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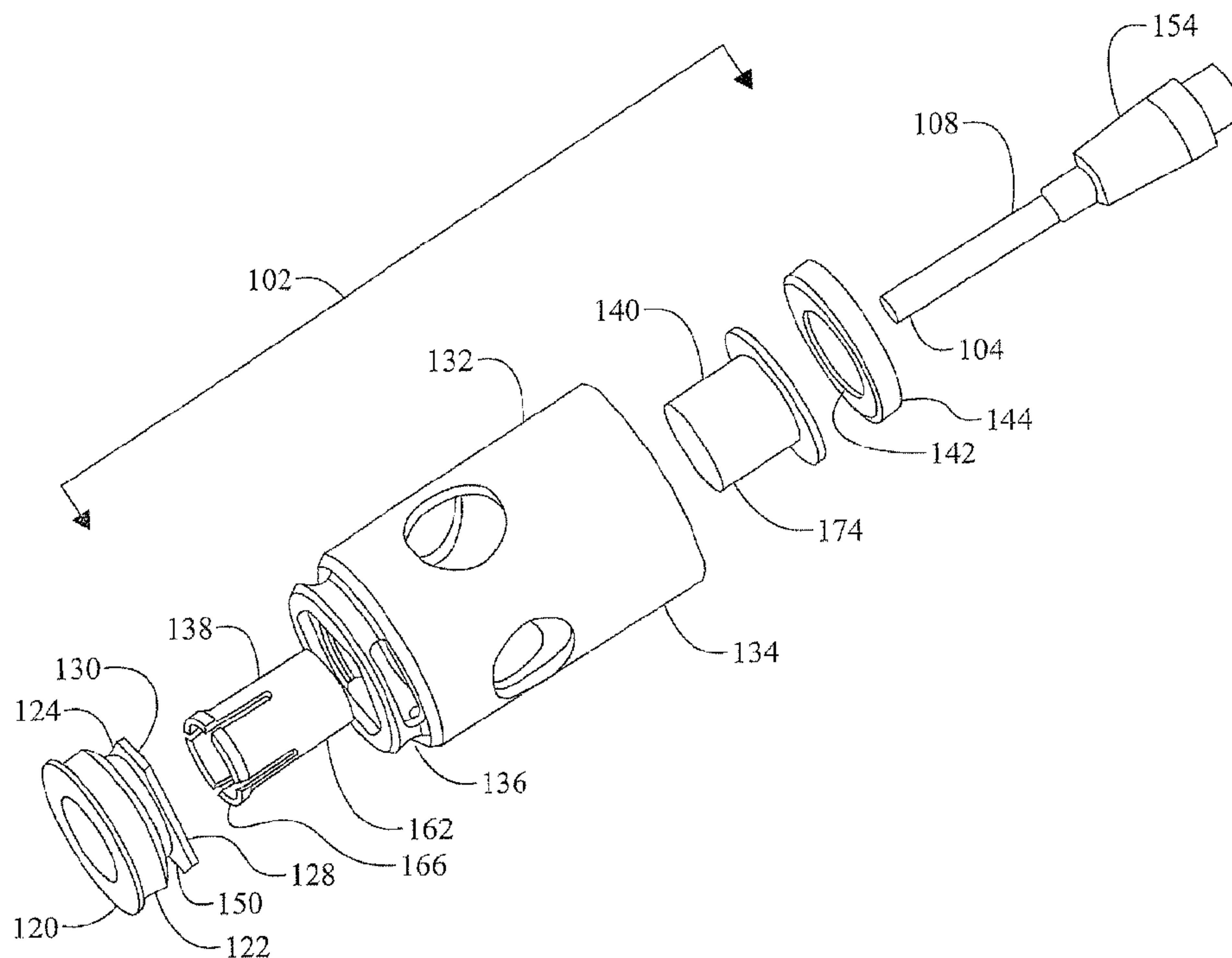
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(54) **Titre : ALIGNEMENT DE MACHINE-OUTIL AVEC EMPLACEMENT DE CIBLE SUR UNE STRUCTURE**

(54) **Title: ALIGNING A MACHINE TOOL WITH A TARGET LOCATION ON A STRUCTURE**



(57) **Abrégé/Abstract:**

An apparatus for aligning a machine tool with a target location on a structure. A machine plate positionable on the structure has a plate bushing providing a hole through the plate. The apparatus also includes a nosepiece for guiding a distal end of the tool through the plate bushing to the target location. The nosepiece has a collet configured to be moved at least partly through and sideward in the plate bushing to center the nosepiece on an element projecting from the structure at the target location. The nosepiece can be attached to the plate bushing to establish normality of the tool relative to the projecting element.



