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(54) Title: THERMAL ISOLATION OF PIEZO ACTUATOR

(57) Abstract: A dispensing module that may include a cooling assembly that is configured to direct a cooling fluid to an actuator. The cooling assembly may provide for a reduced size envelope of the dispensing module and effectively cool the actuator. Further, the disclosure provides for a dispensing module that includes a cooling assembly is unlockable to provide for stroke length adjustment of the needle. The cooling assembly may be attached to a frame body of the dispensing module. The frame body may be a single piece. The frame body may define a small envelope.



THERMAL ISOLATION OF PIEZO ACTUATOR

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This Application claims the benefit of U.S. Provisional Application Serial No. 63/386,652 filed December 8, 2022, the contents of which is hereby incorporated by reference as if set forth in its entirety herein.

TECHNICAL FIELD

[0002] The present disclosure relates generally to liquid dispensing devices used for a variety of purposes and, in particular, to jetting liquid dispensing devices for viscous liquids, such as hot melt adhesives. Such devices may be referred to in some contexts as fluid control valves, dispensing guns, or modules.

BACKGROUND

[0003] A typical dispensing device for supplying a material, such as hot melt adhesive, includes a body having a needle that has a valve element that opens and closes a dispensing orifice. The needle is typically actuated in at least one direction by an actuating mechanism, such as pressurized air, springs, piezoelectric devices, or a combination thereof, to dispense discrete amounts of material. The actuating mechanism can also be used to move the valve element in the opposite direction against a valve seat, which stops the flow of material from the dispensing orifice.

[0004] More specifically, material dispensing modules include a flow channel adjacent the dispensing orifice and an actuator chamber at an opposite end of the device. The actuator chamber contains a portion of the needle which is typically connected with a piston member. Due to force from the actuating mechanism acting on the piston member, the valve element on the needle is moved in a direction away from the valve seat. When an opposing force is applied to the piston member, the piston member will actuate the needle towards a closed position where the valve element engages the valve seat.

[0005] Some dispensing devices include a cooling device, which may indirectly cool a piezoelectric device that actuates the needle. Also, some dispensing devices include a multi-component frame that can be bulky and result in misalignment of the needle and/or the piezoelectric device due to manufacturing tolerances.

SUMMARY

[0006] The present application provides for a dispensing module that may include a cooling assembly that is configured to direct a cooling fluid to an actuator. The cooling assembly may provide for a reduced size envelope of the dispensing module and effectively cool the actuator. Further, the disclosure provides for a dispensing module that includes a cooling assembly is unlockable to provide for stroke length adjustment of the needle. The cooling assembly may be attached to a frame body of the dispensing module. The frame body may be a single piece. The frame body may define a small envelope.

[0007] The cooling assembly may direct cooling air to flow directly across top of the actuator.

[0008] The cooling block may mount to the actuator, and allow the actuator to freely slide on a pin or protrusion of a flow path body during stroke adjustment. For example, the cooling block may include a locking collar that clamps/locks to the pin or protrusion of the flow path body, when a screw is tightened into a threaded bore of the cooling block. The actuator may be attached to the cooling block, and thus locked into position when the locking collar is locked onto the pin or protrusion.

[0009] The screw may be accessed from outside the frame body (also referred to as a cover). Prior frame configurations may require an exterior cover to be removed before access to the respective fastener is allowed.

[0010] The frame body may have a longitudinally intermediate plate with an expanded surface area that pulls heat away from a top of the frame body by providing increased surface for convection to dissipate heat. Also, the frame body may have a plurality of posts that have a small cross-section, thereby limiting vertical transmission of heat (e.g., from a nozzle body of the dispensing module) to the longitudinally intermediate plate. By limiting how much heat that can transfer to the actuator from the nozzle body (also referred to as a heated manifold) below it and increasing the cooling air efficiency (direct flow across the actuator, instead of cooling another separate/intermediate block).

[0011] Maintaining consistent (cooler) temperatures within the actuator may help to ensure the response times of actuation are consistent. If temperature changes, the response time may change accordingly.

[0012] The frame body may provide for improved needle alignment. For example, by reducing the number of components that the frame body is comprised of (e.g., to a single piece) and the simplicity in the circular features that connect them.

[0013] For the longitudinal ends of the needle, it can be important to align such with other features of the dispensing module with minimal runout. As runout and angularity increase, multiple undesirable performance issues may begin to arise.

[0014] For example, uncentered striking against the nozzle seat may reduce the pumping efficiency of the hydraulic discharge generated by the kinetic energy during impact. Rubbing in the guide region of the seal pack may generate more friction and reduces needle velocity, thereby reducing the resultant kinetic energy upon needle impact. Also, side loading against piezo actuator “arms” (what the needle is connected to) of the actuator may lower the available force that can be produced by the actuator. Side loading may reduce the ability of the dispensing module to process high-viscosity adhesives and to maintain consistent impact forces at the nozzle.

[0015] The dispensing module may provide for easier service/maintenance, for example due to the single screw that may be accessible to a user from outside of the frame body. The single piece frame body may provide for improved alignment between the actuator and connected needle, which may be easier to control or limit stacked tolerances. Size may be reduced while maintaining or increasing reliability of the actuator.

[0016] In aspects, the frame body may be decoupled from the syringe holder. On the other hand, prior designs may require specific assembly steps to ensure alignment was not affected.

[0017] According to an embodiment of the present disclosure, a dispensing module for dispensing a material. The dispensing module may comprise a module body having an inlet, an outlet, and a flow channel that extends from the inlet to the outlet. The dispensing module may comprise an actuator disposed within the module body. The dispensing module may comprise a needle connected to the actuator and extending through the module body. The dispensing module may comprise a cooling assembly including a fluid flow path that is configured to direct a cooling fluid to the actuator .

[0018] According to another embodiment of the present disclosure, a dispensing module for dispensing a material. The dispensing module may comprise a module body having an inlet, an outlet, and a flow channel that extends from the inlet to

the outlet. The dispensing module may comprise an actuator disposed within the module body. The dispensing module may comprise a needle connected to the actuator and extending through the module body. The dispensing module may comprise a frame body. The dispensing module may comprise a cooling assembly that is attached to the frame and the actuator. In an unlocked state of the cooling assembly, the actuator may be movable relative to the frame body to adjust a stroke length of the needle. In a locked state of the cooling assembly, the actuator may not be movable relative to the frame body to adjust the stroke length of the needle.

[0019] Any of the features of the above and below disclosed embodiments of the dispensing modules may be used in combination with one another. For example, a dispensing module may include a seal, a frame body, a module body that comprises a main body, an actuator, body, and a nozzle body, a cooling assembly, and a thermally insulative body that is separable from a thermally conductive body that partially defines a heating chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The foregoing summary, as well as the following detailed description of illustrative embodiments of the dispensing module of the present application, will be better understood when read in conjunction with the appended drawings. For the purposes of illustrating the dispenser module of the present application, there is shown in the drawings illustrative embodiments. It should be understood, however, that the application is not limited to the precise arrangements and instrumentalities shown. In the drawings:

[0021] Fig. 1 is a front oblique view of a dispenser module according to aspects of the disclosure.

[0022] Fig. 2 is a front cross-sectional view of the dispenser module of Fig. 1.

[0023] Fig. 3A is an enlarged cross-sectional view of a portion of the dispenser module of Fig. 2, including a needle that is actuatable in a first direction and a second direction, a seal abutting the needle, and a nozzle body.

[0024] Fig. 3B is an enlarged cross-sectional view of a portion of the dispenser module of Fig. 3A.

[0025] Fig. 3C is an enlarged cross-sectional view of a portion of the dispenser module of Fig. 3B, where the seal is actuated in the second direction.

[0026] Fig. 3D is an oblique cross-sectional view of a portion of the dispenser module of Fig. 3C, where the seal is actuated in the first direction.

[0027] Fig. 3E is an oblique cross-sectional view of a portion of the dispenser module of Fig. 3D.

[0028] Fig. 4 is a front cross-sectional view of the seal of Fig. 3 in a pre-installed configuration.

[0029] Fig. 5 is a front oblique view of the seal of Fig. 3 in an installed configuration.

[0030] Fig. 6A is a front view of the seal of Fig. 5 when actuated in the first direction.

[0031] Fig. 6B is a cross-sectional view of the seal of Fig. 6A.

[0032] Fig. 7 is a front view of the seal of Fig. 6A actuated in the second direction;

[0033] Fig. 8A is an oblique cross-sectional view of a portion of a dispenser module of Fig. 2.

[0034] Fig. 8B is an oblique cross-sectional view of a portion of another embodiment of the dispenser module, without showing a syringe.

[0035] Fig. 8C is an enlarged cross-sectional view of a portion of the dispenser module of Fig. 8A.

[0036] Fig. 8D is an enlarged cross-sectional view of a portion of the dispenser module of Fig. 8B.

[0037] Fig. 9A is an oblique exploded view of a portion of the dispenser module of Fig. 8A.

[0038] Fig. 9B is an oblique upper view of a lower sub assembly of the dispenser module of Fig. 9A.

[0039] Fig. 10A is an oblique view another embodiment of a thermally insulative body of the dispenser module of Fig. 8A.

[0040] Fig. 10B is a different oblique view of the thermally insulative body of Fig. 10A.

[0041] Fig. 11 is a side view of the dispenser module with the thermally insulative body of Fig. 10A, where a portion of the dispenser module is removed such that the thermally insulative body is visible.

[0042] Fig. 12A is an oblique view of a portion of a dispenser module of Fig. 9A.

[0043] Fig. 12B is an oblique exploded view of the portion of the dispenser module of Fig. 12A.

[0044] Fig. 12C is an oblique partial cross-sectional side view of the dispenser module of Fig. 12A, where a flow path of a cooling assembly of the dispenser module is represented.

[0045] Fig. 12D is an oblique view of the portion of the dispenser module of Fig. 12A, where an imaginary cuboid envelope is represented bounding a frame body, an actuator, a cooling block, and a flow path body of the dispenser module.

[0046] Fig. 12E is an oblique exploded view of a portion of the dispenser module of Fig. 12A.

[0047] Fig. 12F is an oblique side view of a cooling block of the dispenser module of Fig. 12E.

[0048] Fig. 13A is an oblique cross-sectional view of a portion of the dispenser module of Fig. 8A.

[0049] Fig. 13B is an enlarged oblique cross-sectional view of the portion of the dispenser module of Fig. 13A.

[0050] Fig. 13C is an enlarged oblique cross-sectional view of the portion of the dispenser module of Fig. 13B.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0051] The present disclosure can be understood more readily by reference to the following detailed description taken in connection with the accompanying figures and examples, which form a part of this disclosure. It is to be understood that this disclosure is not limited to the specific devices, methods, applications, conditions or parameters described and/or shown herein, and that the terminology used herein is for the purpose of describing particular embodiments by way of example only and is not intended to be limiting of the scope of the present disclosure. Also, as used in the specification including the appended claims, the singular forms “a,” “an,” and “the” include the plural, and reference to a particular numerical value includes at least that particular value, unless the context clearly dictates otherwise.

[0052] The term “plurality”, as used herein, means more than one. When a range of values is expressed, another embodiment includes from the one particular value and/or to the other particular value. Similarly, when values are expressed as

approximations, by use of the antecedent “about,” it will be understood that the particular value forms another embodiment. All ranges are inclusive and combinable.

[0053] Referring to Fig. 1, a dispensing module 100 is shown according to one example. As exemplified in Fig. 2, the dispensing module 100 may include a module body 101, material reservoir 102, an actuator 104 (e.g., a piezoelectric actuator), a needle 106 operably coupled to the actuator 104 such that the actuator 104 is configured to actuate the needle 106.

[0054] The module body 101 may include a heater 110 that is configured to heat fluid that is provided by the material reservoir 102 to the module body 101.

[0055] Turning to Figs. 3A-3E, the module body 101 of the dispensing module 100 may include a main body 120, a dispenser body 122, and a nozzle body 124. A first end 190 of the nozzle body 124 may be received in an opening 192 of the main body 120. For example, the first end 190 of the nozzle body 124 may be threadedly coupled to the opening 192 of the main body 120 such that the nozzle body 124 is directly attached to the main body 120.

[0056] The actuator 104 may actuate the needle 106 into an upward position (an example of a second position) when viewing Figs. 3A-3C, such that the needle 106 is in an open position, as exemplified in Figs. 3A-3C. The actuator 104 may actuate the needle 106 into a downward position (an example of a first position) when viewing Figs. 3A-3C, such that the needle 106 is in a closed position, as exemplified in Figs. 3D and 3E.

[0057] In aspects, the nozzle body 124 may be formed of a metallic material providing good thermal transfer; and the main body 120 may be formed of a metallic material providing good thermal transfer. Moreover, the direct attachment of the main body 120 and the nozzle body 124 may provide good thermal transfer therebetween. In this regard, heat from the heater 110 may be more efficiently transferred from the dispenser body 122 and the nozzle body 124 providing improved performance of the dispensing module 100.

[0058] The dispensing module 100 may include a seal 130 that seals against the needle 106. The seal 130 may define a radially inner portion 194 (as illustrated in Figure 4) such that the needle 106 extends along a longitudinal axis X through the radially inner portion 194.

[0059] The needle 106 may include a radially outwardly facing groove 132 that faces away from the longitudinal axis X (e.g., along a lateral direction Y that is

perpendicular to the longitudinal axis X). The radially outwardly facing groove 132 may be configured to receive the radially inner portion 194 of the seal 130.

[0060] The seal 130 may be secured by the dispenser body 122. For example, the dispenser body 122 may include a radially outer body 140 and a radially inner body 142 that sandwich a radially outer portion 188 of the seal 130 to secure the radially outer portion 188 of the seal 130 in place. The radially outer portion 188 of the seal 130 may be axially compressed by such sandwiching of the radially outer portion 188 of the seal 130, which is represented by the radially inner body 142 overlapping with the radially outer portion 188 of the seal 130. It will be understood that the radially outer portion 188 of the seal 130 may be axially compressed by less than 100%, 50%, or 25% of its original axial thickness.

[0061] The radially outer body 140 may define a fluid flow path 182 to receive fluid from a fluid passage 196 of the main body 120 and to provide such fluid to the nozzle body 124 for dispensing by the needle 106. For example, the radially outer body 140 may include radial seal elements 150 and 152 that are configured to seal between the radially outer body 140 and the main body 120. The radial seal elements 150 and 152 may be configured to seal against respective axially offset portions of the main body 120 to prevent leakage at a connection between the fluid flow path 182 of the radially outer body 140 and the fluid passage 196 of the main body 120.

[0062] The radially inner body 142 may be attached to the radially outer body 140 such that the radially inner body 142 does not axially move relative to the radially outer body 140. For example, the radially inner body 142 may be press-fit within the radially outer body 140. In another embodiment, the radially inner body 142 may be threadedly coupled to the radially outer body 140.

[0063] The nozzle body 124 may include a nozzle attachment body 160 and a nozzle cone 162. The nozzle cone 162 may include a needle seat that receives the needle 106 and defines a dispensing orifice 164 for dispensing fluid received from the dispenser body 122.

[0064] The needle 106 may have a radial thickness of anywhere from 0.05 inches to 0.1 inches. For example, the needle 106 may have a radial thickness of 1/16 of an inch (.0625 inches) at a location where the seal 130 seats on the needle 106.

[0065] The nozzle attachment body 160 (an example of a threaded nut) may include a central opening that the nozzle cone 162 extends longitudinally through. For example, the nozzle attachment body 160 may define a radially inwardly extending

ledge that abuts a radially outwardly extending ledge of the nozzle cone 162, thereby preventing movement of the nozzle cone 162 away from the needle 106.

[0066] The nozzle attachment body 160 may directly attach to the main body 120 to secure the nozzle cone 162 relative to the main body 120. For example, the nozzle attachment body 160 may be threadedly coupled to the main body 120.

[0067] Turning to Fig. 4, when in a pre-installed configuration, the seal 130 may not be deformed. The seal 130 may be flat when in the pre-installed configuration. For example, a radially outer portion 188 of the seal 130 may define an outer thickness T_{O1} that is equal to an inner thickness T_{I1} defined by a radially central opening defined by the radially inner portion 194 of the seal 130. The outer thickness T_{O1} and the inner thickness T_{I1} may be .01 inches - .05 inches, .02 inches - .04 inches, or .025 inches - .035 inches, prior to installation of the seal 130.

[0068] The seal 130 may define an outer diameter OD a first inner diameter ID_1 when in the pre-installed configuration. For example, the outer diameter OD may be 0.1 inches - 0.4 inches, 0.15 inches - 0.25 inches, or 0.25 inches - 0.4 inches and the first inner diameter ID_1 may be .04 inches - .06 inches, .045 inches - .055 inches, or .055 inches - .06 inches.

[0069] Turning to Figs. 5-7, when in an installed configuration, the seal may be deformed from being installed on the needle 106. The seal 130 may not be flat when in the installed configuration. For example, the radially outer portion 188 of the seal 130 may define an outer thickness T_{O2} that is not equal to an inner thickness T_{I2} defined by the radially inner portion 194 of the seal 130. The inner thickness T_{I2} may be 25% greater than the inner thickness T_{I1} . In an embodiment, the inner thickness T_{I2} is anywhere from 5%-50%, 10%-40%, 15%-30%, or 20%-30% greater than the inner thickness T_{I1} .

[0070] For example, the inner thickness T_{I2} may be .0375 inches after installation and the inner thickness T_{I1} may be .03 inches prior to installation of the seal 130.

[0071] The groove 132 (Figs. 3A-3E) may have an axial length 170 that is 20% greater than the outer thickness T_{O2} , thereby providing for the central portion of the seal 130 to move axially within the groove 132. In an embodiment, the axial length 170 of the groove 132 is anywhere from 5%-50%, 10%-40%, 15%-30%, or 15%-25% greater than the inner thickness T_{I2} . For example, the axial length 170 of the groove 132 may be anywhere from .044 to .046 inches (e.g., .045 inches).

[0072] The seal 130 may define a second inner diameter ID_2 when in the installed configuration. For example, the second inner diameter ID_2 may be 25% greater than the first inner diameter ID_1 . In an embodiment, a second inner diameter ID_2 is anywhere from 5%-50%, 10%-40%, 15%-30%, or 20%-30% greater than the first inner diameter ID_1 .

[0073] For example, the second inner diameter ID_2 may be .0625 inches after installation and the first inner diameter ID_1 may be .05 inches prior to installation of the seal 130.

[0074] The outer diameter OD may be 0.2 inches. In an embodiment, the outer diameter OD is anywhere from 50%-1000%, 150%-800%, 200%-500%, 250%-350% (e.g., 300%) greater than the first inner diameter ID_1 .

[0075] Figs. 6A-6B illustrate an example of the seal 130 in a first actuated position (e.g., when the needle 106 is actuated into the downward position when viewing Figs. 3A-3D), and Fig. 7 illustrates an example of the seal 130 in a second actuated position (e.g., when the needle 106 is actuated into the upward position when viewing Figs. 3A-3C). The first actuated position and the second actuated position may be symmetrical. In an embodiment, the first actuated position and the second actuated position may be asymmetrical.

[0076] In aspects, the seal 130 may be formed of an elastomer material. Due to mating part geometries, such as the groove 132 of the needle 106, and the radially outer body 140 and the radially inner body 142, and compression of the elastomer material of the seal 130, an otherwise flat seal form develops a convolution and permits enough flexibility to handle the stroke of the needle 106 displacement that is typical in applications of the dispensing module 100, such as jetting applications. The seal 130 may be configured to move around within the groove 132 or gland on the needle 106. However, a wear rate of the elastomer material of the seal 130 at its contact point at the groove 132 of the needle 106 may be reduced. Accordingly, longer intervals between service may be realized by the various components of the dispensing module 100. Moreover, implementations of the dispensing module 100 including the seal 130 may realize reduced contamination in the dispensing module 100 due to fluid leaks, such as adhesive leaks. Further, aspects of the dispensing module 100 as described herein may result in lower maintenance costs for the customer.

[0077] Turning to Figs. 8A-8D, the material reservoir 102 may include a thermally conductive body 200, a thermally insulative body 204, and a syringe 206 (shown in Figs. 8A and 8C).

