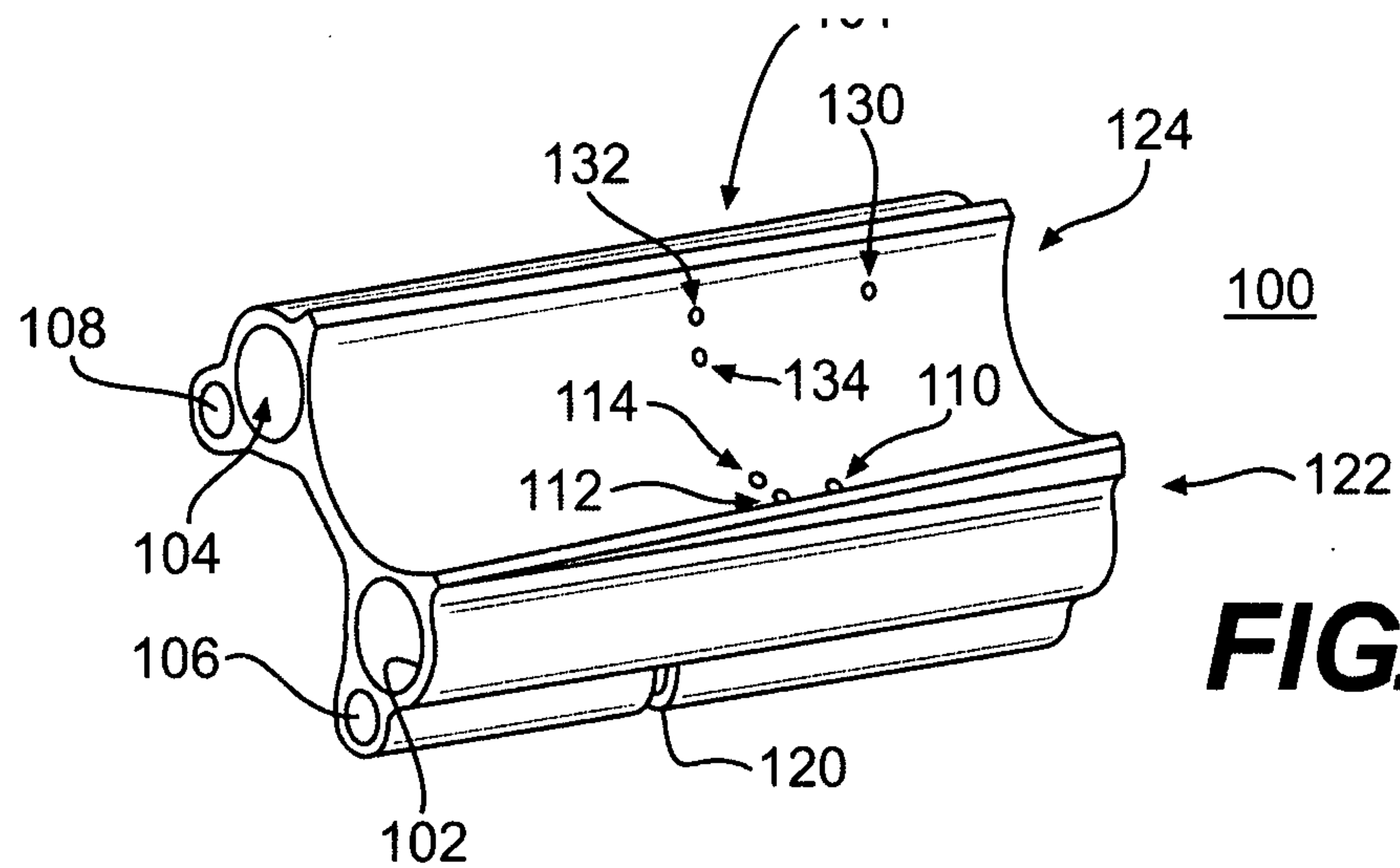
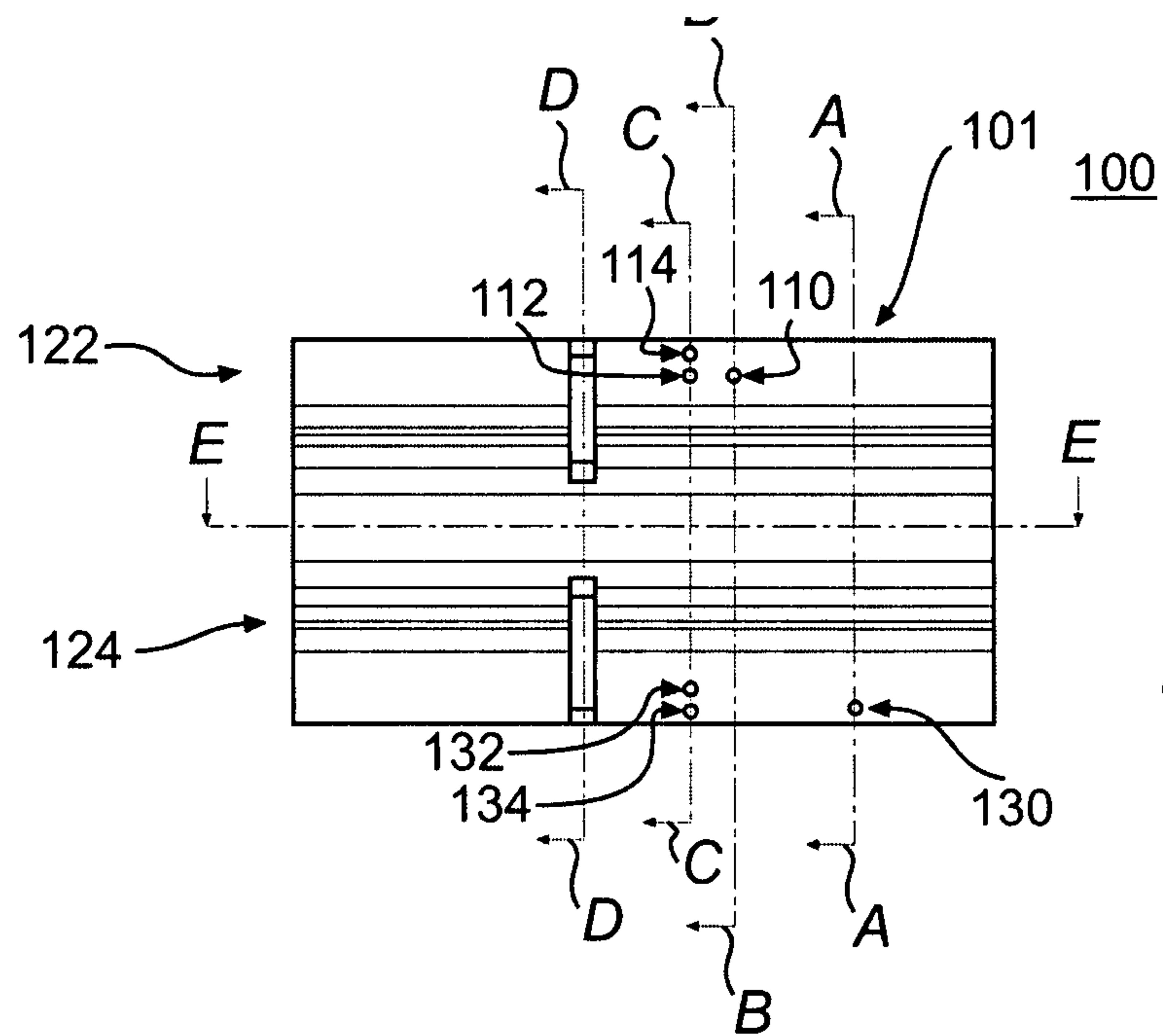