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ABSTRACT OF THE DISCLOSURE

An apparatus for aligning a machine tool with a target location on a structure. A machine plate positionable on the structure has a plate bushing providing a hole through the plate. The apparatus also includes a nosepiece
5 for guiding a distal end of the tool through the plate bushing to the target location. The nosepiece has a collet configured to be moved at least partly through and sideward in the plate bushing to center the nosepiece on an element projecting from the structure at the target location. The nosepiece can be attached to the plate bushing to establish normality of the tool relative
10 to the projecting element.

FIELD

10 BACKGROUND

[0003] In the construction of aircraft, two or more parts may be

20 SUMMARY

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[0005] In another configuration, the disclosure is directed to a machine assembly including a machine tool and an apparatus for aligning a distal end of the machine tool with a target location on a structure. The apparatus includes a machine plate positionable on the structure and having one or more plate bushings each providing a hole through the machine plate. The apparatus also includes a nosepiece for guiding the tool distal end through the plate bushing to the target location when the plate bushing is placed over the target location. The nosepiece has a housing and a collet attached to and extending distally from the housing. The collet has a distal end configured to pass through the plate bushing. The collet is further configured to be moved radially in the plate bushing to center the nosepiece over an element projecting from the structure at the target location. The housing is configured for attachment to the plate bushing to establish normality of the tool relative to the projecting element.

15 [0006] In another implementation, the disclosure is directed to a method of aligning a machine tool with a target location on a structure. A distal end of the machine tool is inserted into a nosepiece for guiding a distal end of the tool. The nosepiece has a housing and a collet attached to and extending distally from the housing. The method includes inserting a distal end of the collet through a plate bushing in a machine plate positioned over an element projecting from the structure at the target location. The collet is moved radially in the plate bushing to center the collet distal end over the element projecting from the structure. The method includes affixing the centered collet distal end to the projecting element, and affixing a distal end of the housing to the plate bushing.

20 [0007] In yet another configuration, the disclosure is directed to a machine plate for use with a machine tool. The machine plate has a body including at least one plate bushing having a hole positionable relative to a target location on a structure. The plate bushing includes a rim graspable by a nosepiece through which the machine tool is operable. The plate bushing is configured to allow passage therethrough of a distal end of a collet attached to the nosepiece. The plate bushing is further configured to allow radial

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movement of the collet therein for centering of the collet over an element projecting from the structure at the target location. The plate bushing is further configured to establish a predefined angle of approach by the machine tool relative to the projecting element when the nosepiece has grasped the rim of
5 the plate bushing.

9. A machine assembly comprising:
a machine tool; and
an apparatus for aligning a distal end of the machine tool with a target location on a structure, the apparatus including a machine plate positionable
10 on the structure and having one or more plate bushings each providing a hole through the machine plate, and a nosepiece for guiding the tool distal end through the plate bushing to the target location when the plate bushing is placed over the target location, the nosepiece having a housing and a collet attached to and extending distally from the housing;
15 the collet having a distal end configured to pass through the plate bushing;
the collet further configured to be moved radially in the plate bushing to center the nosepiece over an element projecting from the structure at the target location;
20 the housing configured for attachment to the plate bushing to establish normality of the tool relative to the projecting element.

10. The machine assembly of claim 9, the housing having a distal end configured to be fitted over the plate bushing.
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11. The machine assembly of claim 9, the nosepiece further comprising a clamp operable to clamp the collet onto the projecting element.

12. The machine assembly of claim 9, the nosepiece further comprising a clamp and a piston operable to push the clamp at least partially through the housing to clamp the collet onto the projecting element and the housing onto the plate bushing.
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13. The machine assembly of claim 12, wherein the piston is attached to the clamp.