[0078] The dispensing module 100 may include a luer connector 210 that is configured to fluidly connect an outlet of the syringe to an inlet of the fluid passage 196 of the main body 120. The luer connector 210 may be disposed within an opening of the thermally insulative body 204. For example, the luer connector 210 may be entirely radially spaced from the thermally insulative body 204 (e.g., the luer connector 210 may not contact the thermally insulative body 204).

[0079] The luer connector 210 may directly attach to the main body 120. For example, the luer connector 210 may threadedly connect to the main body 120.

[0080] The thermally insulative body 204 may be separable from the thermally conductive body 200. For example, the thermally insulative body 204 may include an inlet end 212 that is press-fit into an adjacent end of the thermally conductive body 200. The thermally insulative body 204 may be attached to the main body 120 (e.g., by fasteners, not shown herein). Additionally, removal of the thermally insulative body 204 from the thermally conductive body 200 may facilitate cleaning of the thermally insulative body 204. For example, removal of the thermally conductive body 200 from the thermally insulative body 204 provides easy access to various surfaces of the thermally insulative body 204. Accordingly, once the thermally insulative body 204 is separated from the thermally conductive body 200, the thermally insulative body 204 may be easily cleaned. This is in contrast to current implementations of reservoirs that have a single piece configuration or a bottom that cannot be removed without damaging the respective reservoir.

[0081] The thermally insulative body 204 may be formed of a different material from the thermally conductive body 200, such that an insulative material that forms the thermally insulative body 204 has a lower heat transfer coefficient than a conductive material that forms the thermally conductive body 200. For example, the thermally insulative body 204 may be formed of polyetheretherketone (PEEK). In other aspects, the thermally insulative body 204 may be formed of plastic materials, synthetic materials, and/or the like. In other aspects, the thermally insulative body 204 may be formed of any other thermally insulative materials. The thermally conductive body 200 may be formed of aluminum. In aspects, the thermally conductive body 200 may be formed of other types of metallic materials.

[0082] The thermally conductive body 200 may be entirely spaced from the main body 120. For example, the material reservoir 102 may include an insulator 220 that circumscribes most of the thermally conductive body 200.

[0083] The insulator 220 may not contact the thermally insulative body 204. For example, the insulator 220 may not extend past an outlet end of the thermally conductive body 200. The insulator 220 may be spaced from the outlet end of the thermally conductive body 200 that is adjacent to the thermally insulative body 204. The spacing of the insulator 220 from the outlet end may provide for a pathway for heat to travel from the thermally conductive body 200, instead of to the thermally insulative body 204. In aspects, the insulator 220 may not be located laterally adjacent the thermally insulative body 204. In aspects, no insulation may be located laterally adjacent the thermally insulative body 204.

[0084] The spacing of the insulator 220 from the outlet end may provide for electrical wiring clearance. Additionally, a space adjacent to the thermally insulative body 204 may form a void such that thermal transfer between the thermally insulative body 204 and other portions of the dispensing module 100 is greatly diminished. Further, the thermally insulative body 204 may be configured with extensions extending from a lower surface thereof adjacent the main body 120 and contacting the main body 120. The extensions of the thermally insulative body 204 may be configured with a very small contact surface to reduce thermal transfer between the main body 120 and the thermally insulative body 204.

[0085] The thermally conductive body 200 may be heated to maintain the material inside the syringe 206 at a temperature below that of the material within the fluid passage 196 of the main body 120. For example, the material inside the syringe 206 may be maintained at 10°C below that of the material within the fluid passage 196. In aspects, the material inside the syringe 206 may be maintained at more than 5°C below that of the material within the fluid passage 196. The temperature of the material inside the syringe 206 may be maintained at, for example, 100°C, whereas the temperature of the material inside the fluid passage 196 of the main body 120 may be maintained at 110°C. In an embodiment, the syringe 206 may be maintained at more than, for example, 10°C below that of the material within the fluid passage 196. In an embodiment, the syringe 206 may be maintained at less than 10°C below that of the material within the fluid passage 196.

[0086] Turning to Figs. 9A-9B, the dispensing module 100 may include an upper subassembly 240 and a lower subassembly 242. The upper subassembly 240 may include a main housing 244 and the thermally conductive body 200 of the material reservoir 102. The lower subassembly 242 may include the main body 120 and the thermally insulative body 204.

[0087] The upper subassembly 240 and the lower subassembly 242 may be configured to be quickly detached one another (e.g., to clean the thermally insulative body 204). For example, two fasteners 246 may be the only fasteners that attach the upper subassembly 240 and the lower subassembly 242 together.

[0088] The two fasteners 246 may each attach the main housing 244 to the lower subassembly 242. For example, the fasteners 246 may each extend along different orthogonal axes. In an embodiment, only one fastener attaches the main housing to the lower subassembly. In an embodiment, more than two fasteners attach the main housing to the lower subassembly.

[0089] The main housing 244 may be fixed relative to the material reservoir 102. For example, the material reservoir 102 may be coupled to the main housing 244.

[0090] The lower subassembly 242 may include the actuator 104 and a frame body 248. For example, the main housing 244 may be coupled to the frame body 248. The frame body 248 may be coupled to the main body 120 such that the thermally insulative body 204 and the frame body 248 are fixed relative to one another. Thus, when the frame body 248 and the main housing 244 are coupled together (e.g., via one or more fasteners 246), the thermally insulative body 204 may be fixed relative to the main housing 244.

[0091] In aspects, when the upper subassembly 242 and the lower subassembly are coupled together, the main body 120, the thermally insulative body 204, the main housing 244, and the frame body 248 are fixed relative to one another.

[0092] In aspects, implementations of the dispensing module 100 may use a low thermal conductivity material in the bottom half of the two-piece syringe cartridge. In aspects, implementations of the dispensing module 100 may be configured with increased size gaps between mating parts. In this aspect, this may increase the temperature differential that can be obtained between the adhesive syringe set point and nozzle temperature setpoints. Further, this aspect may permit lower syringe of temperature set points to reduce degradation of the adhesive.

[0093] In aspects, implementations of the dispensing module 100 may utilize a two-piece cartridge. In this aspect, this will not only help facilitate the thermal isolation required, but also improve serviceability during cleaning procedures of the dispensing module 100.

[0094] Further, aspects of the dispensing module 100 allow a higher set point temperature differential in comparison to current implementations. In aspects, implementations of the dispensing module 100 may provide a reduced amount of time to service/clean the syringe cartridge interior. In aspects, implementations of the dispensing module 100 may provide slower adhesive degradation rate. In aspects, implementations of the dispensing module 100 may provide increased dispense consistency. In aspects, implementations of the dispensing module 100 may provide longer operating time before needing service. In aspects, implementations of the dispensing module 100 may provide easier to remove dripped adhesive from bottom of cartridge cavity. In aspects, implementations of the dispensing module 100 may provide faster removal/disassembly of nozzle body assembly from main applicator assembly.

[0095] Referring now to Figs. 10A and 10B, a second embodiment of the thermally insulative body 204' is shown. It is to be appreciated that the second embodiment can be similar to the first embodiment of the thermally insulative body 204 shown in Fig. 8A, for example. Accordingly, the same reference numbers used above with reference to the first embodiment can be also used with a "prime" notation in reference to a second embodiment. It is also to be appreciated that, unless otherwise set forth below, the components (and features thereof) of the thermally insulative body 204' of the second embodiment can be similar to those of the thermally insulative body 204 of the first embodiment.

[0096] The thermally insulative body 204' may include a tab 250 that may be configured to attach to the thermally conductive body 200'. For example, the tab 250 may extend upwardly along the longitudinal axis X.

[0097] The tab 250 may extend along a plane defined by the lateral axis Y and a normal axis Z that is orthogonal to the lateral axis Y and the longitudinal axis X. For example, the tab 250 may extend along a curvate path along an outer periphery of a shoulder 254 of the thermally insulative body 204'. The curvate path may correspond to a portion of an outer surface of the thermally conductive body 200' such that an interior surface of the tab 250 matches the shape of the portion of the outer surface of the thermally conductive body 200'.

[0098] Attaching the tab 250 to the thermally conductive body 200' may provide for maintaining sealing between the syringe and a nozzle (e.g., the syringe 206 and the luer connector 210 shown in Fig. 8A) and/or may provide for maintaining sealing between the thermally insulative body 204' and the thermally conductive body 200'. For example, the attachment may prevent the thermally insulative body 204' from becoming misaligned with or separated from the thermally conductive body 200' during use, when the material (e.g., inside the syringe 206) is pressurized. The attachment may prevent the luer connector 210 from becoming misaligned with or separated from the syringe 206 during use.

[0099] Referring also to Fig. 11, in which a portion of the dispenser module 100' is removed such that the thermally insulative body 204' is visible, a fastener 256 may be configured to couple the tab 250 to the thermally conductive body 200'. For example, the tab 250 may include a through hole 252 that is configured to align with the outer surface of the thermally conductive body 200', such that the fastener 256 is configured to extend through the through hole 252 to the thermally conductive body 200'.

[0100] The thermally conductive body 200' may include a hole that aligns with the through hole 252, when the thermally conductive body 200' and the thermally insulative body 204' are assembled together. The fastener 256 may thus be received in the through hole 252 and the hole of the thermally conductive body 200' when assembled. In aspects, the hole of the thermally insulative body 204' is unthreaded such that the fastener 256 can slide through the through hole 252 to reach the thermally conductive body 200'. In aspects, the thermally conductive body includes a threaded hole that is configured to receive a threaded shaft of the fastener 256.

[0101] The insulator 220' may not extend past the tab 250. For example, the insulator 220' may not overlap the tab 250 along the longitudinal axis X.

[0102] Turning to Figs. 12A-12F, the lower subassembly 242 may include the actuator 104, the frame body 248, and a cooling assembly 262 that is configured to direct a cooling fluid (e.g., cleaned, dried, and pressurized air) to the actuator 104.

[0103] The cooling assembly 262 may include a cooling block 270 (represented partially transparently in Fig. 12C so that internal features of the cooling block 270 are represented), a flow path body 272 (represented partially transparently in Fig. 12C so that internal features of the flow path body 272 are represented), and an inlet port 274. The cooling block 270 may be configured to attach to the actuator 104.

For example, multiple (e.g., two) fasteners 280 (e.g., screws) may fix the cooling block 270 to a mounting surface 282 of the actuator 104.

[0104] The flow path body 272 may be configured to attach to the frame body 248. For example, multiple (e.g., three) fasteners 284 (e.g., screws) may fix the flow path body 272 to the frame body 248.

[0105] The flow path body 272 may include a protrusion 286 (e.g., a pin) that is configured to extend through an opening 288 of the frame body 248 when the flow path body is fixed to the frame body 248. The protrusion 286 may be configured to be received in an opening 290 of the cooling block 270 when the protrusion 286 extends through the opening 288, such that the cooling block 270 may be fixed to the protrusion 286.

[0106] For example, the cooling block 270 may include a locking collar 300 that includes a first leg 300a that defines a threaded bore and a second leg 300b that defines a through hole leading to the threaded bore. The threaded bore may be configured to receive a fastener 302 (e.g., a screw), such that tightening of the fastener 302 (e.g., rotating the fastener 302 in a clockwise rotational direction when viewing a head of the fastener 302) may lock the locking collar 300 to the protrusion 286. Loosening the fastener 302 (e.g., rotating the fastener 302 in a counter-clockwise rotational direction when viewing a head of the fastener 302) may unlock the locking collar 300 to the protrusion 286.

[0107] When the locking collar 300 is unlocked, the actuator 104 may move longitudinally relative to the flow path body 272. For example, the entire actuator 104 may be slid longitudinally along the protrusion 286 to adjust a stroke length of the needle 106.

[0108] The cooling assembly 262 may define a flow path 310 that is configured to direct the cooling fluid to the actuator 104. For example, the cooling block 270 may define a first portion 310a (shown in Figs. 12C and 12F) of the flow path 310 that is configured to direct the cooling fluid from the opening 290 to respective grooves 312 of the cooling block 270 that extend open toward and extend along the mounting surface 282 of the actuator 104. The first portion 310a may define two separate flow paths that each lead to a respective groove 312 (shown in Figs. 12C and 12F). The grooves 312 may be spaced apart from one another along the lateral axis. In another aspect, the first portion may define a single fluid line or more than two fluid lines that each lead to a respective groove.

[0109] The flow path body 272 may define a second portion 310b of the flow path 310. The second portion 310b may be configured to direct the cooling fluid from the inlet port 274 to the first portion 310a. For example, the second portion 310b may extend from the inlet port 274 to a radially outwardly facing portion of the protrusion 286, such that the second portion 310b is fluidly connected with the first portion 310a. In another aspect, the second portion may define more than one fluid line each lead to a respective first portion of the flow path of the cooling block.

[0110] Thus, the cooling fluid received via the inlet port 274 may be directed through the flow path body 272 to the grooves 312 of the cooling block 270 so that the cooling fluid absorbs heat directly from the mounting surface 282 of the actuator 104.

[0111] Turning particularly to Fig. 12D, an imaginary cuboid envelope 320 that bounds the combination of the frame body 248, the actuator 104, the cooling block 270, and the flow path body 272 may have a total volume of 5 inches squared (in^2). This may result in a volume reduction of 60% compared to prior systems in which cooling fluid is not directly provided to an actuator. In another aspect, the imaginary cuboid envelope may be 1 in^2 , 2 in^2 , 3 in^2 , 4 in^2 , 4.5 in^2 , 4.75 in^2 , 4.9 in^2 , 5.1 in^2 , 5.25 in^2 , 5.5 in^2 , 6 in^2 , 7 in^2 , 8 in^2 , 9 in^2 , 10 in^2 , 11 in^2 , 12 in^2 , anywhere from 2 in^2 to 12 in^2 , anywhere from 3 in^2 to 9 in^2 , anywhere from 4 in^2 to 8 in^2 , anywhere from 4.5 in^2 to 6 in^2 , or anywhere from 4.5 in^2 to 5.5 in^2 .

[0112] Turning to Fig. 12E, the frame body 248 may include multiple longitudinally extending posts 330 and central plates 332. The longitudinally extending posts 330 may have relatively small cross-sectional areas 330a to reduce longitudinal heat transfer (e.g., from the nozzle body toward the central plates 332 and/or to the actuator 104). For example, each cross-sectional area may be .015 in^2 . In another aspect, the cross-sectional area is between .01 in^2 and .05 in^2 , between .0125 in^2 and .03 in^2 , between .014 in^2 and .02 in^2 , between .014 in^2 and .017 in^2 , or between .015 in^2 and .017 in^2 , or .016 in^2 .

[0113] The central plates 332 may not contact the cooling block 270 and the actuator 104, such that an air gap exists between each central plate 332 and the cooling block 270 and between each central plate 332 and the actuator 104. The central plates 332 may span as large an area as possible while still providing a user with access to the fastener 302 to adjust a stroke length of the needle 106 while the cooling block 270 and the actuator 104 are assembled within the frame body 248. For example, the area of the major surfaces of the central plates 332 may be 6 times (e.g., 1 in^2) the cross-

sectional area of each post 330. In another aspect, the area of the major surfaces of the central plates may be anywhere from 2 times to 20 times, 2 times to 10 times, 3 times to 10 times, 4 times to 8 times, 5 times to 7 times, or 5.5 times to 6.5 times the cross-sectional area of each post.

[0114] Turning to Figs. 13A-13C, the frame body 248 of the dispensing module 100 may be a single rigid piece. For example, the frame body 248 may be made of stainless steel.

[0115] As discussed above, the frame body 248 may provide for simple assembly and reduce issues associated with misalignment of the needle 106. For example, the frame body 248 may provide for a reduction of runout error (e.g., misalignment of the needle 106 and the longitudinal axis X). Thus, each end 106a, 106b of the needle 106, circled in Fig. 13A, may be concentric with the longitudinal axis A. In practice, each end 106a, 106b of the needle 106 may be closer to concentric with the longitudinal axis A when compared to needles that are attached to actuators housed in a multi-component frame.

[0116] The needle 106 may be within .004 inches (in) to .005 in of concentric with the longitudinal axis X. In an aspect, the needle is between .001 in to .010 in, .002 in to .009 in, .003 in to .008 in, .004 in to .007 in of concentric with the longitudinal axis X.

[0117] As also discussed above, such concentricity (or relative concentricity) may provide for reduction of uncentered striking of the needle 106 with a corresponding seat 340 when dispensing fluid. Such concentricity may provide for a reduction of rubbing of the needle 106 against a guide region 341 (e.g., a radially inwardly facing surface 142a of the radially inner body 142) circled in Fig. 13C, which may reduce friction and needle velocity losses. Such concentricity may provide for a reduction of side loading of the needle 106 against movable arms 342 of the actuator 104 that actuate the needle 106 along the longitudinal axis X (e.g., along the arrows 344 shown in Fig. 13B).

[0118] The following are a number of nonlimiting EXAMPLES of aspects of the disclosure.

[0119] In one general aspect, a dispensing module may include a module body having an inlet, an outlet, and a flow channel that extends from the inlet to the outlet. The dispensing module may also include an actuator disposed within the module body. Module may furthermore include a needle connected to the actuator and extending

through the module body. The dispensing module may in addition include a cooling assembly including a fluid flow path that is configured to direct a cooling fluid to the actuator. Other embodiments of this aspect include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the methods.

[0120] Implementations may include one or more of the following features. The dispensing module where the cooling assembly may include a cooling block that defines a first portion of the fluid flow path, where the first portion of the fluid flow path is configured to direct the cooling fluid to the actuator. The dispensing module where the cooling block is configured to direct the cooling fluid directly to the actuator. The dispensing module, where the cooling block is directly attached to the actuator. The dispensing module, where the cooling block includes at least one groove that is configured to receive the cooling fluid from the fluid flow path, and where the at least one groove opens toward the actuator such that the cooling fluid received from the fluid flow path flows across the actuator. The dispensing module where the at least one groove opens toward a surface of the actuator such that the cooling fluid received from the fluid flow path flows across the surface of the actuator. The dispensing module where the at least one groove extends along the surface of the actuator. The dispensing module where the at least one groove comprises two grooves that extend along a longitudinal axis and are spaced apart from one another along a lateral axis that is perpendicular to the longitudinal axis. The dispensing module where the first portion of the fluid flow path defines two separate flow paths that each lead to a respective one of the two grooves. The dispensing module, where the cooling assembly further may include a fluid inlet port. Dispensing module, where the cooling fluid is air. The dispensing module may include a frame body. The dispensing module where the frame body is a single rigid body. The dispensing module or claim 10, may include a flow path body that is configured to attach to the frame body. The dispensing module where the flow path body includes a protrusion that extends through an opening of the frame body and is configured to be received by an opening of the cooling block. The dispensing module, where the actuator is a piezoelectric actuator. Implementations of the described techniques may include hardware, a method or process, or a computer tangible medium.

[0121] In one general aspect, a dispensing module may include a module body having an inlet, an outlet, and a flow channel that extends from the inlet to the outlet.

The dispensing module may also include an actuator disposed within the module body. The dispensing module may furthermore include a needle connected to the actuator and extending through the module body. The dispensing module may in addition include a frame body. The dispensing module may moreover include a cooling assembly that is attached to the frame and the actuator, where in an unlocked state of the cooling assembly, the actuator is movable relative to the frame body to adjust a stroke length of the needle, and where in a locked state of the cooling assembly, the actuator is not movable relative to the frame body to adjust the stroke length of the needle. Other embodiments of this aspect include corresponding computer systems, apparatus, and computer programs recorded on one or more computer storage devices, each configured to perform the actions of the methods.