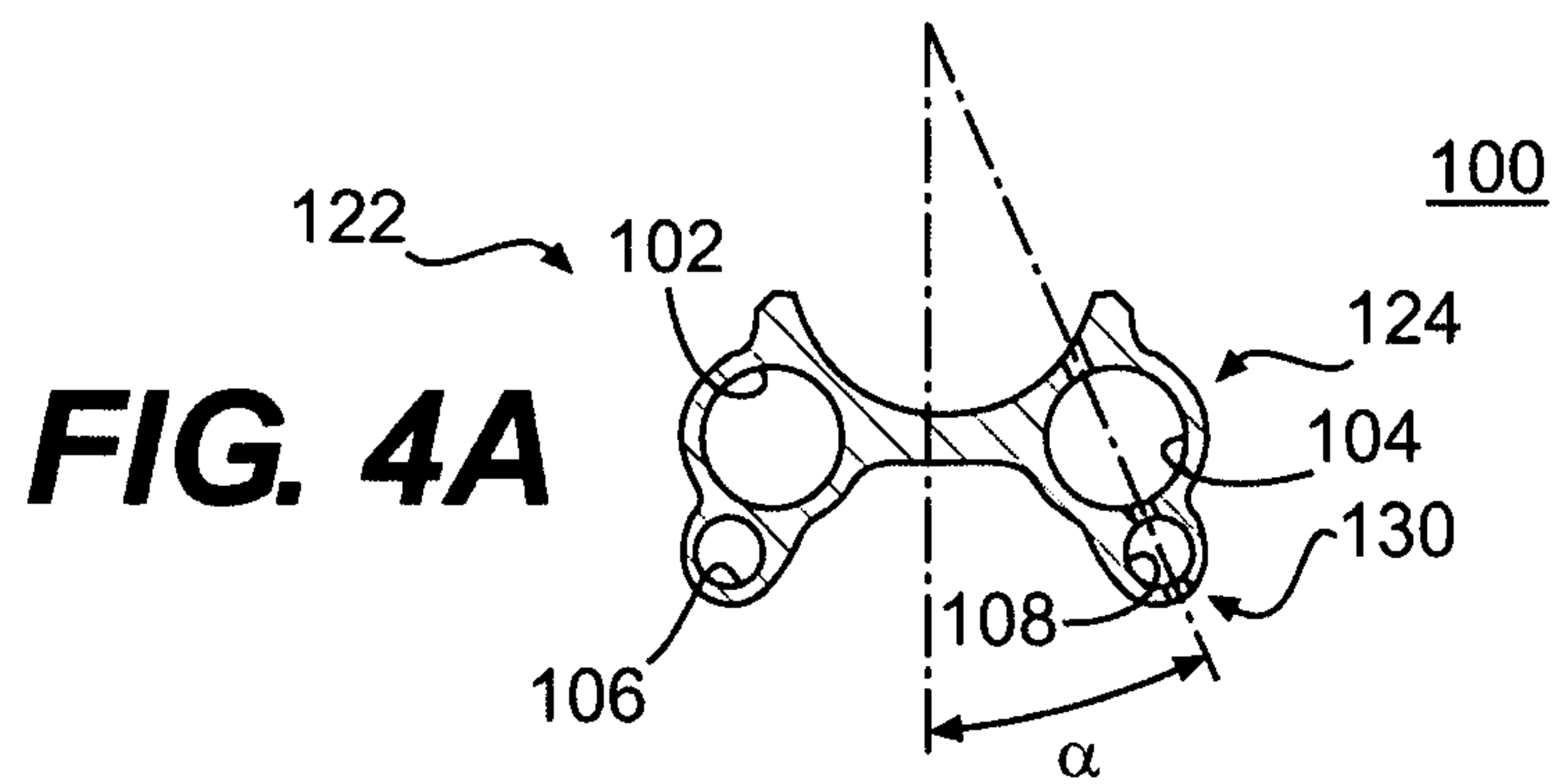
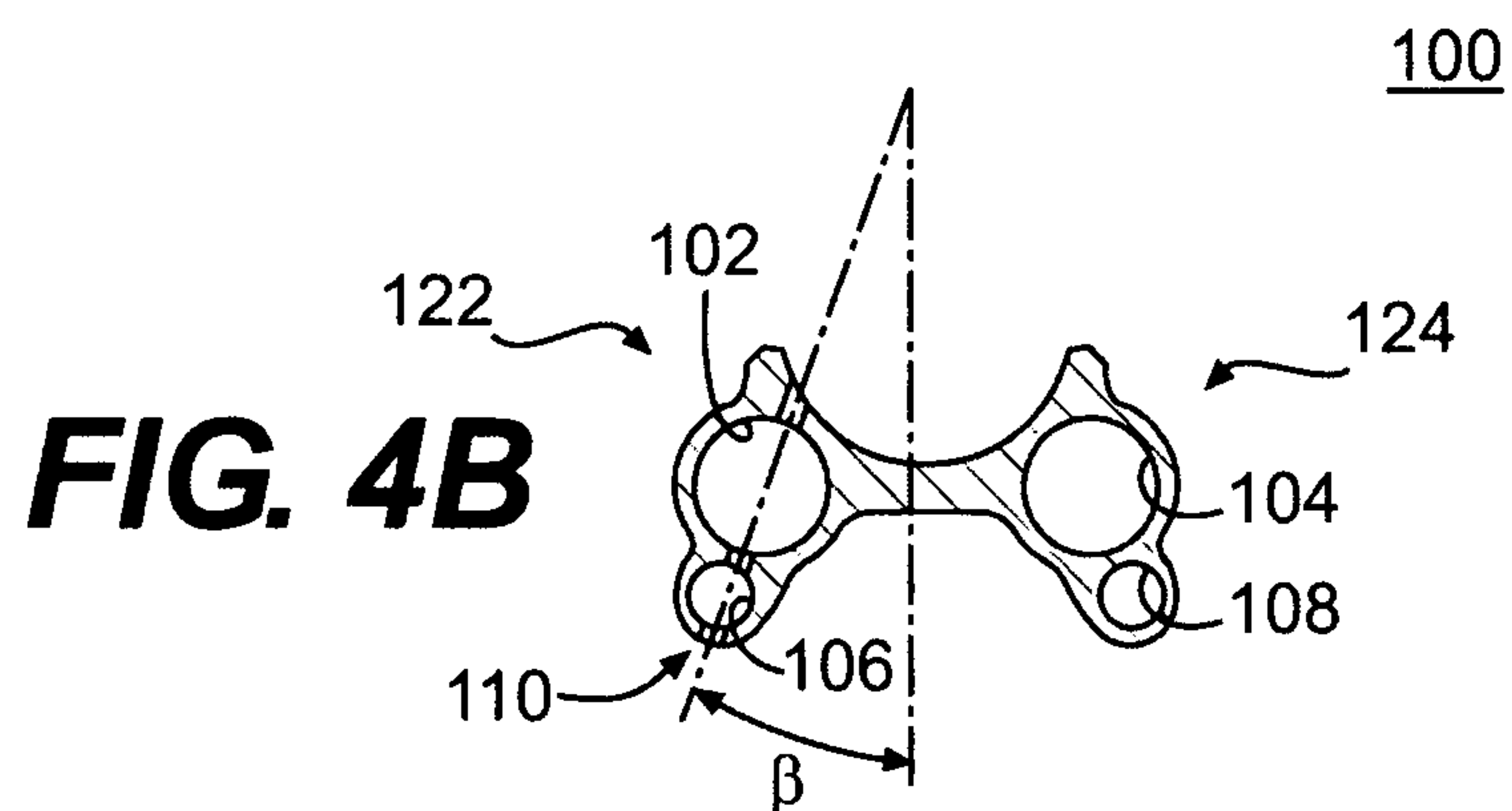