5 14. The machine assembly of claim 9, the plate bushing comprising a proximal rim configured to mate with a distal end of the housing.

15 15. The machine assembly of claim 9, further comprising a machining module affixed to the apparatus and operable to actuate the machine tool.

16. The machine assembly of claim 15, wherein the machining module includes an orbital drill unit.

15 22. A machine plate for use with a machine tool, the machine plate comprising a body including at least one plate bushing having a hole positionable relative to a target location on a structure;

the plate bushing comprising a rim graspable by a nosepiece through which the machine tool is operable, the plate bushing configured to allow
20 passage therethrough of a distal end of a collet attached to the nosepiece, the plate bushing further configured to allow radial movement of the collet therein for centering of the collet over an element projecting from the structure at the target location;

the plate bushing further configured to establish a predefined angle of
25 approach by the machine tool relative to the projecting element when the nosepiece has grasped the rim of the plate bushing.

23. The machine plate of claim 22, wherein the plate bushing is configured to allow the collet to be centered over a bushing in a hole in the
30 structure.

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24. The machine plate of claim 22, wherein the rim of the plate bushing comprises a plurality of lobes configured to mate with the nosepiece.

5 **[0008]** Further areas of applicability will become apparent from the description provided herein. It should be understood that the description and specific examples are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

10 BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The drawings described herein are for illustration purposes only and are not intended to limit the scope of the present disclosure in any way.

[0010] Figure 1 is a cross sectional view of a structure in relation to
15 which an apparatus for aligning a machine tool may be used in accordance with one implementation of the disclosure;

[0011] Figure 2 is a top perspective view of a machine plate in accordance with one implementation of the disclosure;

[0012] Figure 3 is an exploded side perspective view of a nosepiece
20 and plate bushing in accordance with one implementation of the disclosure;

[0013] Figure 4 is a perspective view of a plate bushing in accordance with one implementation of the disclosure;

[0014] Figure 5 is a perspective view of a distal end of a nosepiece housing in accordance with one implementation of the disclosure;

25 **[0015]** Figure 6 is a side view of a nosepiece attached to a plate bushing in accordance with one implementation of the disclosure;

[0016] Figure 7 is a longitudinal sectional view of a nosepiece and a plate bushing in accordance with one implementation of the disclosure, the nosepiece shown in an unclamped position;

30 **[0017]** Figure 8 is a top plan view of a plate bushing centered over a target bushing in accordance with one implementation of the disclosure;

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[0018] Figure 9 is a side perspective view of a nosepiece in clamped position in accordance with one implementation of the disclosure;

[0019] Figure 10 is a flow diagram of aircraft production and service methodology;

5 [0020] Figure 11 is a block diagram of an aircraft;

[0021] Figure 12 is a block diagram of an apparatus for aligning a machine tool with a target location on a structure in clamped position in accordance with one implementation of the disclosure; and

10 [0022] Figure 13 is a flow diagram of a method of aligning a machine tool with a target location on a structure in accordance with one implementation of the disclosure.

DETAILED DESCRIPTION

15 [0023] The following description is merely exemplary in nature and is not intended to limit the present disclosure, application, or uses. It should be understood that throughout the drawings, corresponding reference numerals indicate like or corresponding parts and features.

[0024] Referring more particularly to the drawings, embodiments of
 20 the disclosure may be described in the context of an aircraft manufacturing and service method 60 as shown in Figure 10 and an aircraft 80 as shown in Figure 11. During pre-production, exemplary method 60 may include specification and design 62 of the aircraft 80 and material procurement 64. During production, component and subassembly manufacturing 66 and
 25 system integration 68 of the aircraft 80 takes place. Thereafter, the aircraft 80 may go through certification and delivery 70 in order to be placed in service 72. While in service by a customer, the aircraft 80 is scheduled for routine maintenance and service 74 (which may also include modification, reconfiguration, refurbishment, and so on).

30 [0025] Each of the processes of method 60 may be performed or carried out by a system integrator, a third party, and/or an operator (e.g., a customer). For the purposes of this description, a system integrator may

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include without limitation any number of aircraft manufacturers and major-system subcontractors; a third party may include without limitation any number of vendors, subcontractors, and suppliers; and an operator may be an airline, leasing company, military entity, service organization, and so on.