[0122] Implementations may include one or more of the following features. The dispensing module where the cooling assembly includes a fluid flow path that is configured to direct a cooling fluid to the actuator. The dispensing module, further including a single fastener that is configured to lock the cooling assembly. The dispensing module, where the cooling assembly may include: a cooling block that defines a first portion of the fluid flow path, where the first portion of the fluid flow path is configured to direct the cooling fluid to the actuator; and a flow path body that is configured to attach to the frame body. The dispensing module where the flow path body includes a protrusion that extends through an opening of the frame body and is configured to be received by an opening of the cooling block. The dispensing module where the cooling block defines a first portion of the fluid flow path, where the first portion of the fluid flow path is configured to direct the cooling fluid to the actuator, and where the flow path body defines a second portion of the fluid flow path that extends through the protrusion of the flow path body such that cooling fluid flows from the second portion of the fluid flow path to the first portion, where the cooling fluid is directed to the actuator. The dispensing module, may include a single fastener, where the cooling block may include a locking collar that defines the opening of the cooling block, where the locking collar is configured to compress when transitioning from the unlocked state to the locked state, thereby locking the protrusion in the opening of the cooling block. The dispensing module where the locking collar defines a threaded bore that is configured to receive a fastener, such that when in the unlocked state rotating the fastener in a first rotational direction transitions the locking collar to the locked state, and when in the locked state rotating the fastener in a second rotational direction

opposite the first rotational direction transitions the locking collar to the unlocked state. The dispensing module, where the frame body is a single rigid body. The dispensing module, where the frame body is formed of stainless steel. The dispensing module, where the frame body includes a plurality of posts, each of the plurality of posts having a cross-sectional area between .01 square inches and .05 square inches, between .0125 square inches and .03 square inches, between .014 square inches and .02 square inches, between .014 square inches and .017 square inches, between .015 square inches and .017 square inches, or .016 square inches. Implementations of the described techniques may include hardware, a method or process, or a computer tangible medium.

[0123] It should be noted that the illustrations and descriptions of the examples shown in the figures are for exemplary purposes only, and should not be construed limiting the disclosure. One skilled in the art will appreciate that the present disclosure contemplates various examples. Additionally, it should be understood that the concepts described above with the above-described examples may be employed alone or in combination with any of the other examples described above. It should further be appreciated that the various alternative examples described above with respect to one illustrated example can apply to all examples as described herein, unless otherwise indicated.

[0124] Conditional language used herein, such as, among others, "can," "could," "might," "may," "e.g.," and the like, unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain embodiments include, while other embodiments do not include, certain features, elements, and/or steps. Thus, such conditional language is not generally intended to imply that features, elements, and/or steps are in any way required for one or more examples or that one or more examples necessarily include these features, elements and/or steps. The terms "comprising," "including," "having," and the like are synonymous and are used inclusively, in an open-ended fashion, and do not exclude additional elements, features, acts, operations, and so forth.

[0125] Although the disclosure has been described in detail, it should be understood that various changes, substitutions, and alterations can be made herein without departing from the spirit and scope of the present disclosure as defined by the appended claims. Additionally, any of the embodiments disclosed herein can incorporate features disclosed with respect to any of the other embodiments disclosed

herein. Moreover, the scope of the present disclosure is not intended to be limited to the particular embodiments described in the specification. As one of ordinary skill in the art will readily appreciate from that processes, machines, manufacture, composition of matter, means, methods, or steps, presently existing or later to be developed that perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein may be utilized according to the present disclosure.

[0126] It should be understood that the steps of the exemplary methods set forth herein are not necessarily required to be performed in the order described, and the order of the steps of such methods should be understood to be merely exemplary. Likewise, additional steps may be included in such methods, and certain steps may be omitted or combined, in methods consistent with various embodiments of the present invention.

[0127] Although the elements in the following method claims, if any, are recited in a particular sequence with corresponding labeling, unless the claim recitations otherwise imply a particular sequence for implementing some or all of those elements, those elements are not necessarily intended to be limited to being implemented in that particular sequence.

[0128] It will be understood that reference herein to “a” or “one” to describe a feature such as a component or step does not foreclose additional features or multiples of the feature. For instance, reference to a device having or defining “one” of a feature does not preclude the device from having or defining more than one of the feature, as long as the device has or defines at least one of the feature. Similarly, reference herein to “one of” a plurality of features does not foreclose the invention from including two or more, up to all, of the features. For instance, reference to a device having or defining “one of a X and Y” does not foreclose the device from having both the X and Y.

What is Claimed:

1. A dispensing module for dispensing a material, the dispensing module comprising:
 - a module body having an inlet, an outlet, and a flow channel that extends from the inlet to the outlet;
 - an actuator disposed within the module body;
 - a needle connected to the actuator and extending through the module body; and
 - a cooling assembly including a fluid flow path that is configured to direct a cooling fluid to the actuator.
2. The dispensing module of claim 1, wherein the cooling assembly comprises a cooling block that defines a first portion of the fluid flow path, wherein the first portion of the fluid flow path is configured to direct the cooling fluid to the actuator.
3. The dispensing module of claim 2, wherein the cooling block is configured to direct the cooling fluid directly to the actuator.
4. The dispensing module of claim 2 or claim 3, wherein the cooling block is directly attached to the actuator.
5. The dispensing module of any one of claims 2 to 4, wherein the cooling block includes at least one groove that is configured to receive the cooling fluid from the fluid flow path, and wherein the at least one groove opens toward the actuator such that the cooling fluid received from the fluid flow path flows across the actuator.
6. The dispensing module of claim 5, wherein the at least one groove opens toward a surface of the actuator such that the cooling fluid received from the fluid flow path flows across the surface of the actuator.
7. The dispensing module of claim 6, wherein the at least one groove extends along the surface of the actuator.

8. The dispensing module of any one of claims 5 to 7, wherein the at least one groove comprises two grooves that extend along a longitudinal axis and are spaced apart from one another along a lateral axis that is perpendicular to the longitudinal axis.

9. The dispensing module of claim 8, wherein the first portion of the fluid flow path defines two separate flow paths that each lead to a respective one of the two grooves.

10. The dispensing module of any one of claims 1 to 9, wherein the cooling assembly further comprises a fluid inlet port.

11. The dispensing module of any one of claims 1 to 10, wherein the cooling fluid is air.

12. The dispensing module of any one of claims 1 to 11, further comprising a frame body.

13. The dispensing module of claim 12, wherein the frame body is a single rigid body.

14. The dispensing module of claim 12 or claim 13, further comprising a flow path body that is configured to attach to the frame body.

15. The dispensing module of claim 14, wherein the flow path body includes a protrusion that extends through an opening of the frame body and is configured to be received by an opening of the cooling block.

16. The dispensing module of any one of claims 1 to 16, wherein the actuator is a piezoelectric actuator.

17. A dispensing module for dispensing a material, the dispensing module comprising:

a module body having an inlet, an outlet, and a flow channel that extends from the inlet to the outlet;

an actuator disposed within the module body;
a needle connected to the actuator and extending through the module body;
a frame body; and
a cooling assembly that is attached to the frame body and the actuator,
wherein in an unlocked state of the cooling assembly, the actuator is movable relative to the frame body to adjust a stroke length of the needle, and wherein in a locked state of the cooling assembly, the actuator is not movable relative to the frame body to adjust the stroke length of the needle.

18. The dispensing module of claim 17, wherein the cooling assembly includes a fluid flow path that is configured to direct a cooling fluid to the actuator.

19. The dispensing module of claim 17 or claim 18, further including a single fastener that is configured to lock the cooling assembly.

20. The dispensing module of any one of claims 17 to 19, wherein the cooling assembly comprises:

a cooling block that defines a first portion of a fluid flow path, wherein the first portion of the fluid flow path is configured to direct the cooling fluid to the actuator; and
a flow path body that is configured to attach to the frame body.

21. The dispensing module of claim 20, wherein the flow path body includes a protrusion that extends through an opening of the frame body and is configured to be received by an opening of the cooling block.

22. The dispensing module of claim 21, wherein the cooling block defines a first portion of the fluid flow path, wherein the first portion of the fluid flow path is configured to direct the cooling fluid to the actuator, and wherein the flow path body defines a second portion of the fluid flow path that extends through the protrusion of the flow path body such that cooling fluid flows from the second portion of the fluid flow path to the first portion, whereby the cooling fluid is directed to the actuator.

23. The dispensing module of claim 21 or claim 22, further comprising a single fastener, wherein the cooling block comprises a locking collar that defines the opening

of the cooling block, wherein the locking collar is configured to compress when transitioning from the unlocked state to the locked state, thereby locking the protrusion in the opening of the cooling block.

24. The dispensing module of claim 23, wherein the locking collar defines a threaded bore that is configured to receive a fastener, such that when in the unlocked state rotating the fastener in a first rotational direction transitions the locking collar to the locked state, and when in the locked state rotating the fastener in a second rotational direction opposite the first rotational direction transitions the locking collar to the unlocked state.

25. The dispensing module of any one of claims 17 to 24, wherein the frame body is a single rigid body.

26. The dispensing module of any one of claims 17 to 25, wherein the frame body is formed of stainless steel.

27. The dispensing module of any one of claims 17 to 26, wherein the frame body includes a plurality of posts, each of the plurality of posts having a cross-sectional area between .01 square inches and .05 square inches, between .0125 square inches and .03 square inches, between .014 square inches and .02 square inches, between .014 square inches and .017 square inches, between .015 square inches and .017 square inches, or .016 square inches.