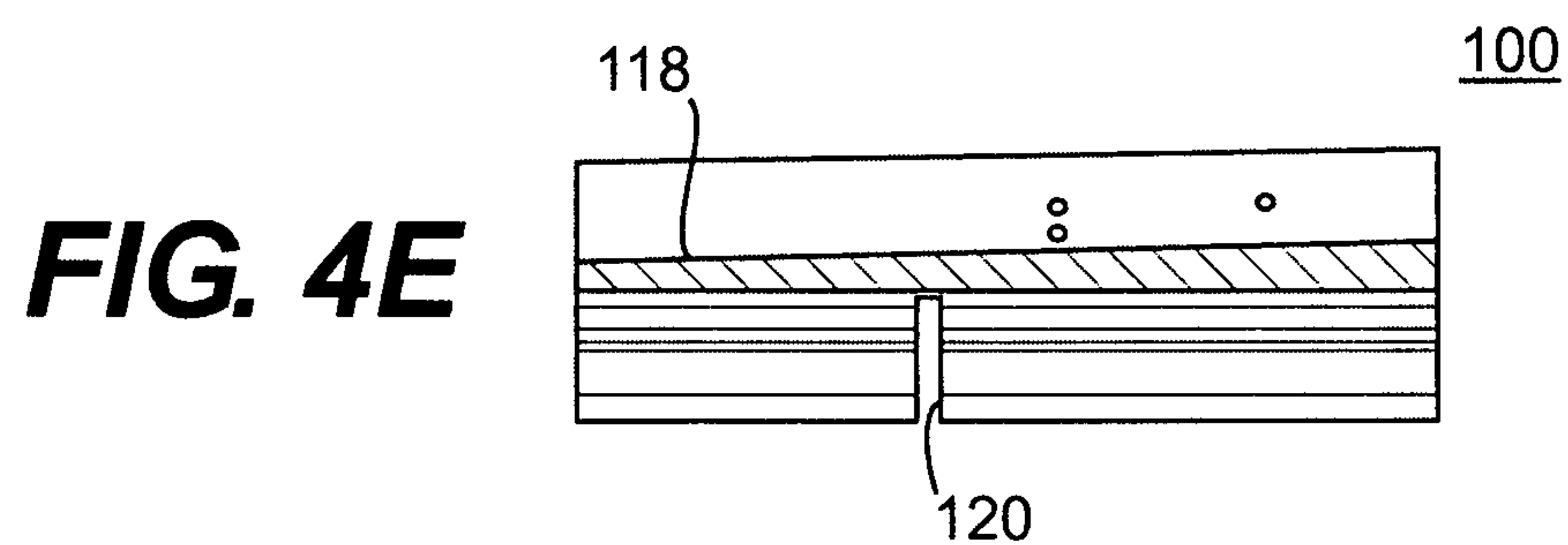
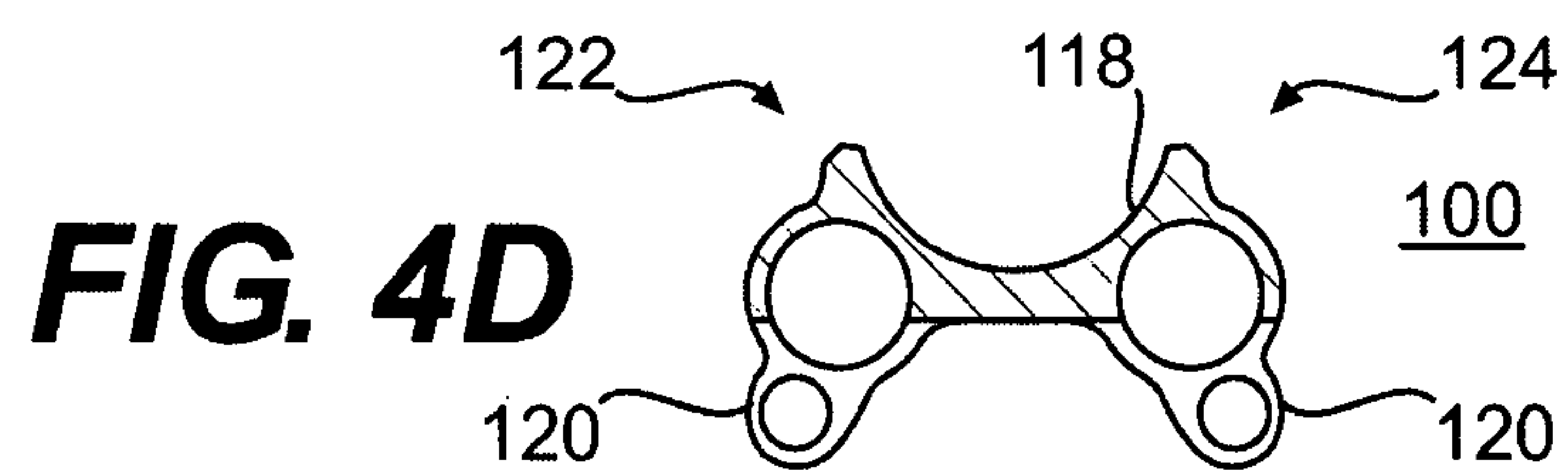