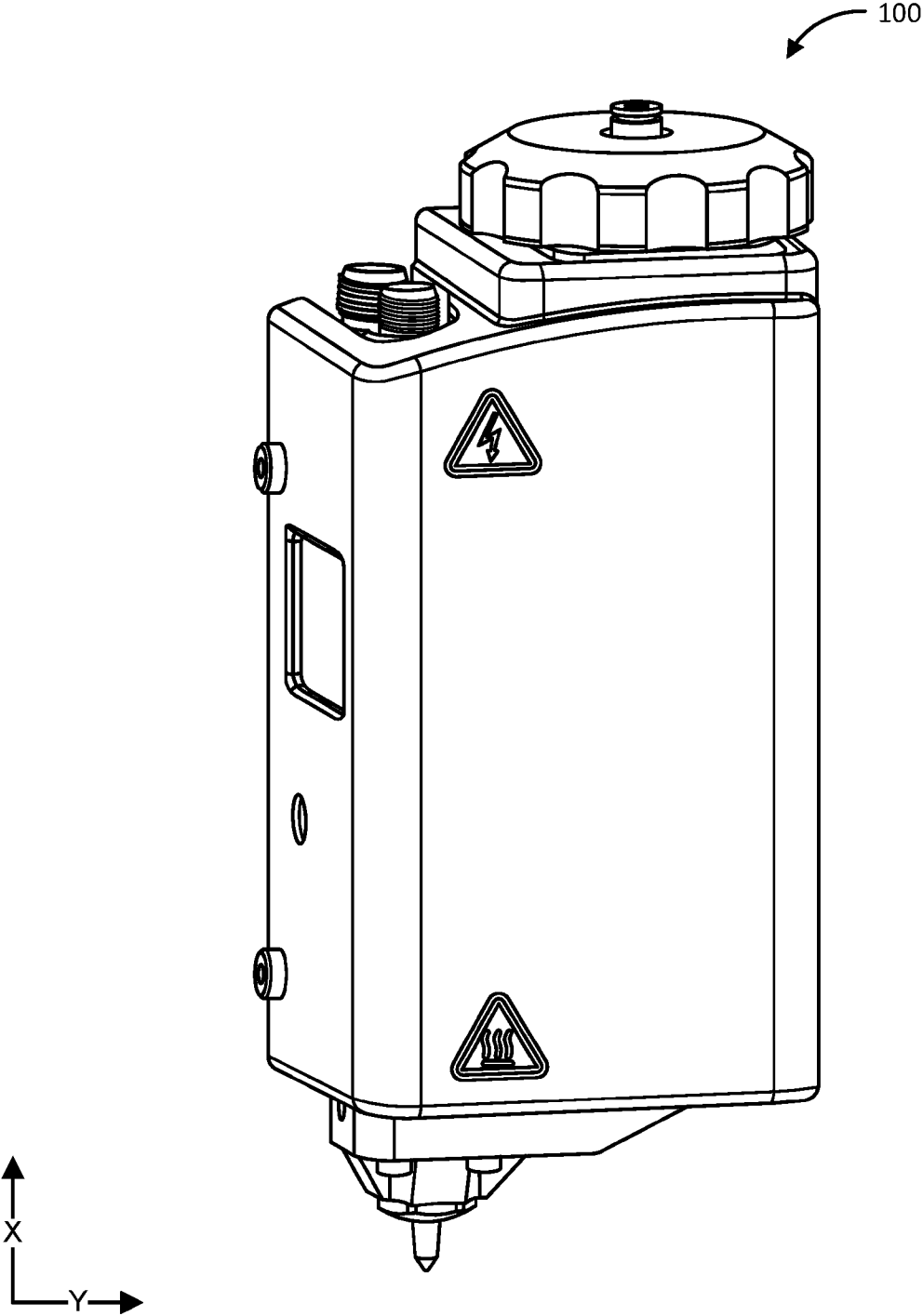


FIG. 1

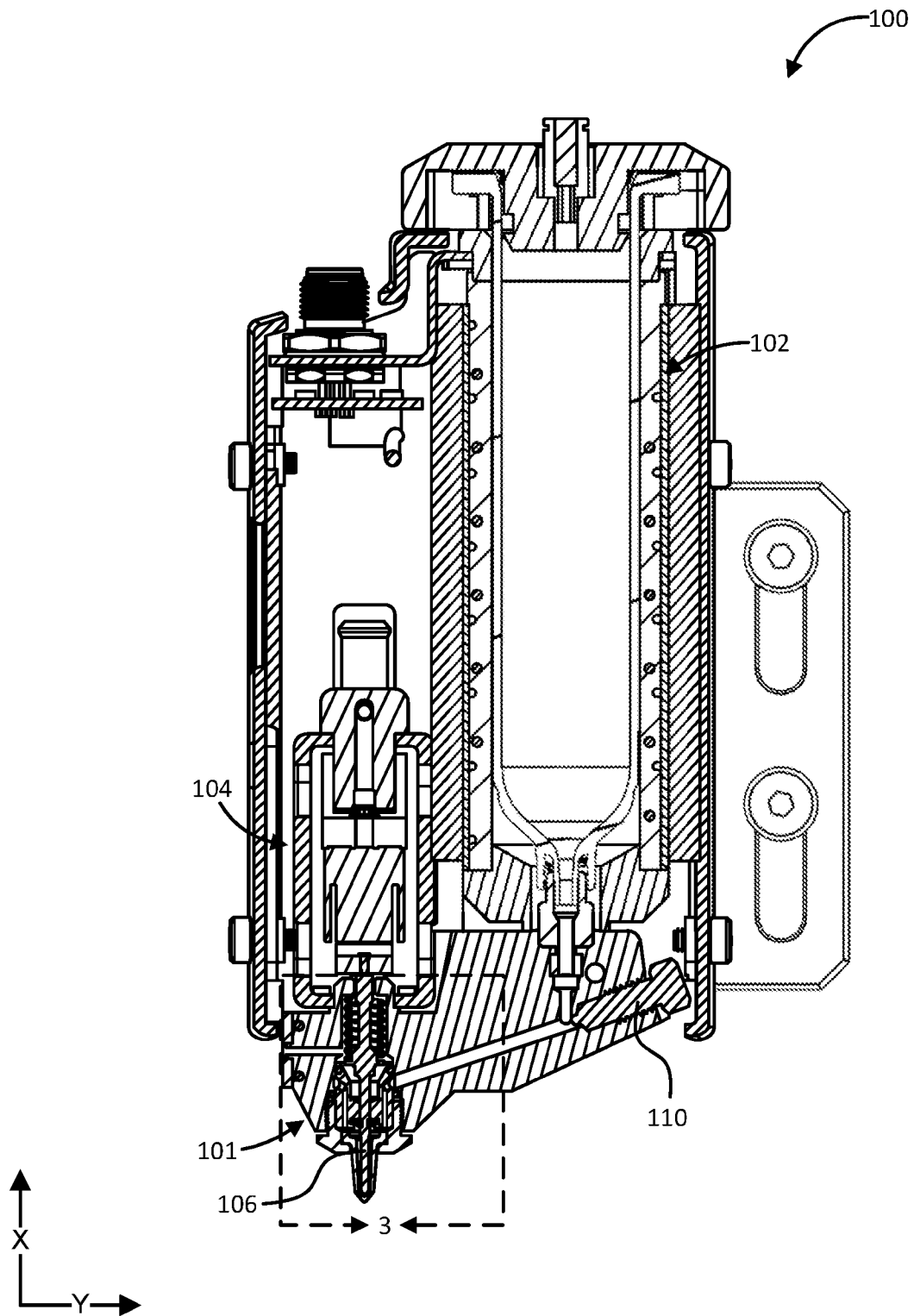


FIG. 2

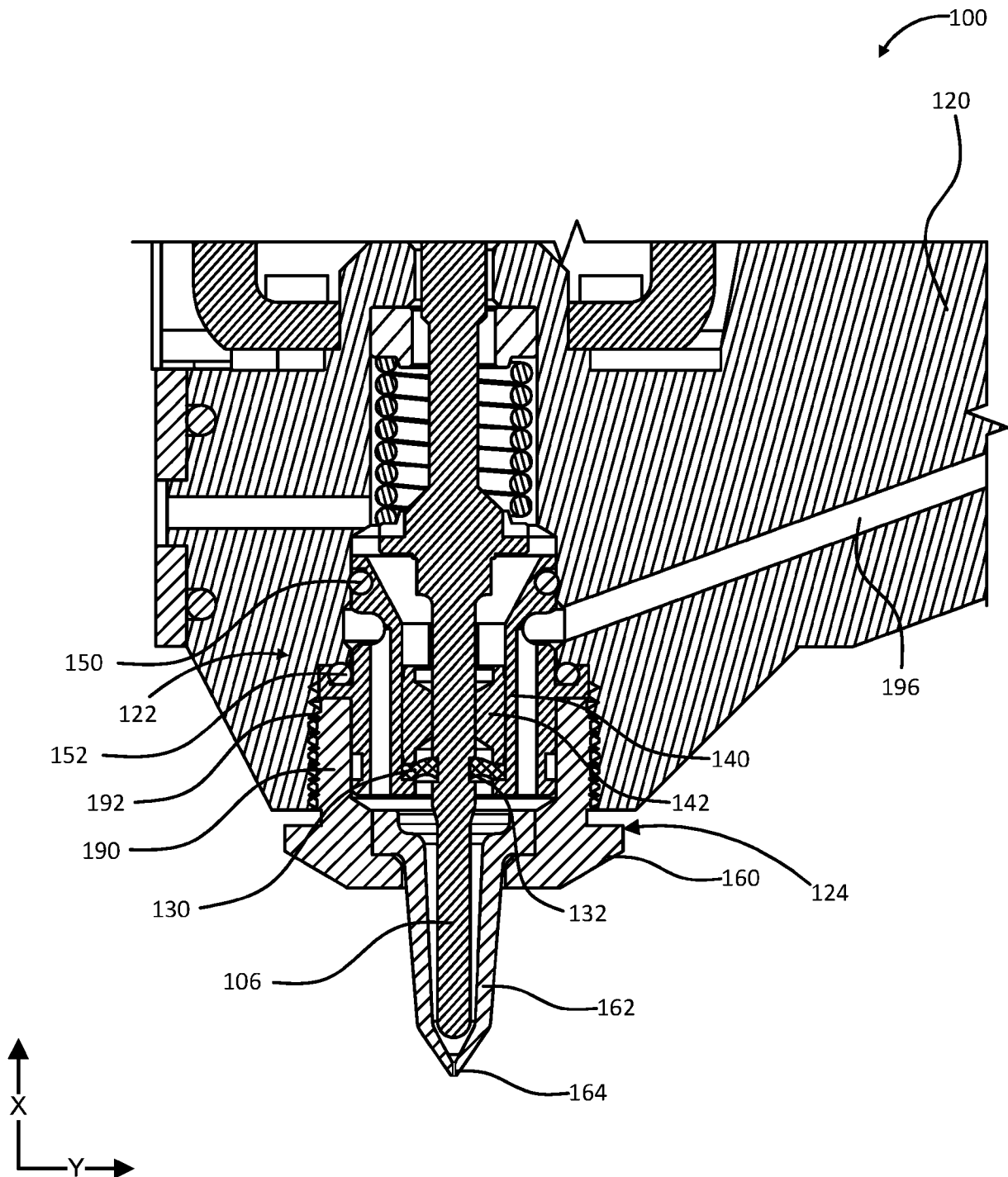


FIG. 3A

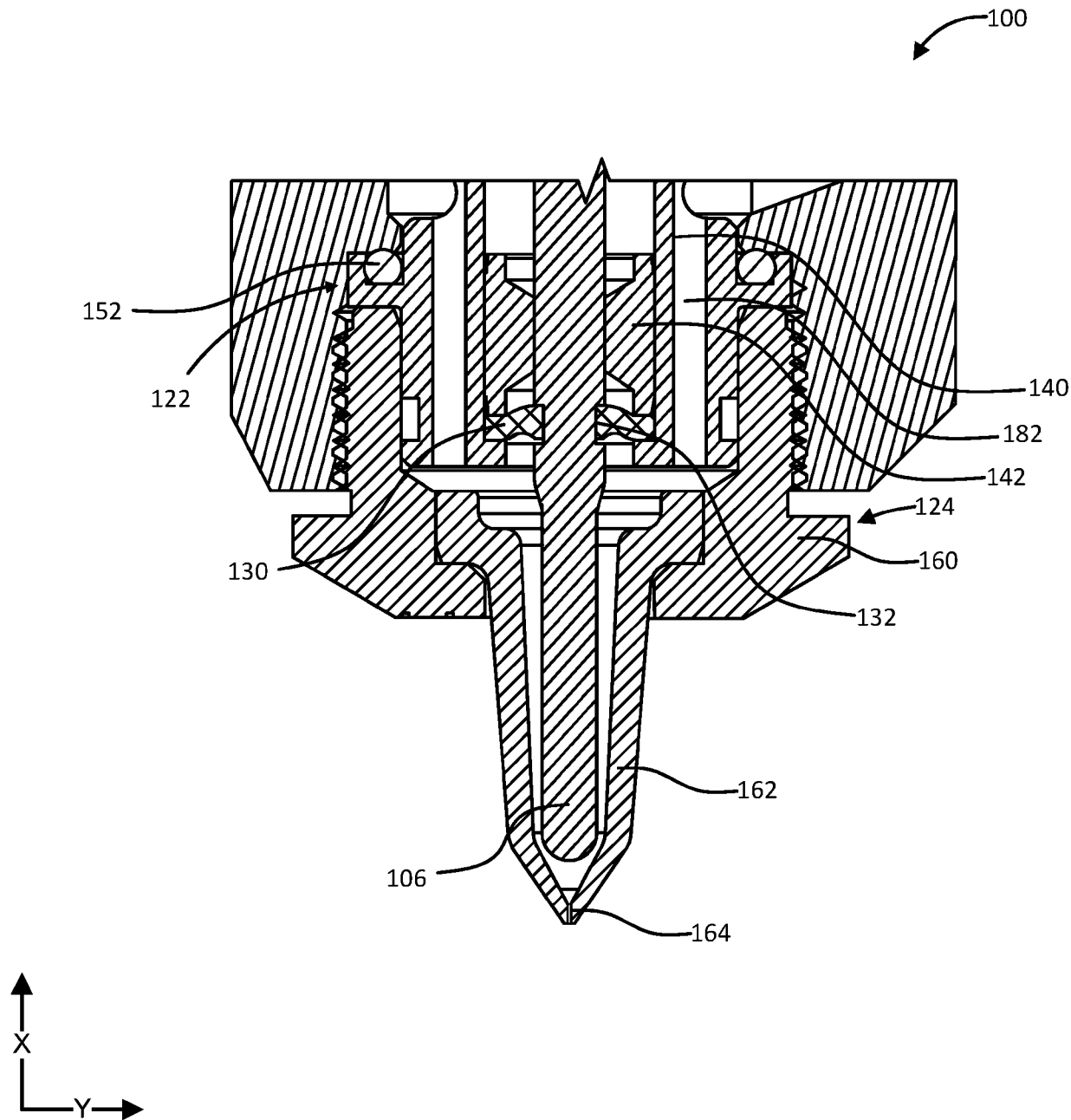


FIG. 3B

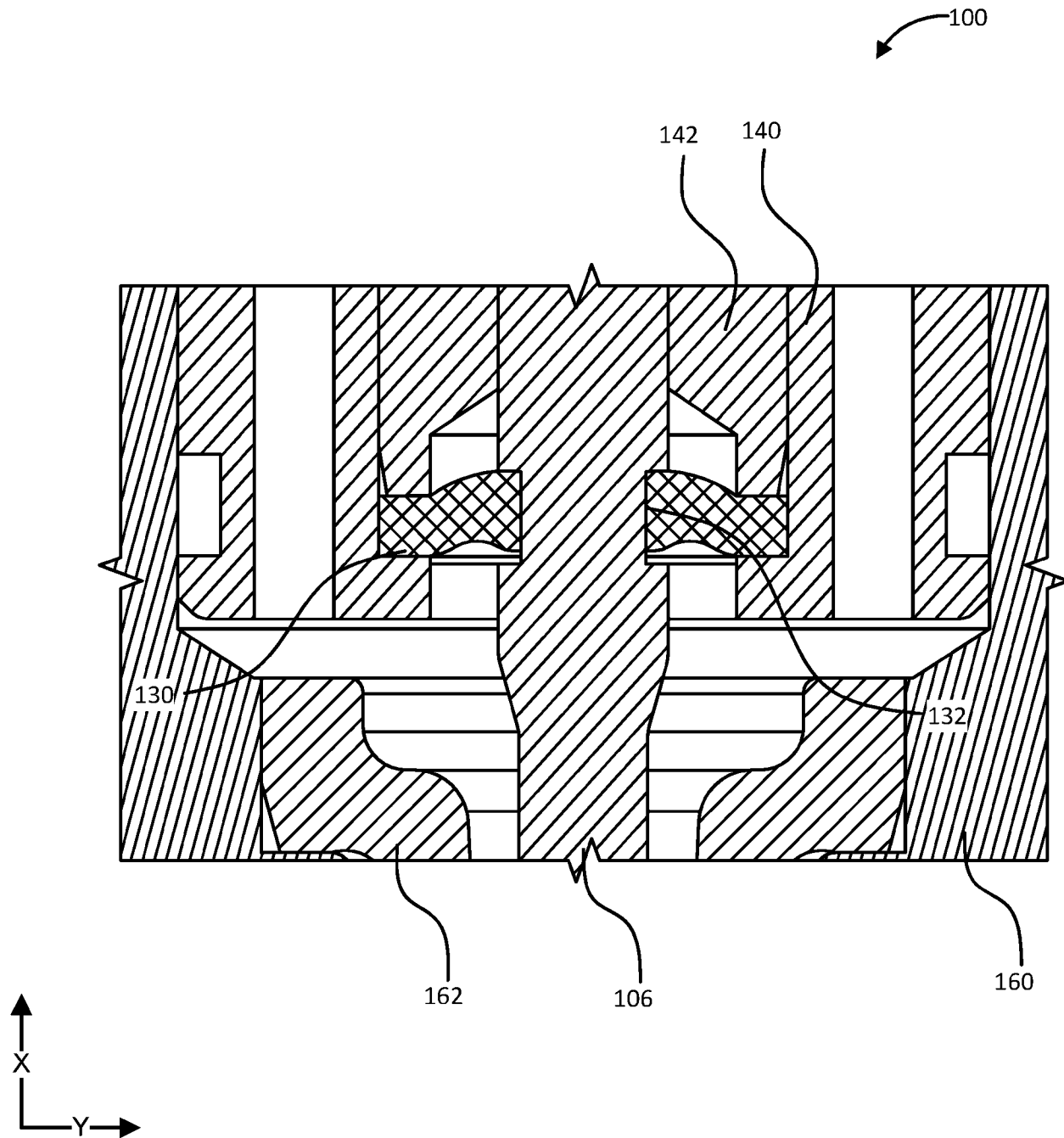


FIG. 3C

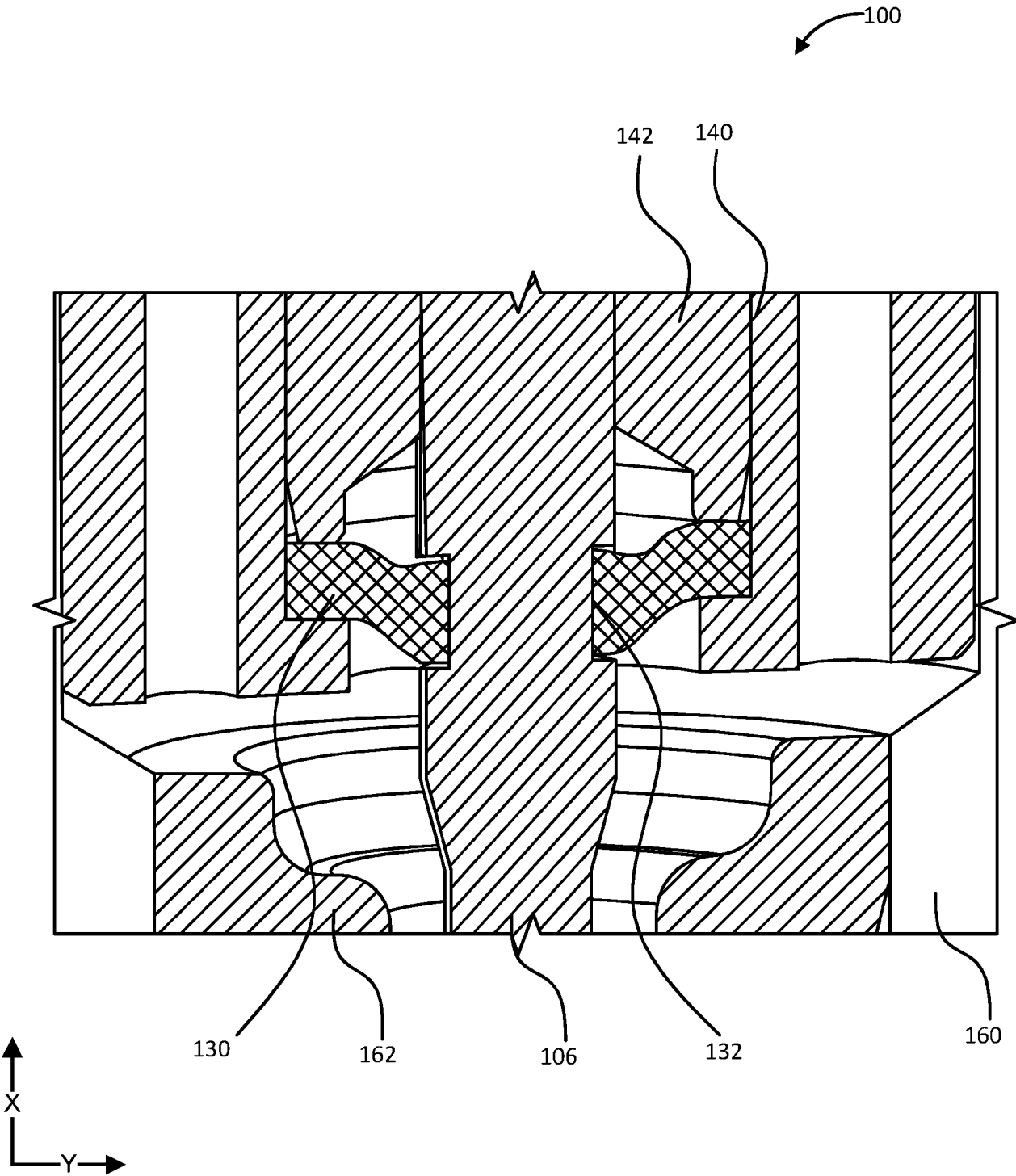


FIG. 3D