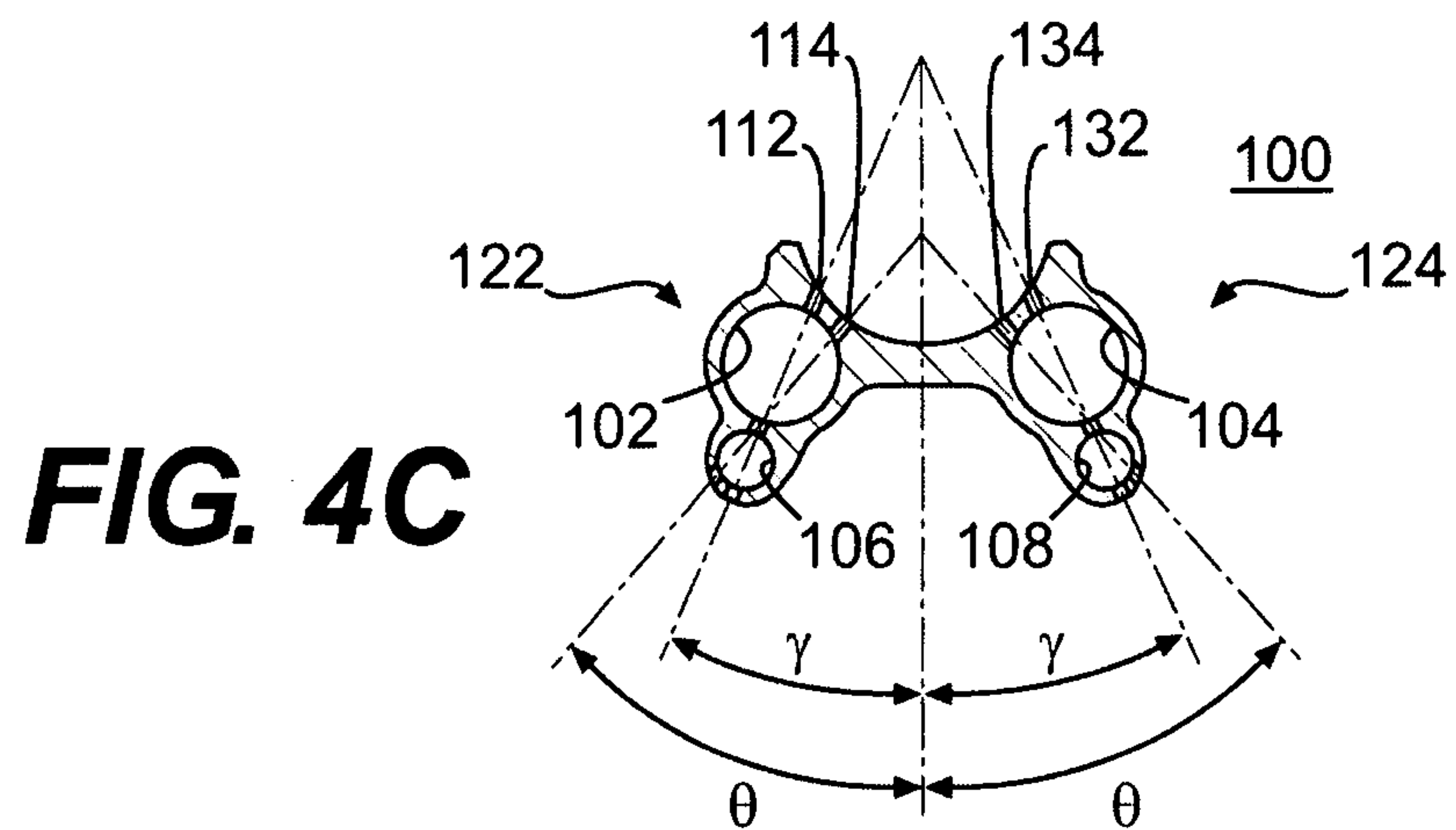


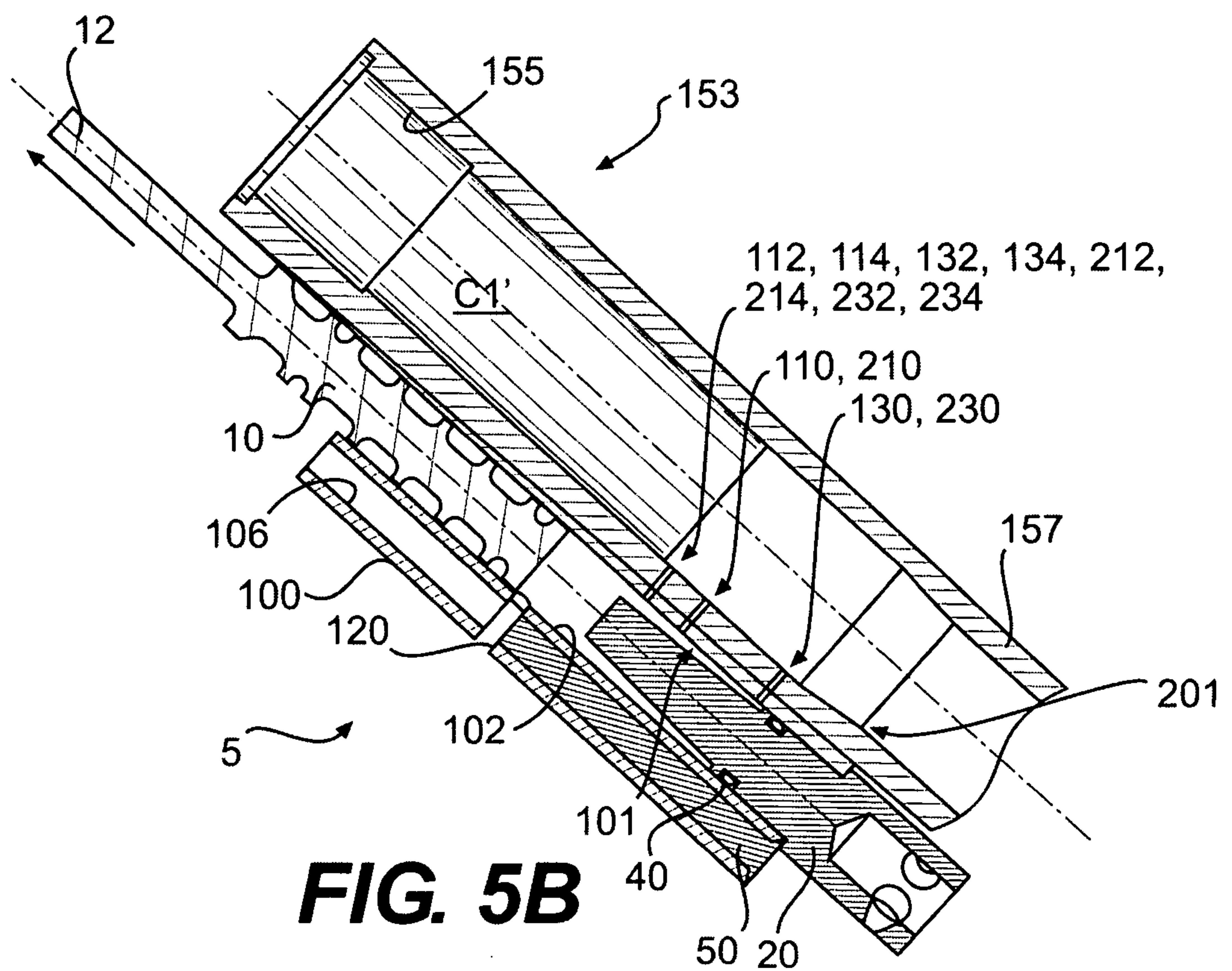