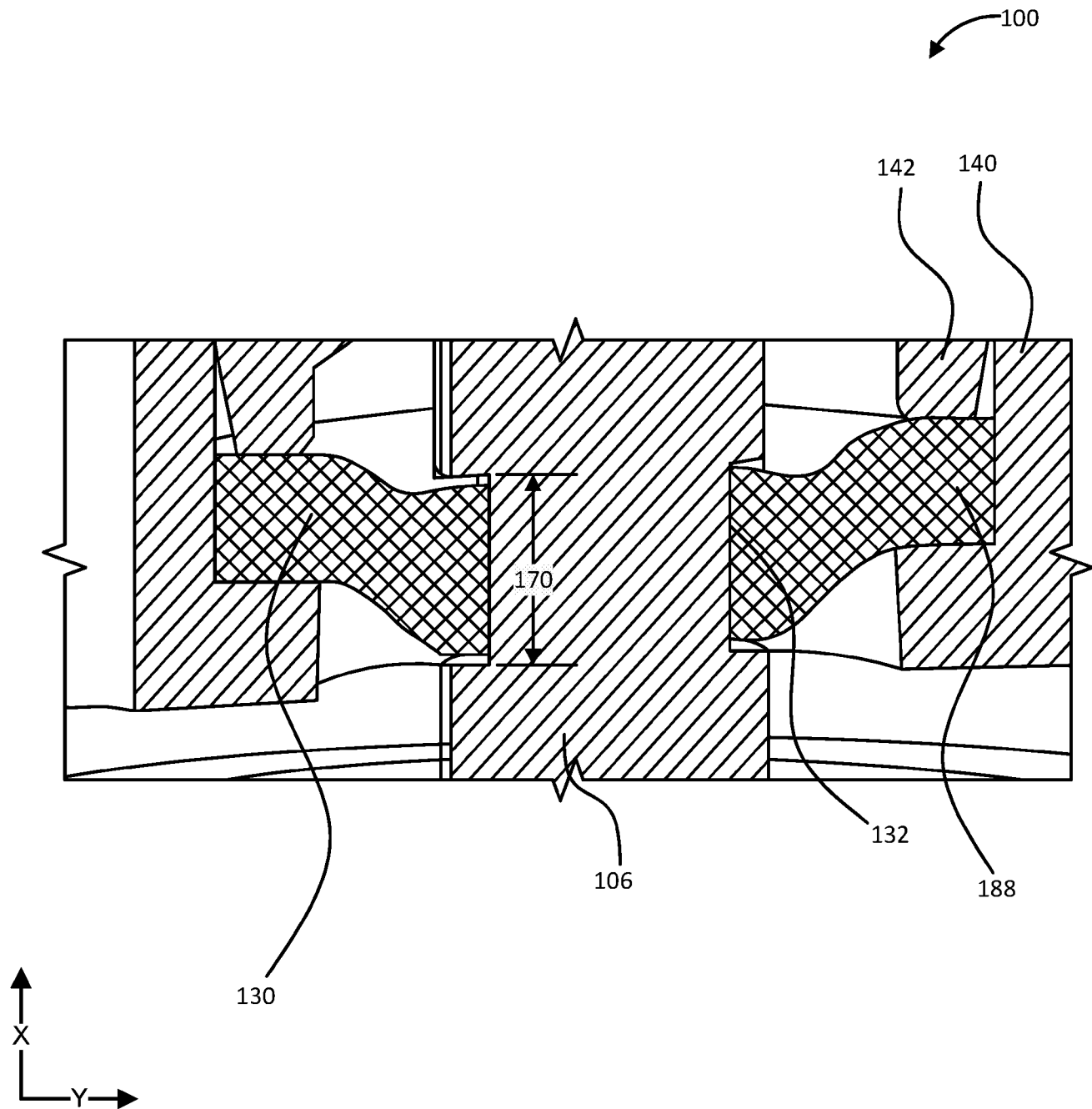


FIG. 3E

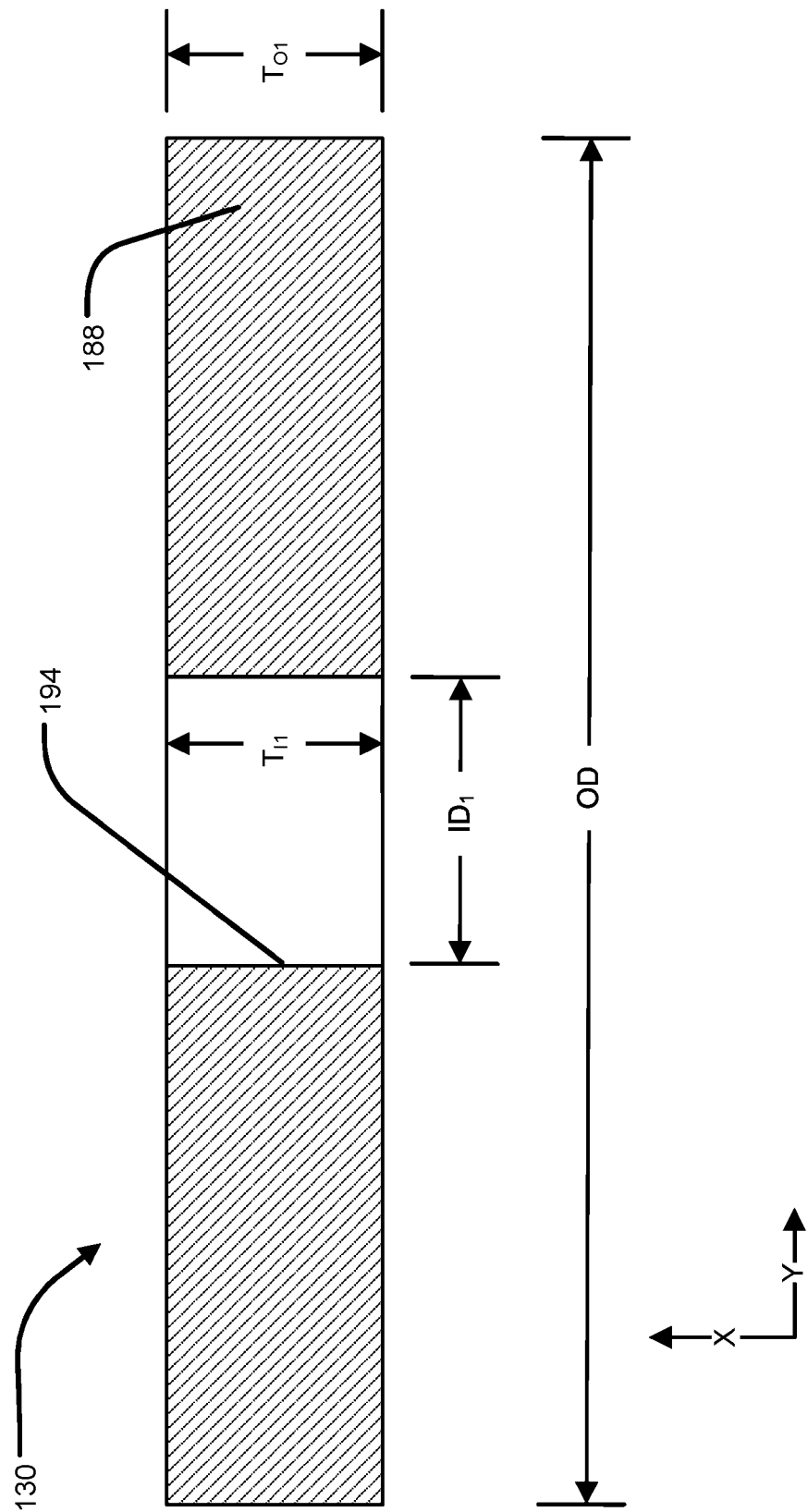


FIG. 4

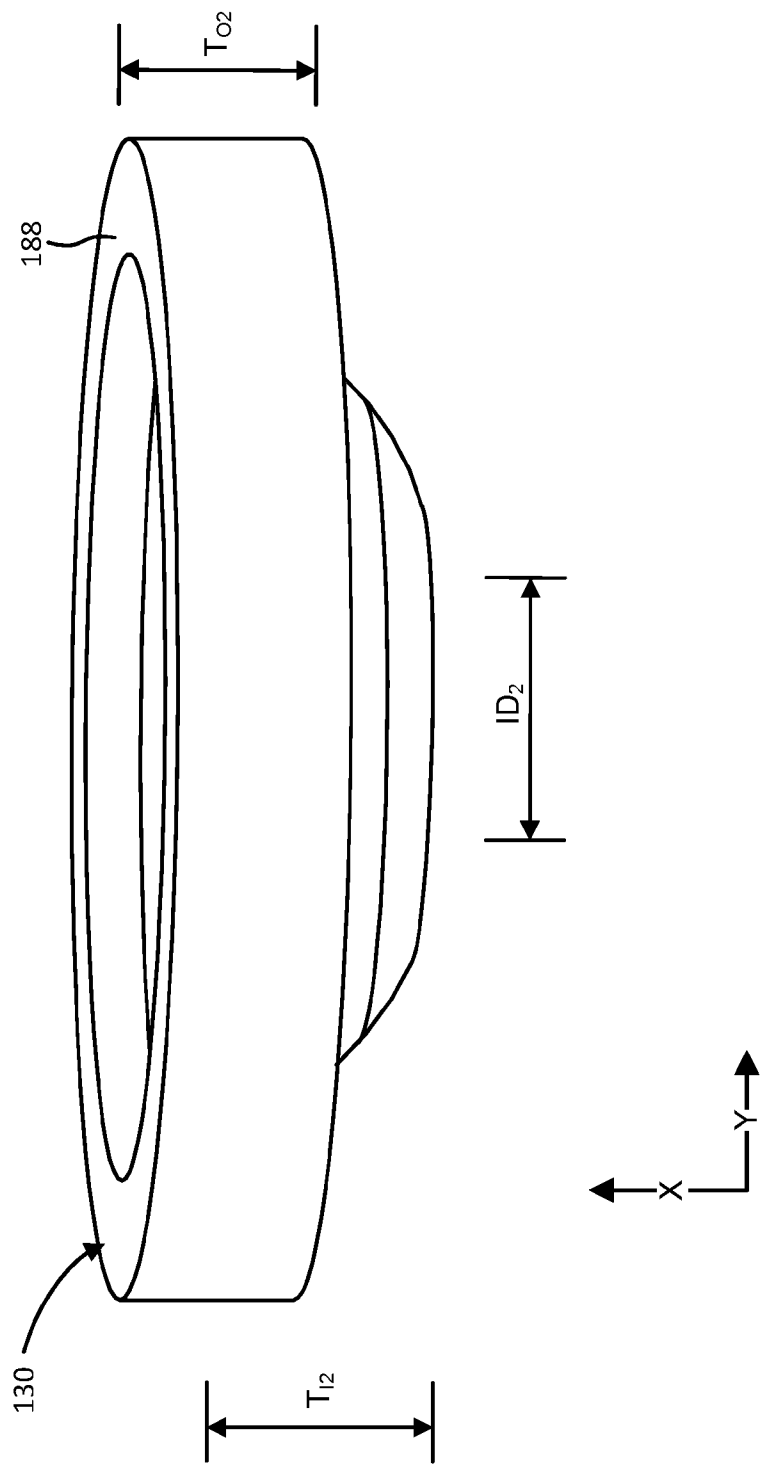


FIG. 5

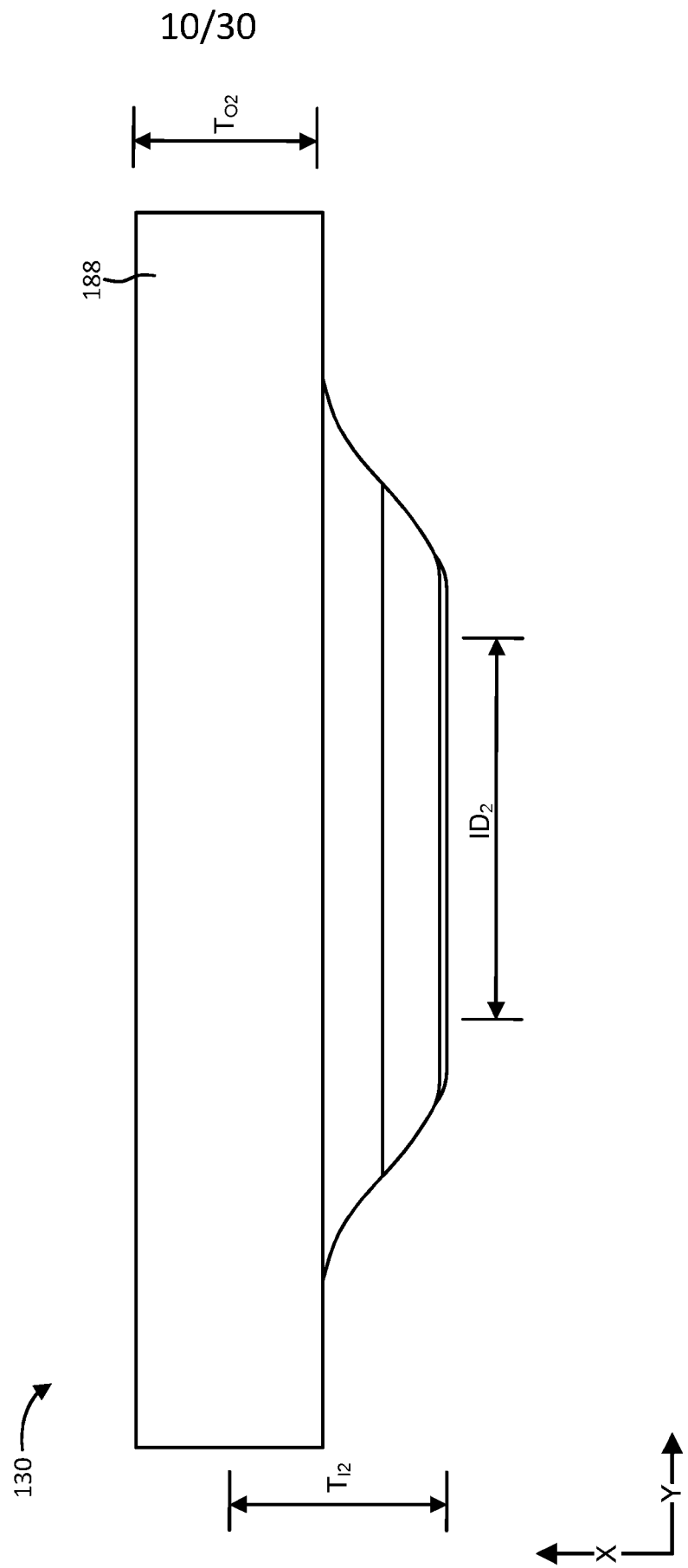


FIG.6A

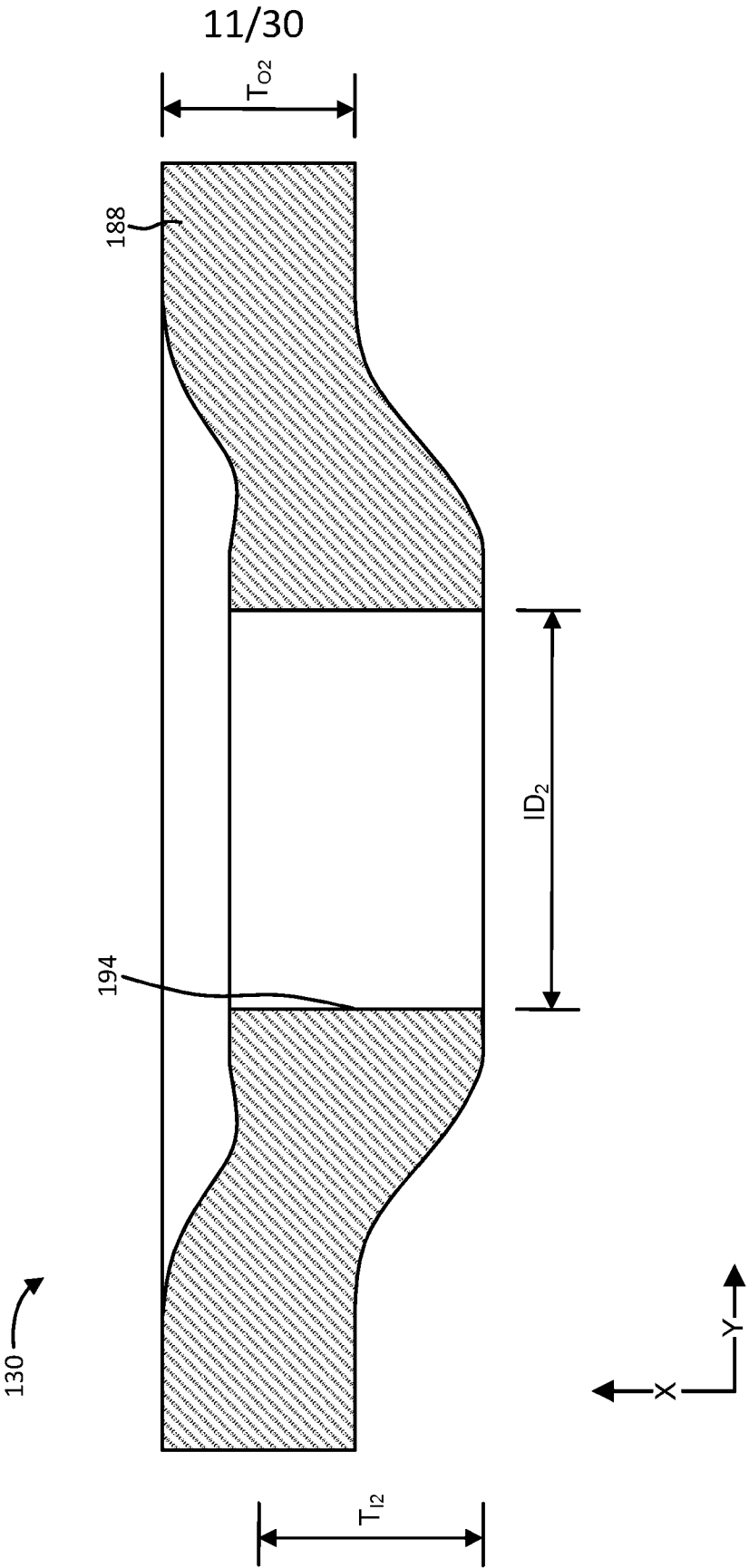


FIG. 6B

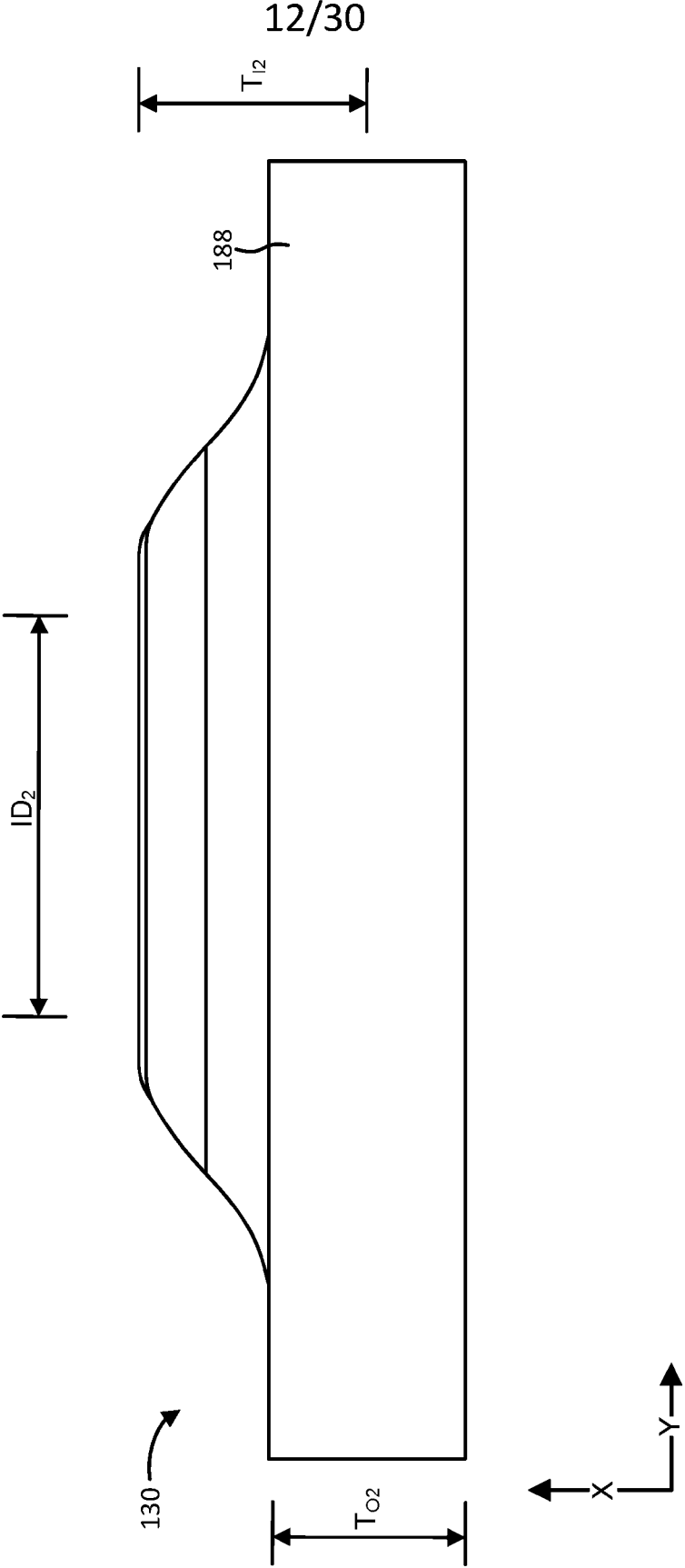


FIG. 7