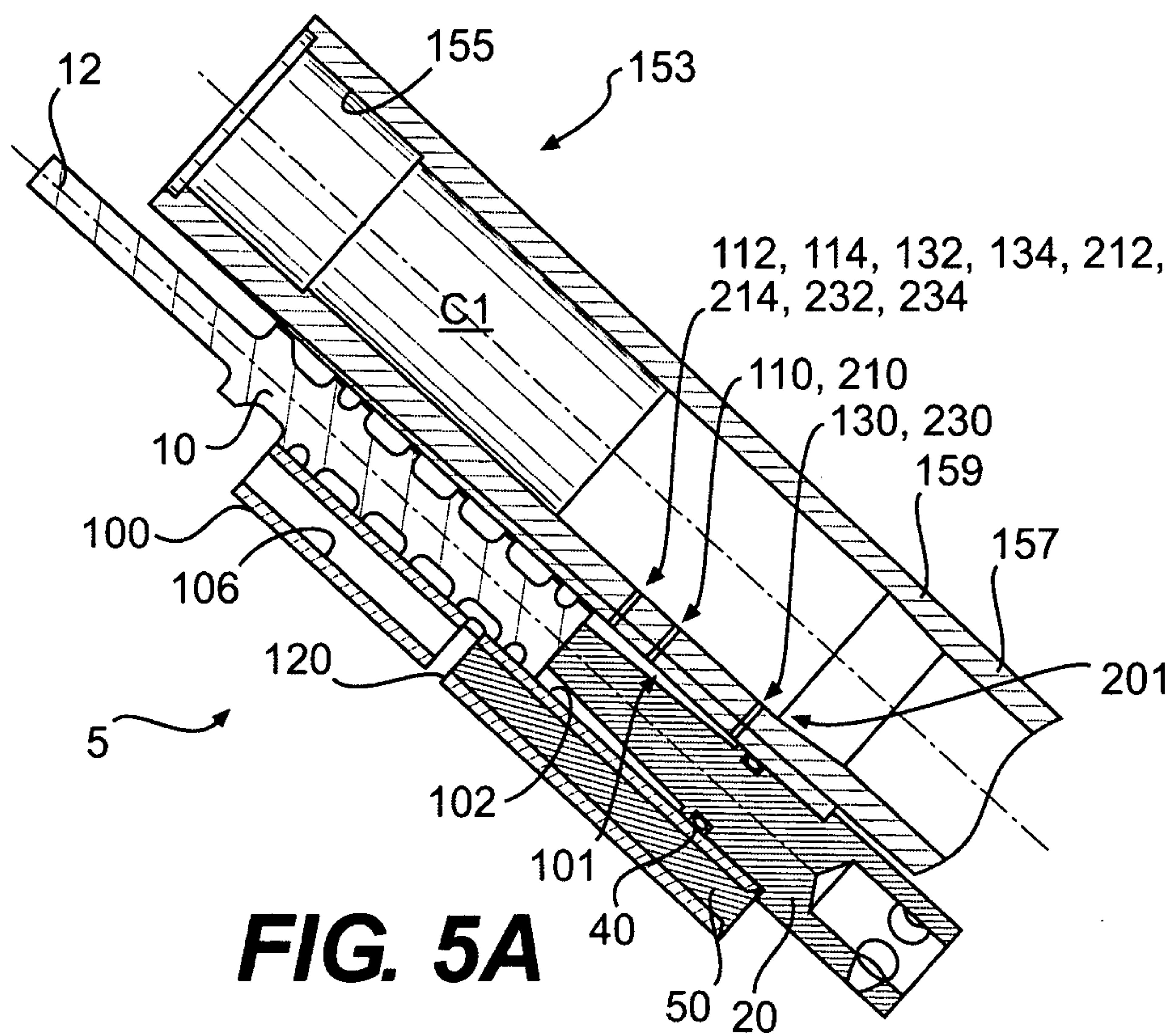
FIG. 1

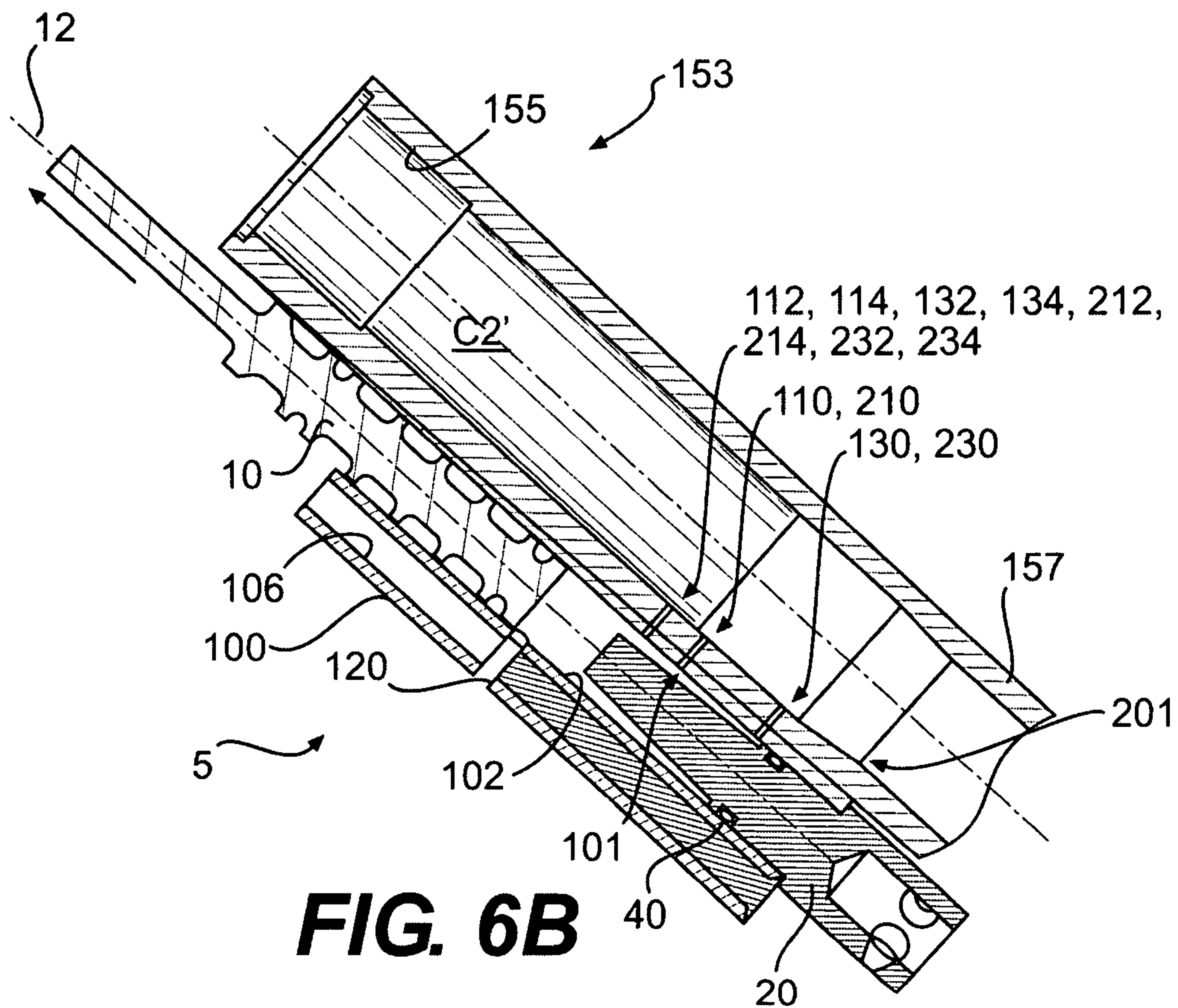