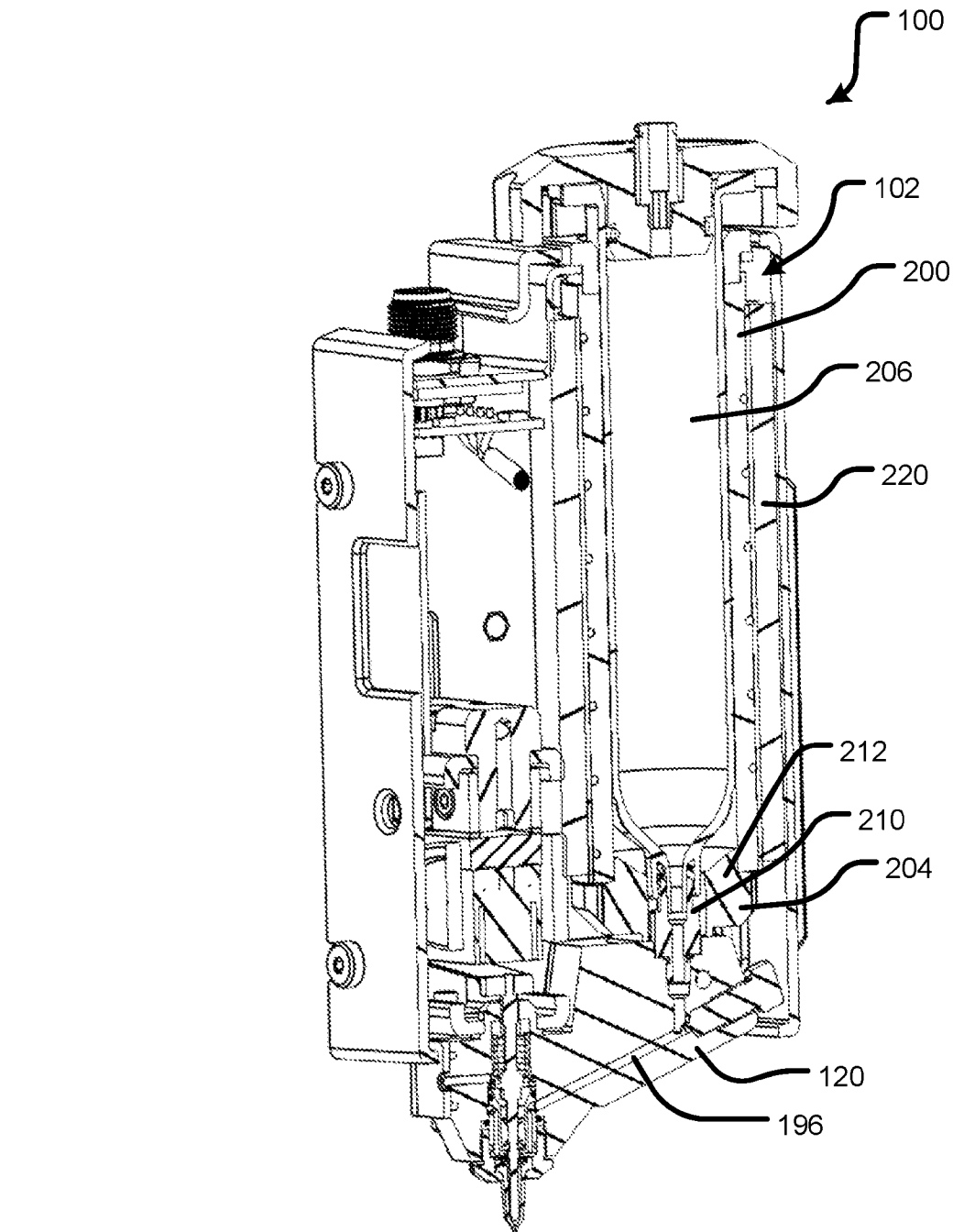


FIG.8A

14/30

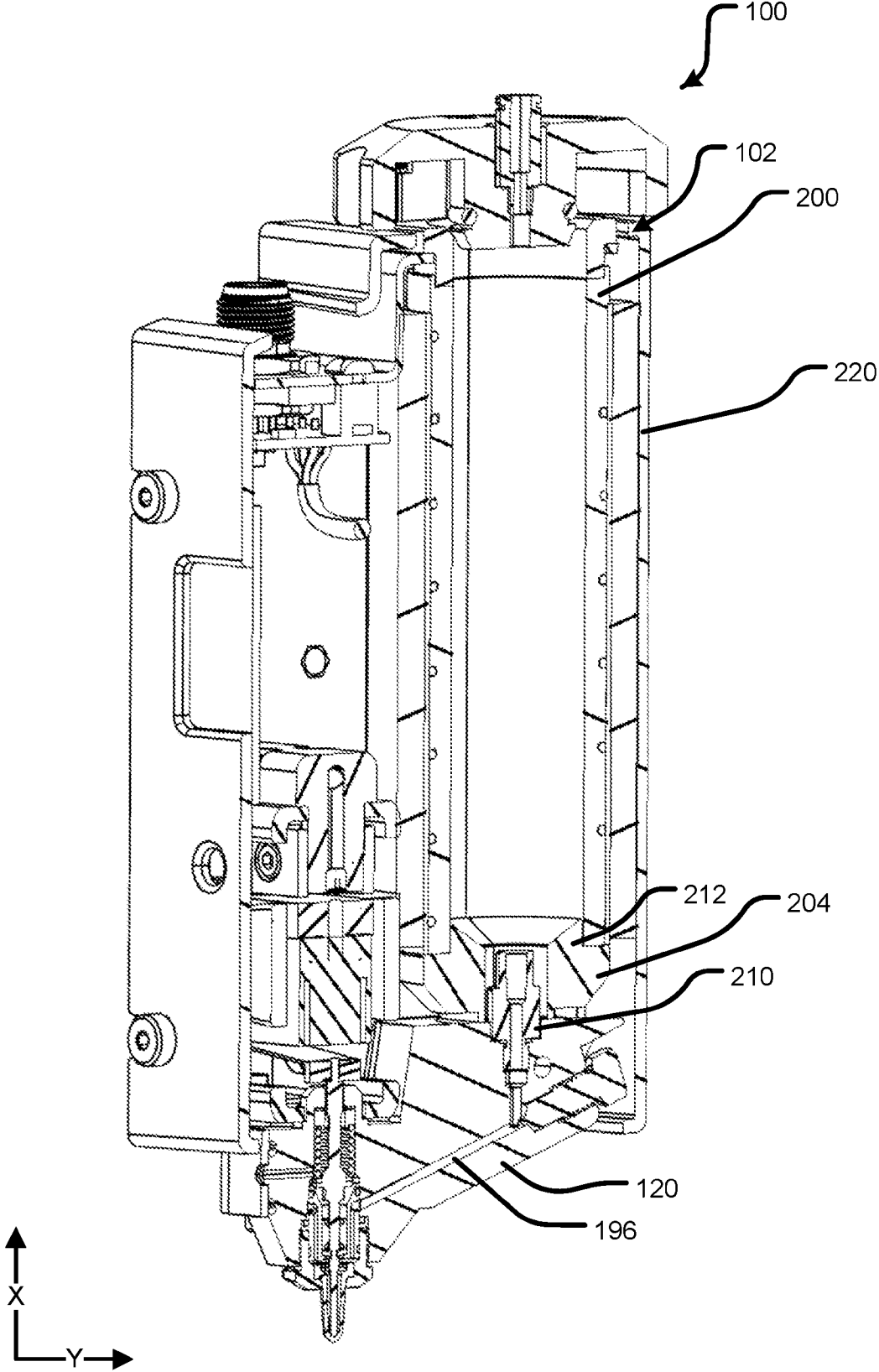


FIG. 8B

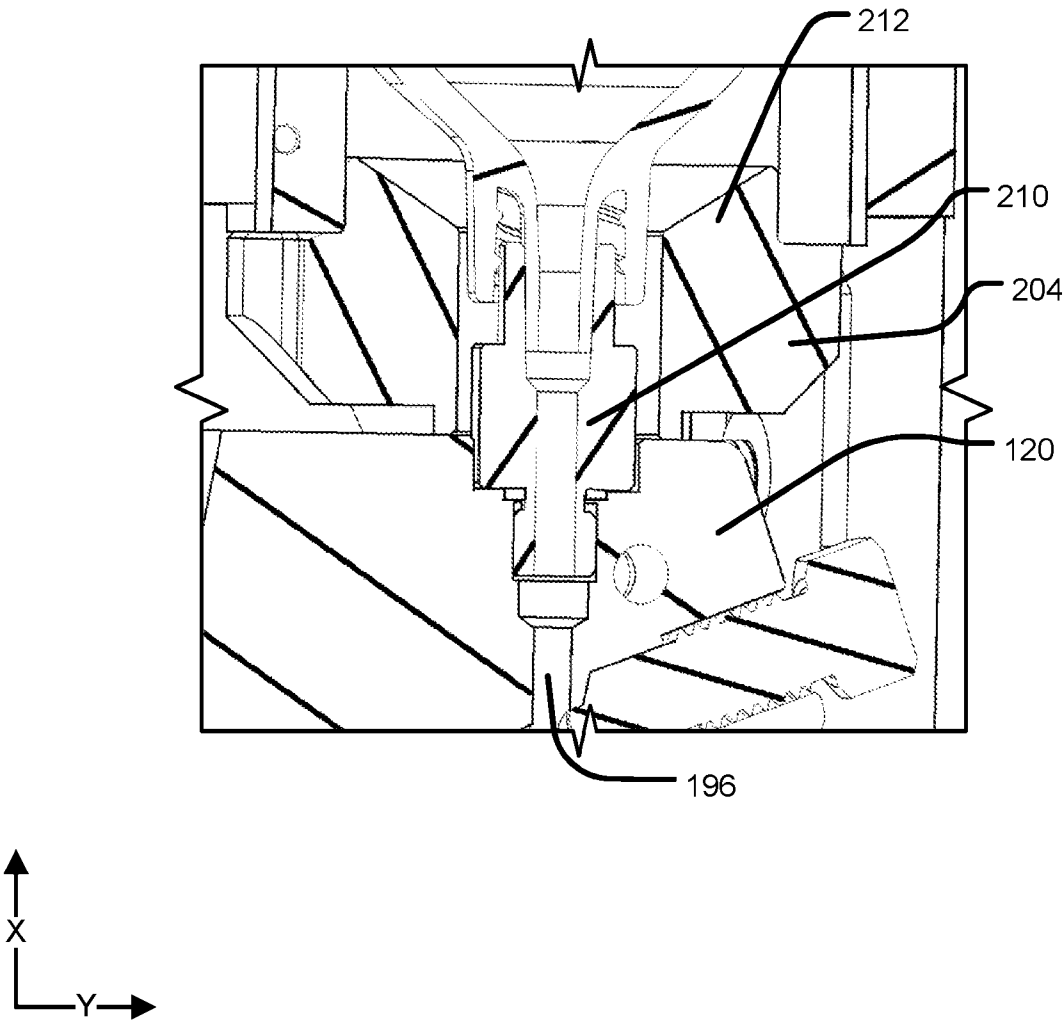


FIG. 8C

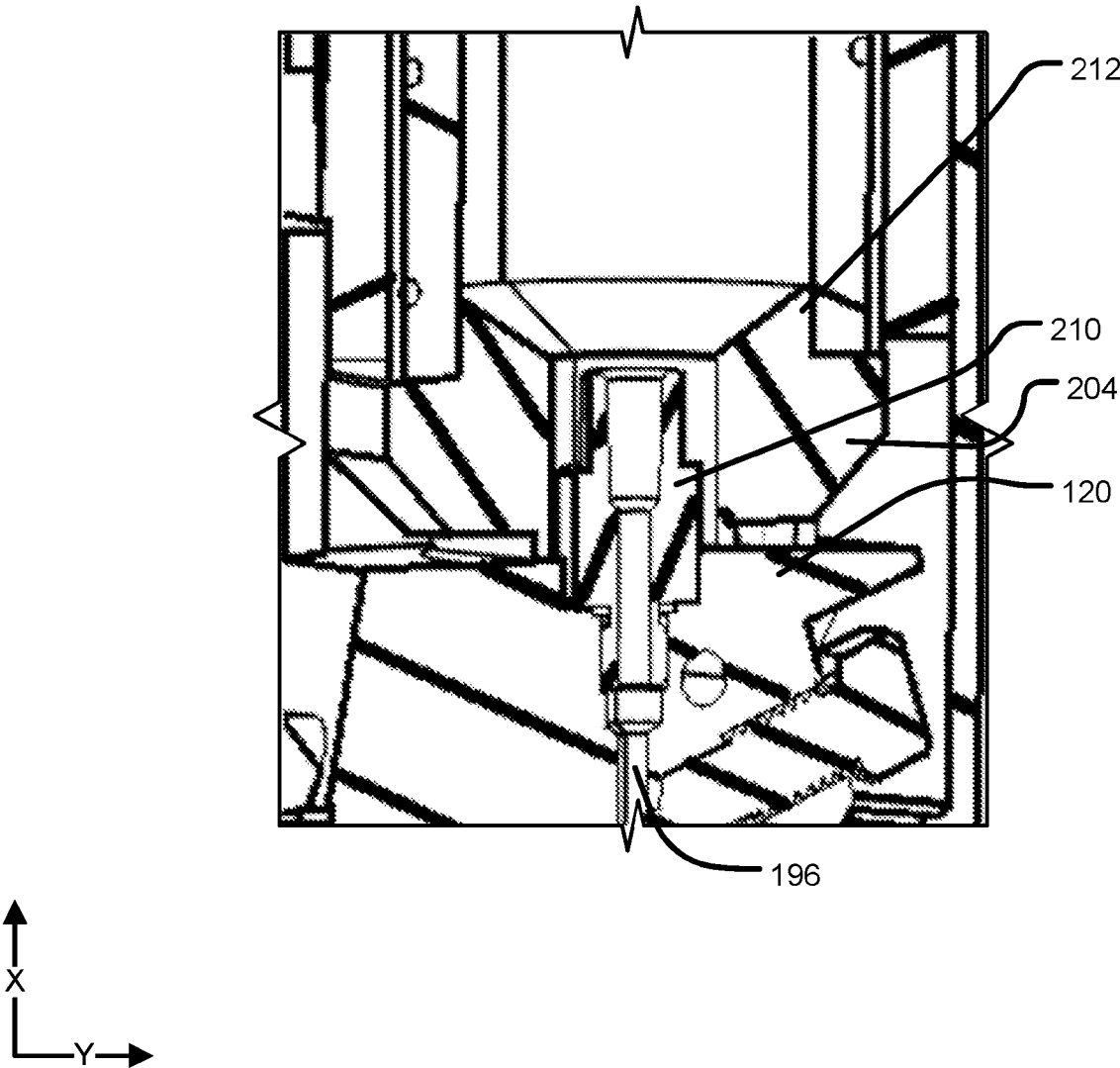


FIG. 8D

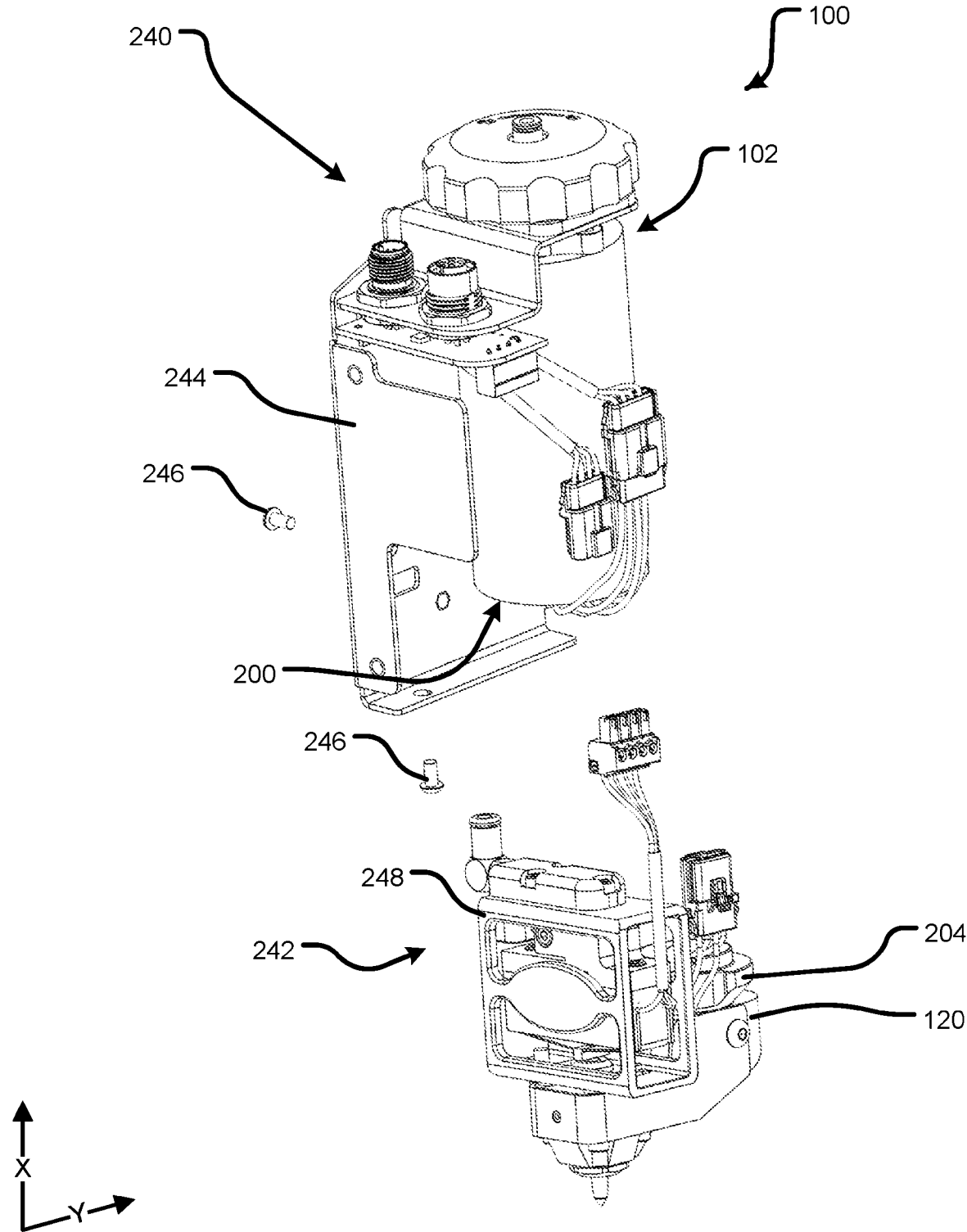


FIG.9A

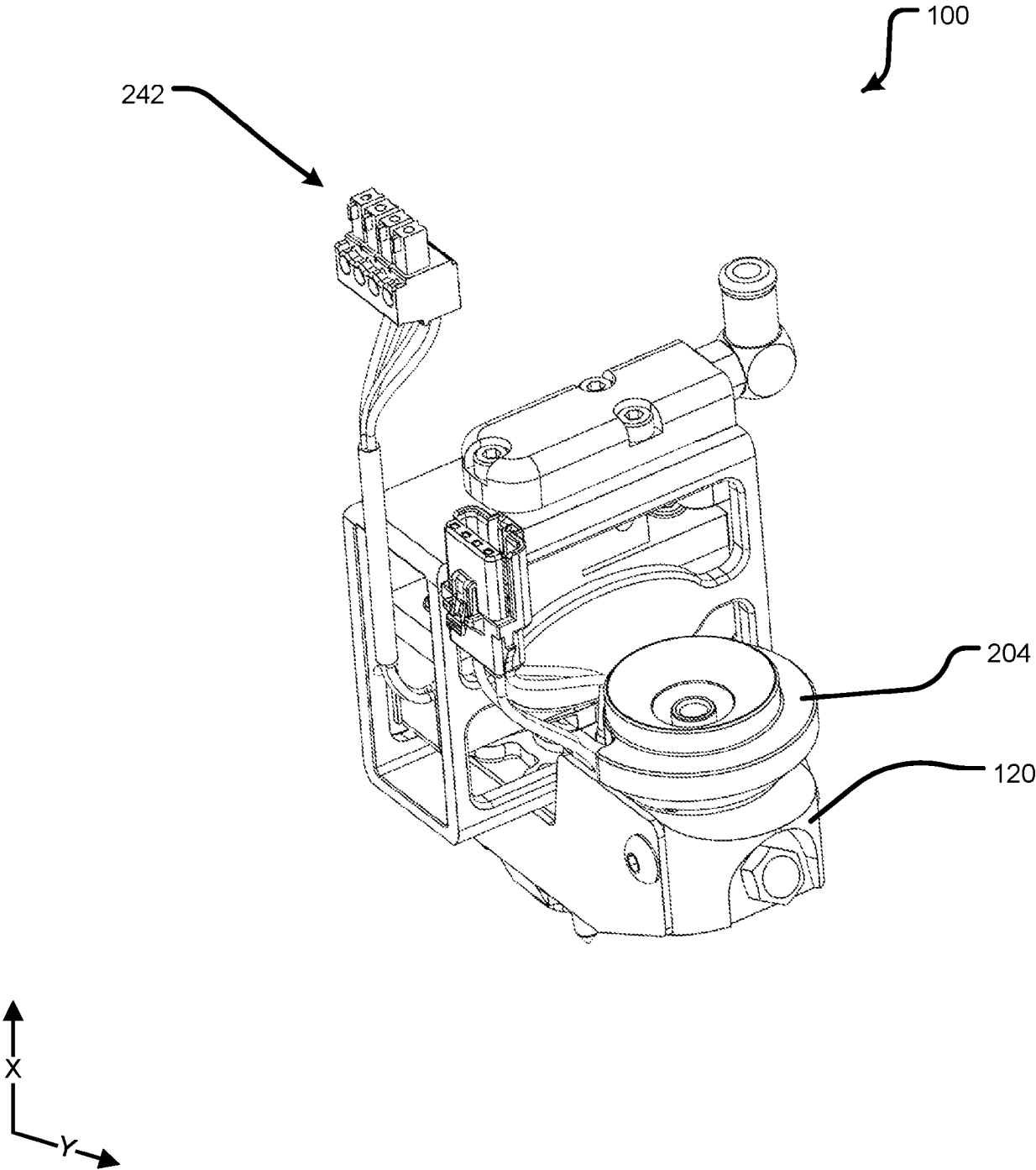


FIG. 9B

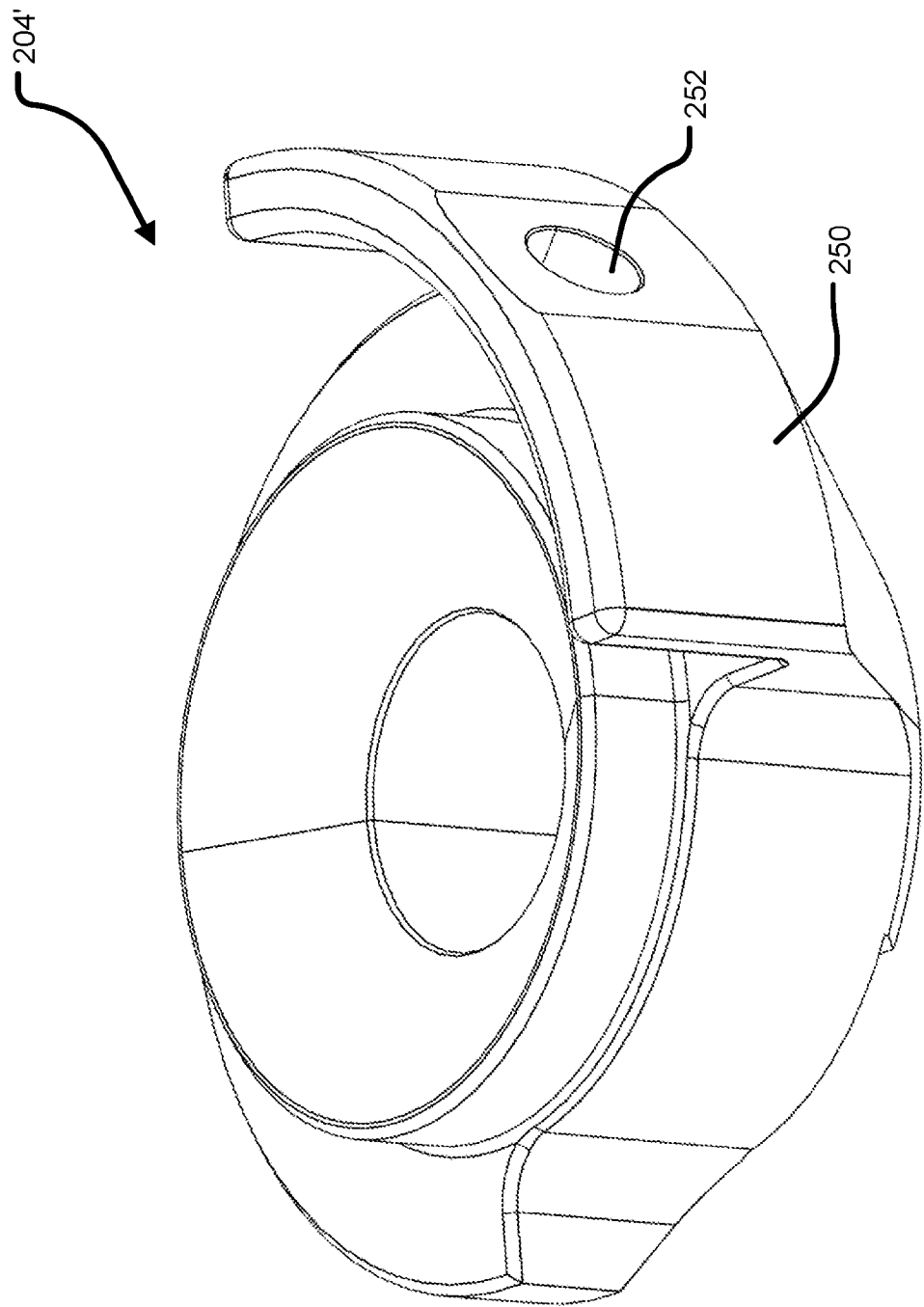


FIG. 10A

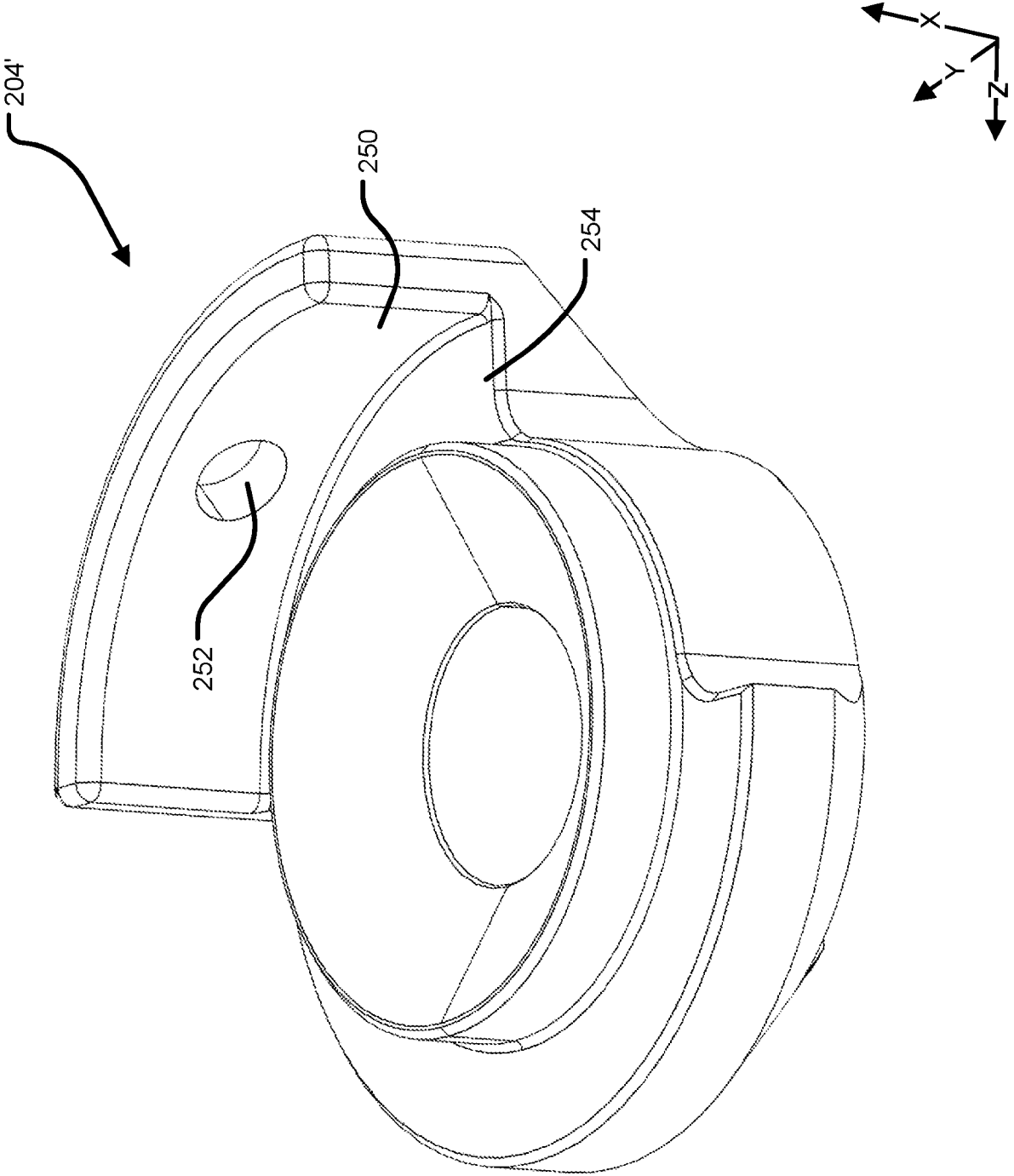


FIG. 10B

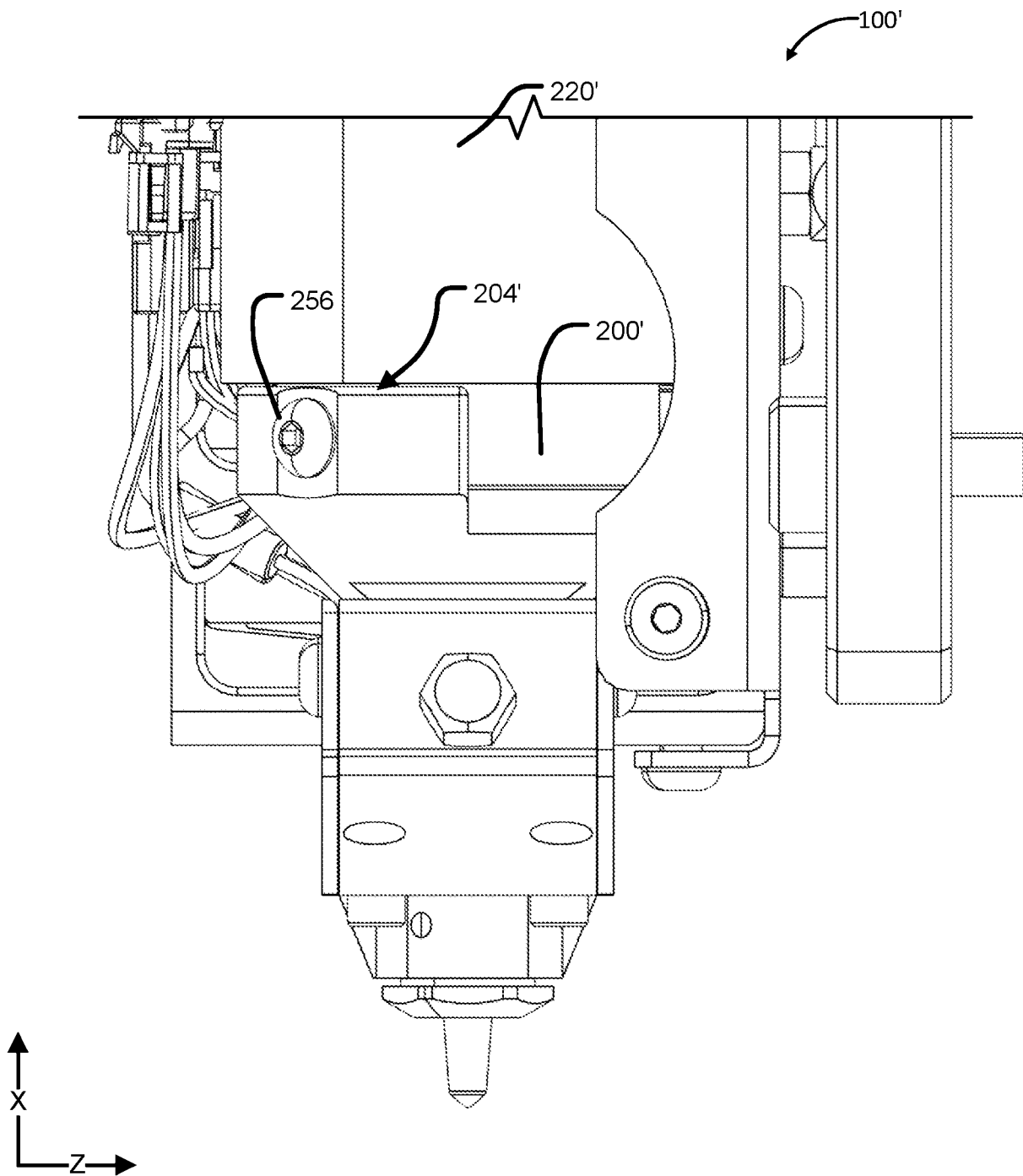


FIG. 11

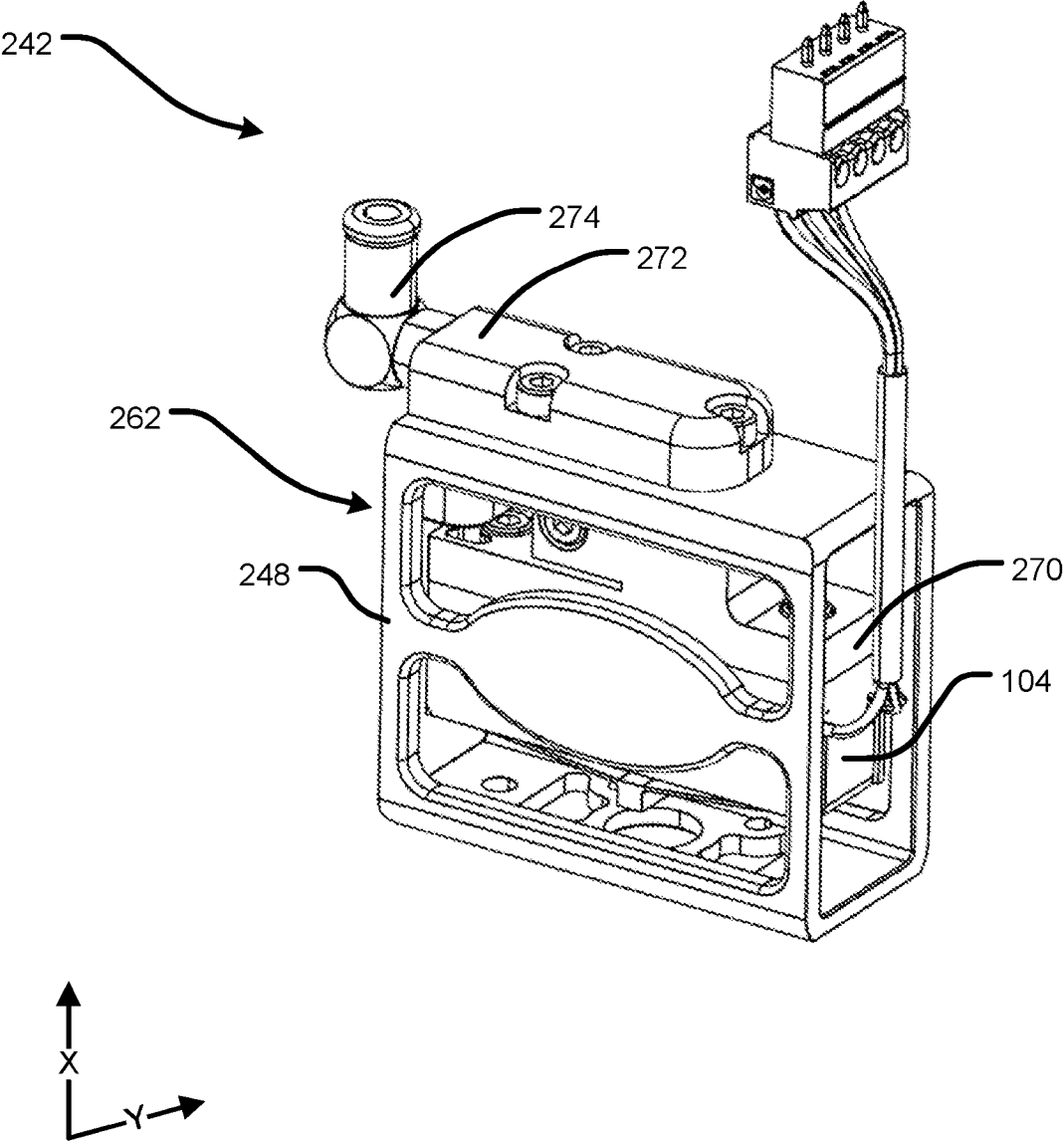


FIG. 12A

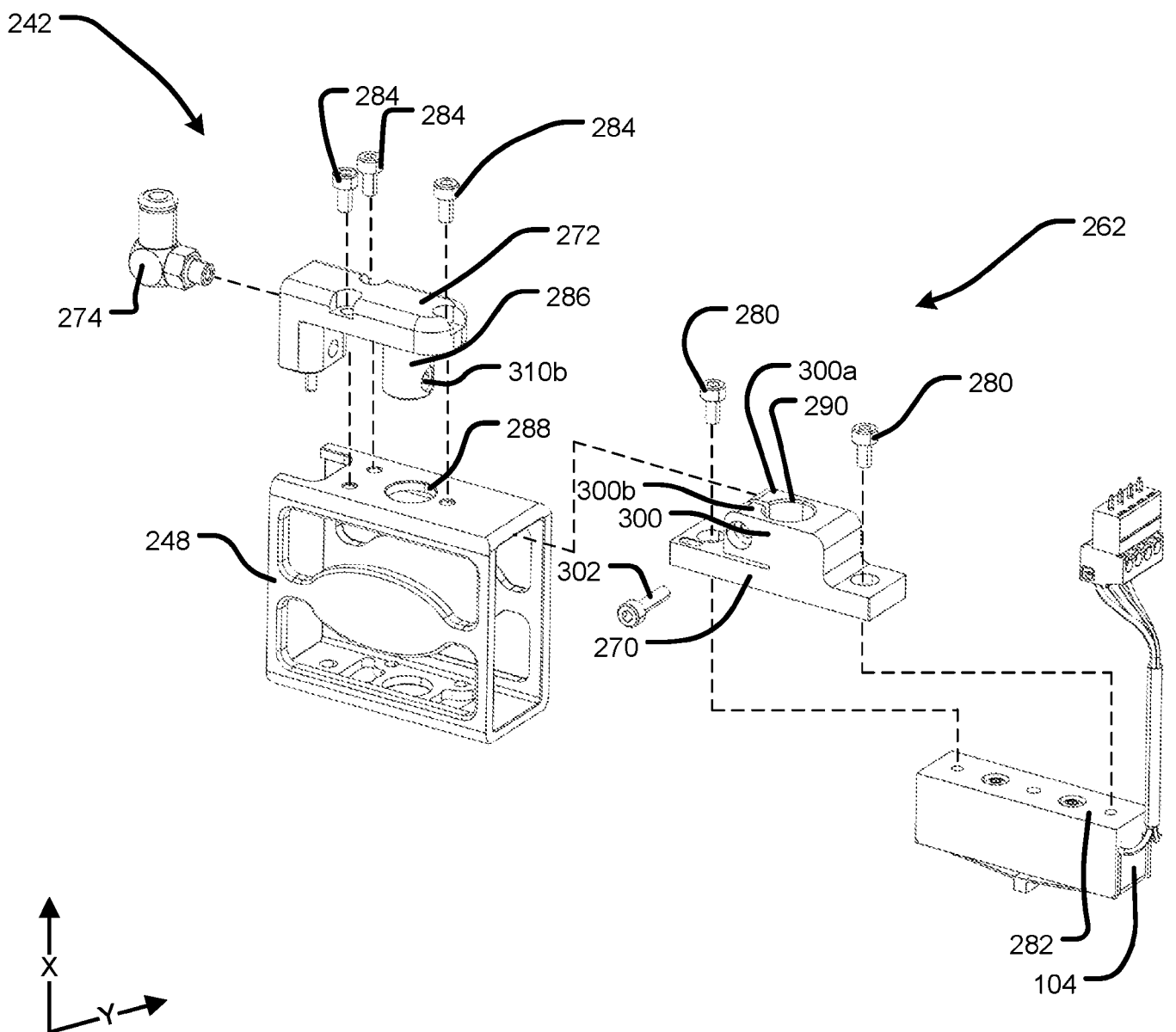


FIG. 12B

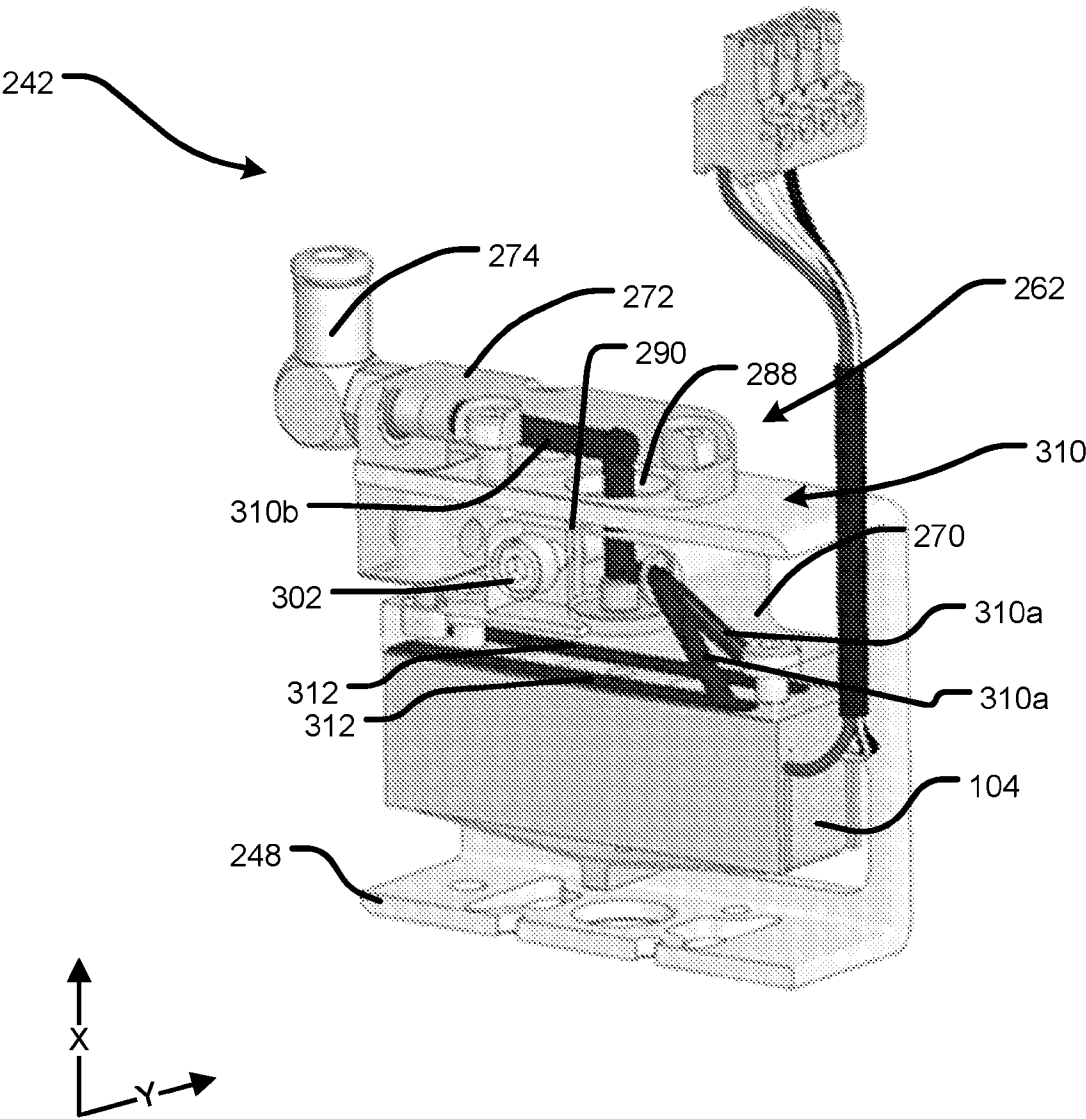


FIG. 12C