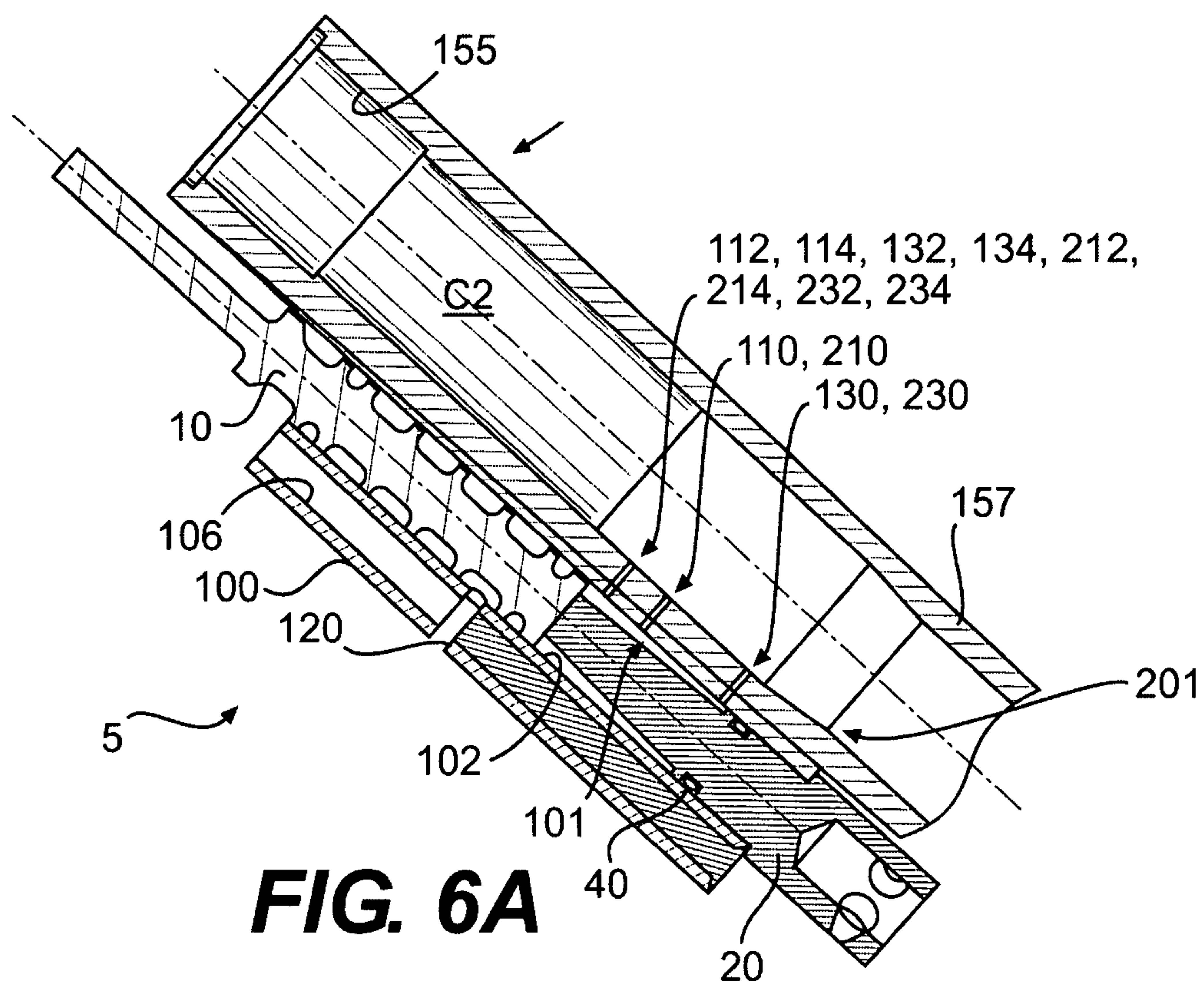