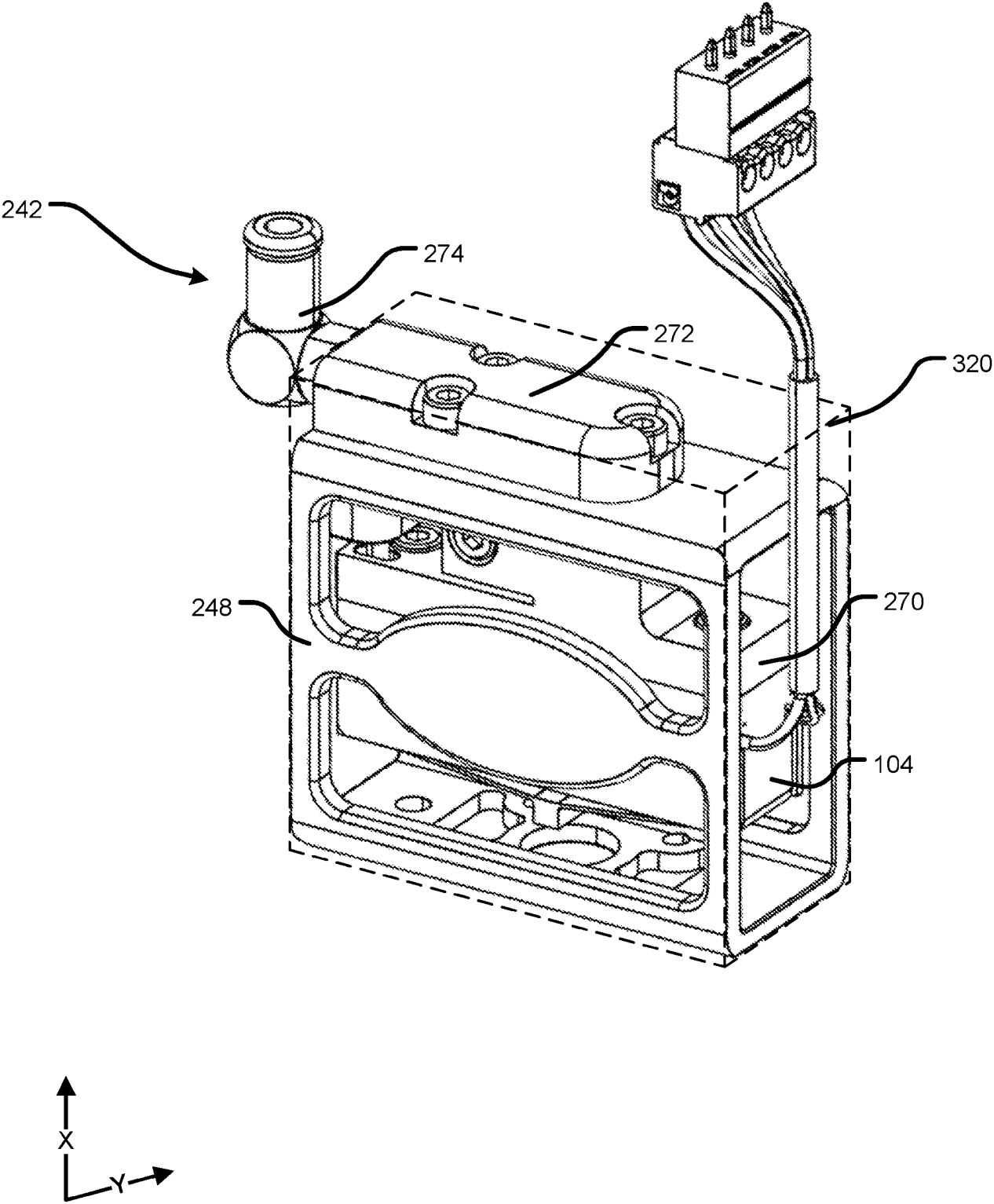


FIG. 12D

26/30

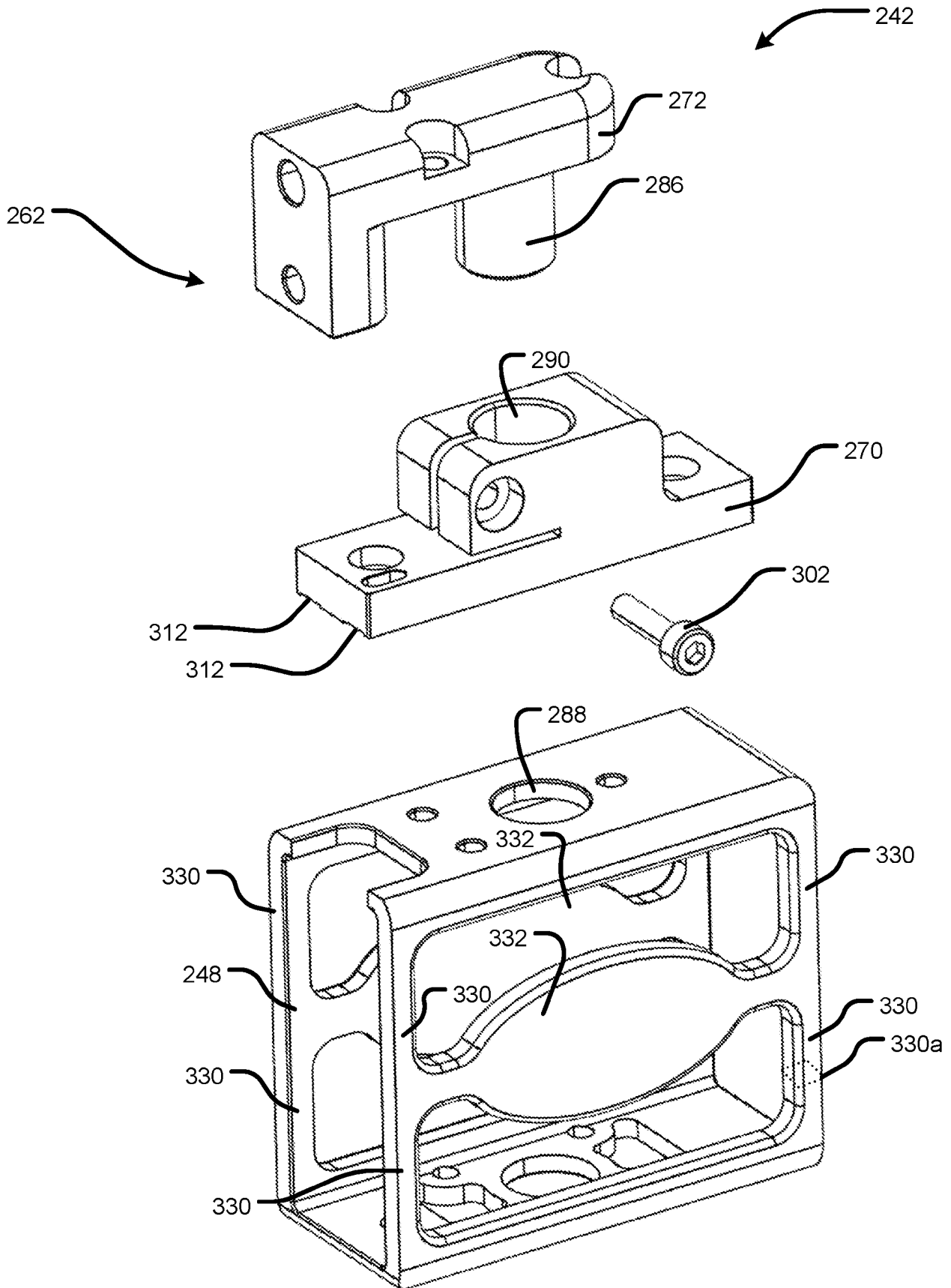


FIG. 12E

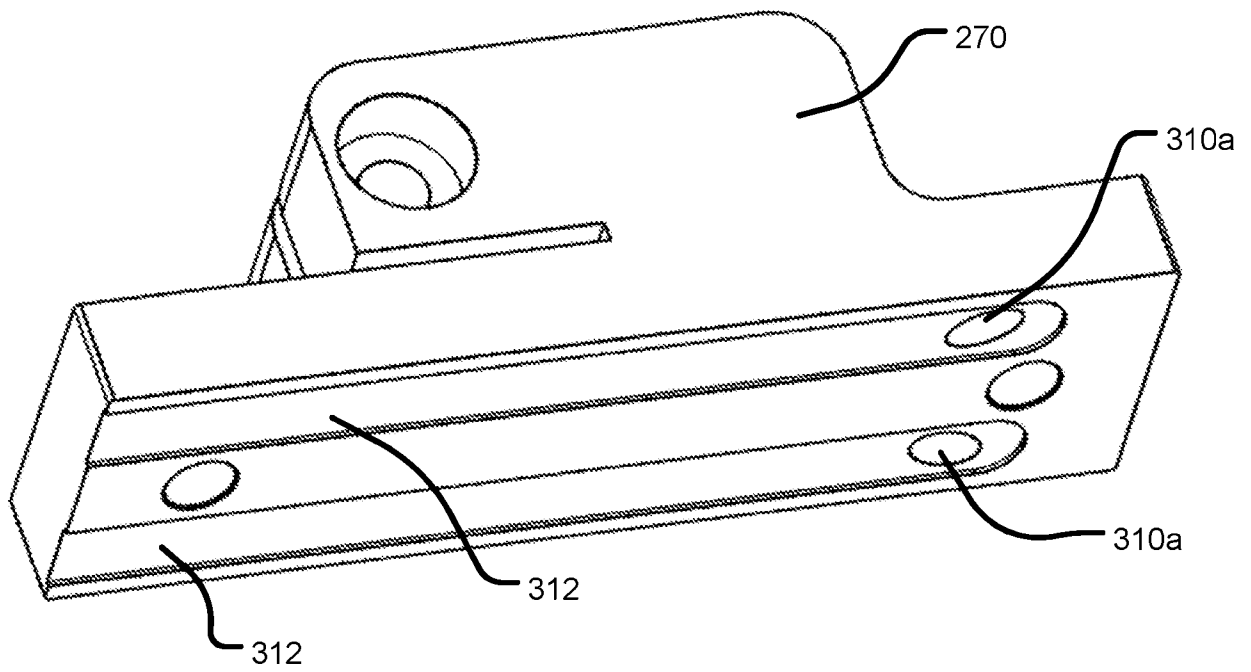


FIG. 12F

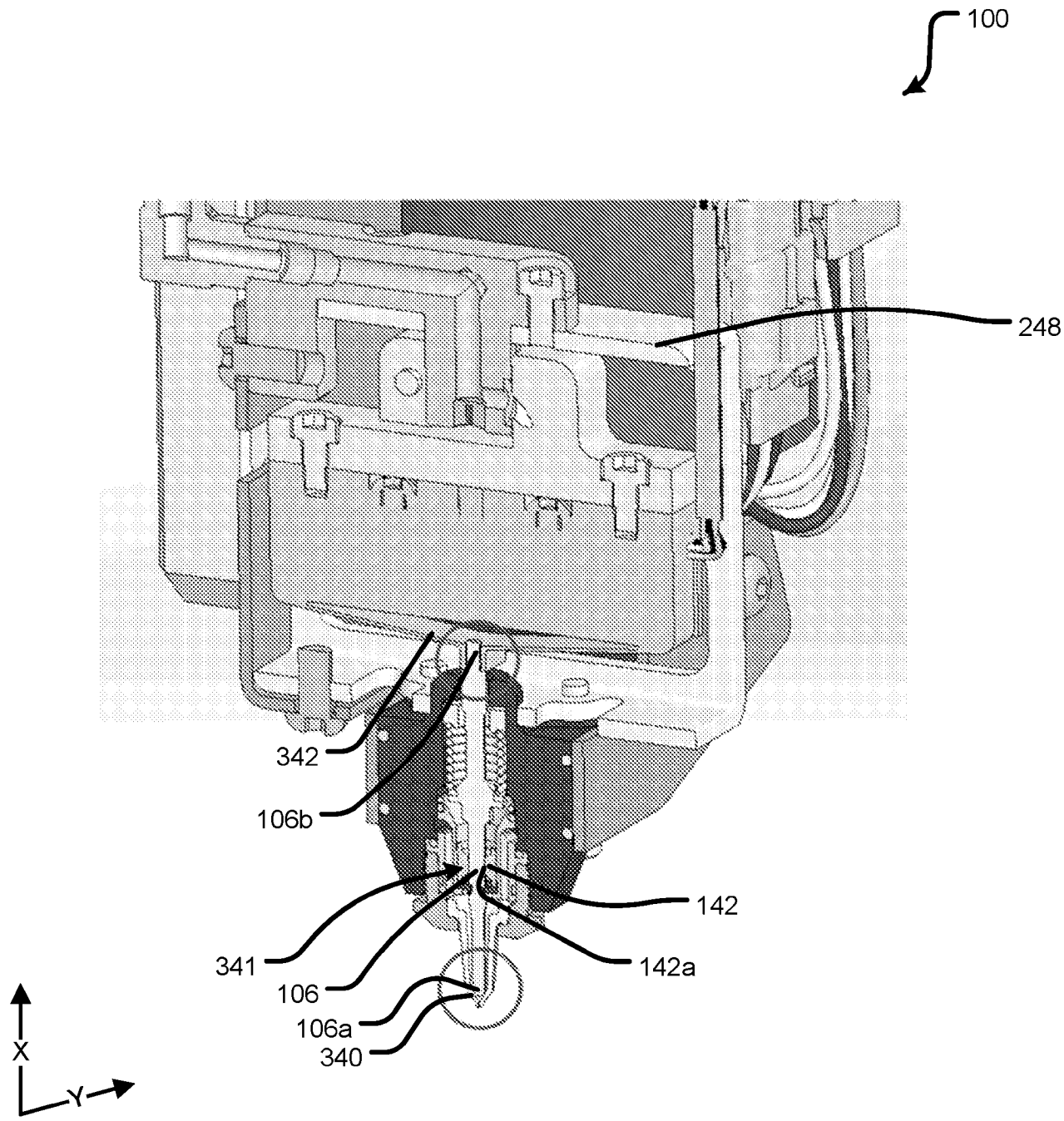


FIG. 13A

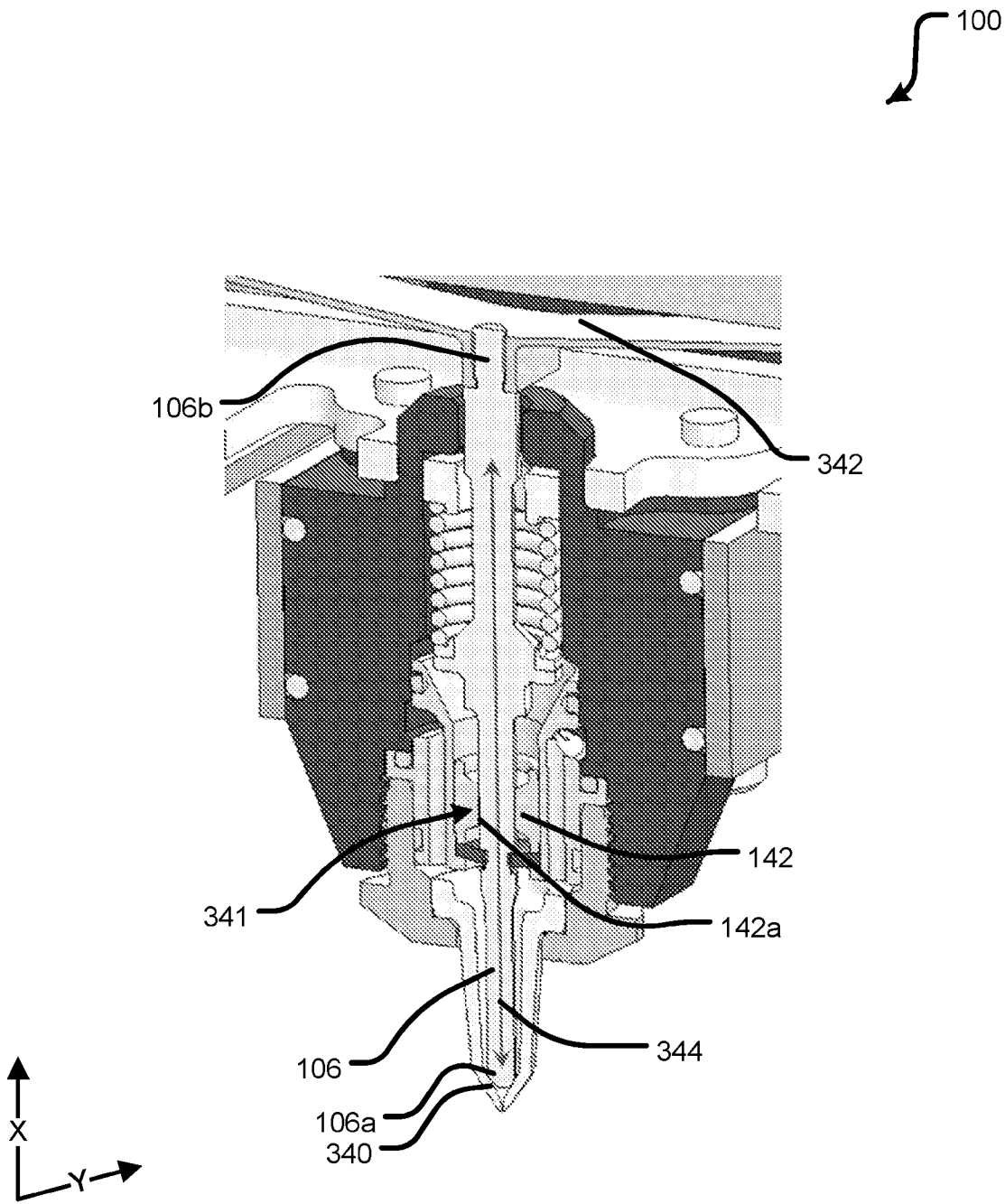


FIG. 13B

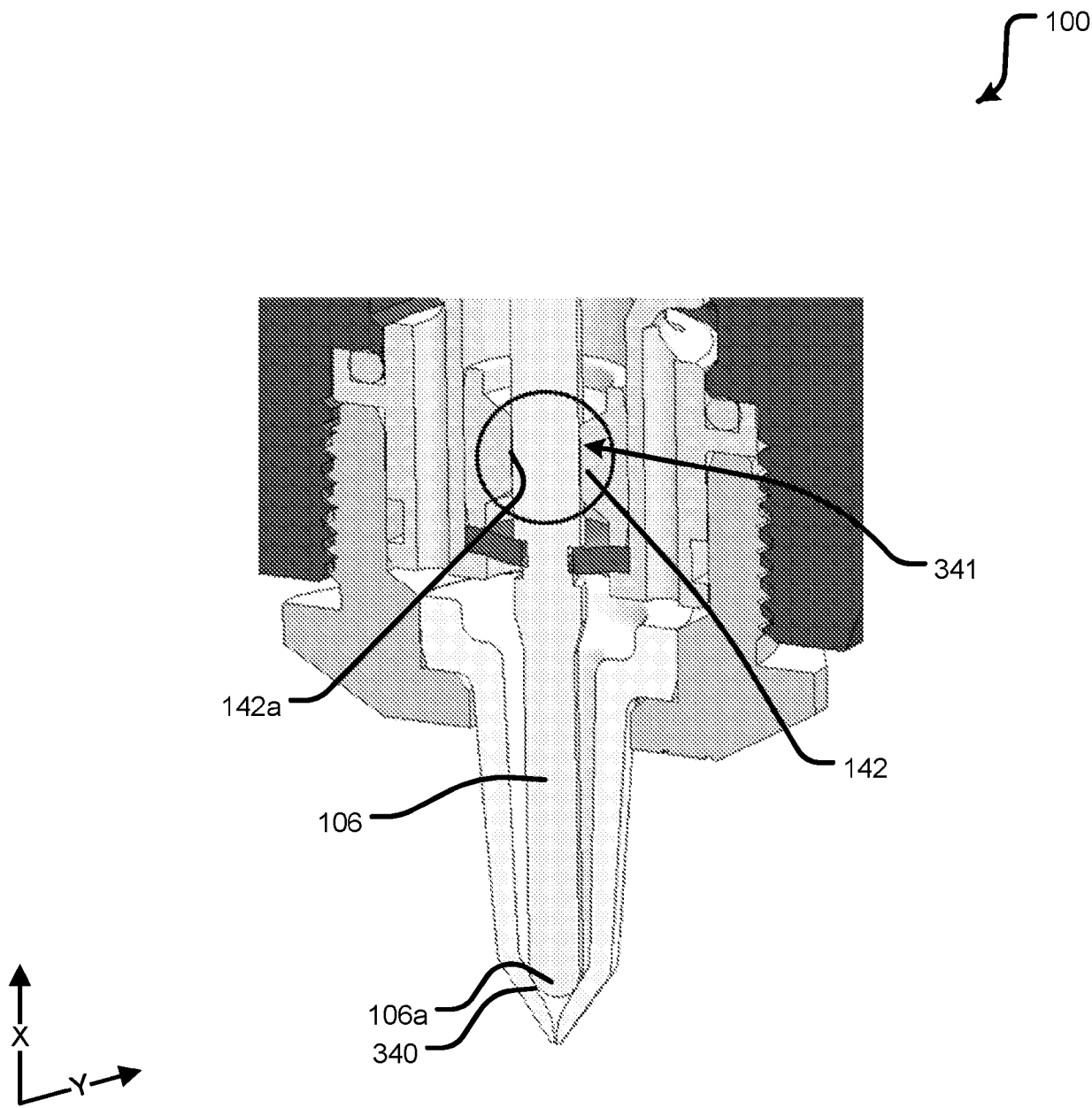


FIG. 13C