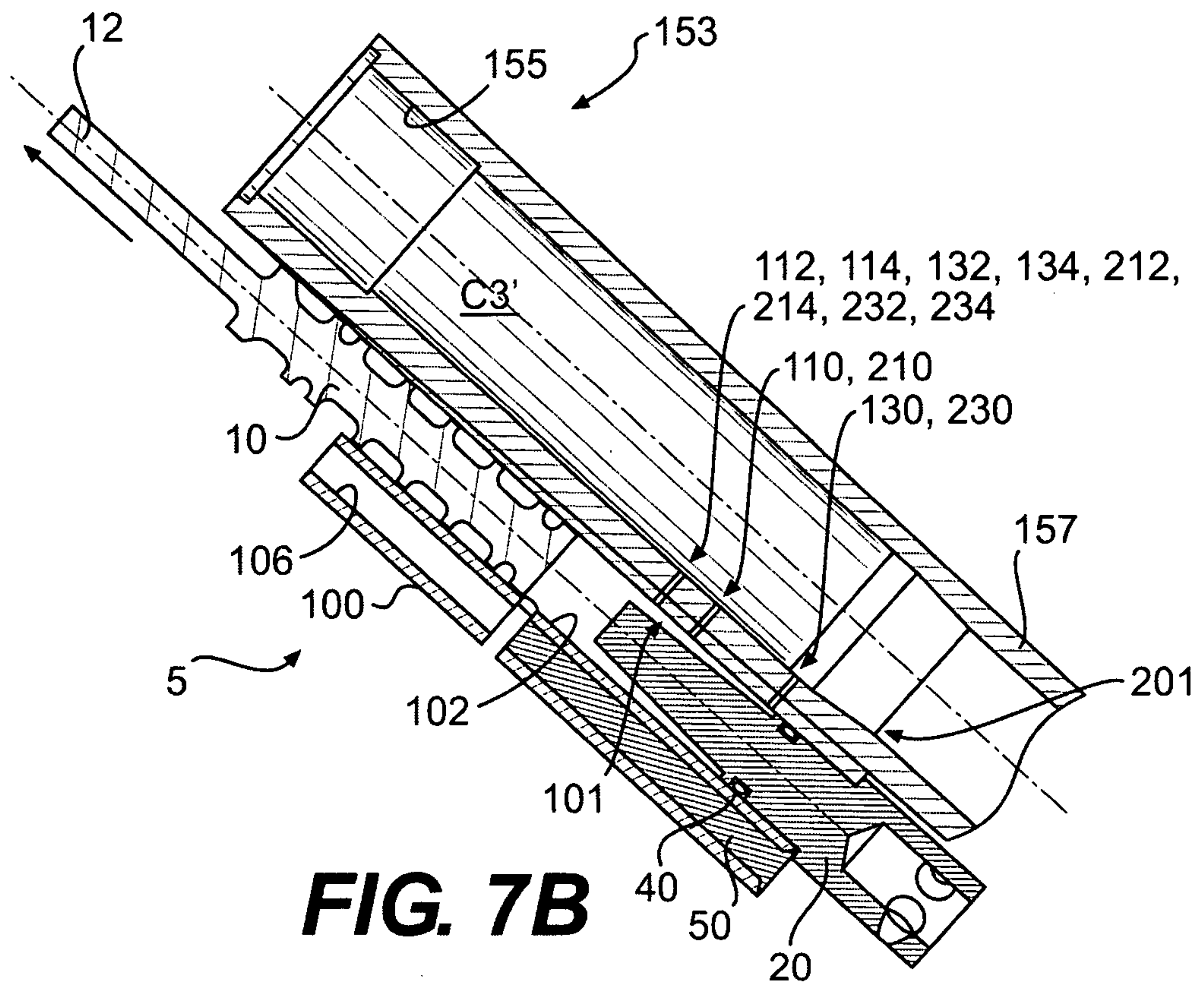
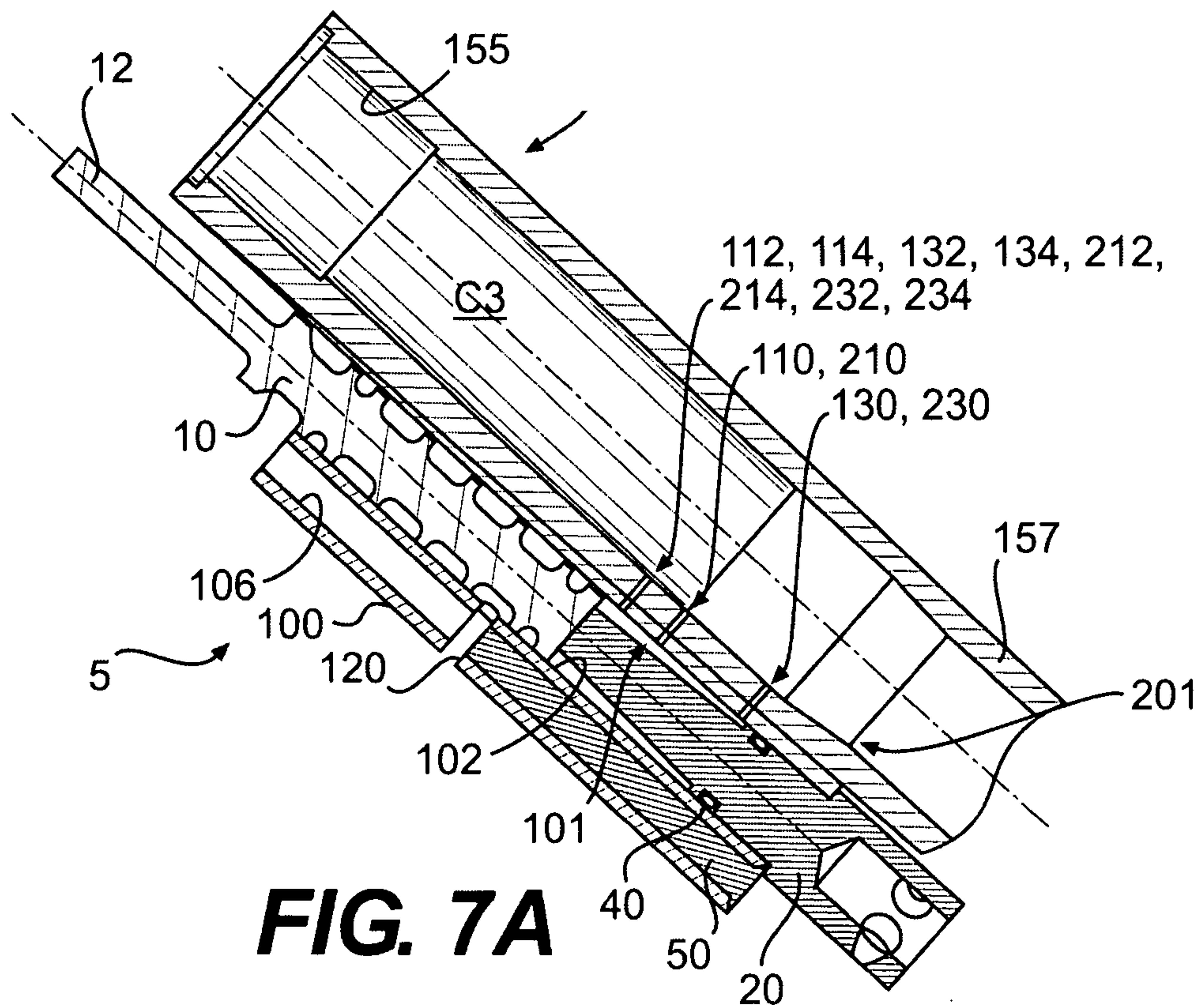


**FIG. 4****FIG. 4A****FIG. 4B**









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