5 **[0026]** As shown in Figure 11, the aircraft 80 produced by exemplary method 60 may include an airframe 82 with a plurality of systems 84 and an interior 86. Examples of high-level systems 84 include one or more of a propulsion system 88, an electrical system 90, a hydraulic system 92, and an environmental system 94. Any number of other systems may be included.
10 Although an aerospace example is shown, the principles of the invention may be applied to other industries, such as the automotive industry.

[0027] Apparatus and methods embodied herein may be employed during any one or more of the stages of the production and service method 60. For example, components or subassemblies corresponding to production
15 process 66 may be fabricated or manufactured in a manner similar to components or subassemblies produced while the aircraft 80 is in service. Also, one or more apparatus embodiments, method embodiments, or a combination thereof may be utilized during the production stages 66 and 68, for example, by substantially expediting assembly of or reducing the cost of
20 an aircraft 80. Similarly, one or more of apparatus embodiments, method embodiments, or a combination thereof may be utilized while the aircraft 80 is in service, for example and without limitation, to maintenance and service 74.

[0028] In various implementations, the present disclosure is directed to methods and apparatus for aligning a machine tool with a target location on
25 a structure. The machine tool may be operable, for example, using an orbital drilling unit or other machining module. Various implementations of the disclosure make it possible to perform machining at a target location that could deviate from a nominal machining location.

[0029] A block diagram of one configuration of an apparatus for
30 aligning a machine tool with a target location on a structure is indicated generally in Figure 12 by reference number 200. The apparatus 200 includes a machine plate 204 positionable on the structure. The plate has a plate

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bushing 208 that provides a hole through the machine plate 204. The apparatus also includes a nosepiece 212 for guiding a distal end of the tool (not shown) through the plate bushing 208 to the target location (not shown). The nosepiece 212 has a collet 216 configured to be moved at least partly
 5 through and sideward in the plate bushing 208 to center the nosepiece 212 on an element (not shown) projecting from the structure at the target location. The nosepiece 212 is configured for attachment to the plate bushing 208 to establish a predefined approach angle of the tool relative to the projecting element.

10 **[0030]** It should be noted that the disclosure could be implemented in connection with many types of machines and/or tools, including but not limited to cutting machines and tools and non-orbital drills. Power feed or positive feed drill motors, plasma cutting torches, water jet nozzles, laser drilling and/or marking equipment, hole saws, broaching heads, and/or
 15 various types of machining heads could be adapted for use in accordance with the disclosure. Additionally, although various implementations may be described with reference to splicing applications, the disclosure is not so limited. The disclosure can be implemented in many applications in which it may be desirable to center a machine tool over a machining location and to
 20 utilize the tool along a specific vector or approach angle relative to that location.

[0031] An exemplary cross section of a structure in which splicing may be performed is indicated generally in Figure 1 by reference number 20. An orbital drilling unit may be used in accordance with one implementation of
 25 the disclosure to drill, *e.g.*, through several aligned parts 24. The parts 24 may be made of different materials, including but not limited to carbon fiber reinforced plastics, metals, *etc.* In the present example, drilling is to be performed in a plurality of target locations 28, one of which is shown in Figure 1. Drilling is to be performed along a path 30 through the parts 24, beginning
 30 at the target location 28, which is defined by a bushing 32 that lines a hole 36 in an upper splice plate 40. Such a bushing may be referred to in this disclosure and the claims as a “target bushing”. Thus drilling may be specified

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to be performed at a nominal location indicated generally by reference number 46. It should be noted, however, that the nominal drilling location 46 may or may not coincide exactly with the target location 28, dependent, *e.g.*, on tolerances provided in the nominal drilling specification. A flange 50 of the target bushing 32 projects from an upper surface 54 of the structure 20.

[0032] Various configurations of an apparatus for aligning a machine tool with a target location on a structure include a machine plate and a nosepiece, *e.g.*, as shown in Figures 2 and 3. A target location may be, for example, the target bushing 32 installed in the structure 20, and various aligning apparatus configurations are described below with reference to the structure 20 and target bushing 32. It should be noted, however, that various implementations are contemplated in relation to other types of target locations. For example, the presence of a hole is not necessary at a target location for configurations of the apparatus to align a machine tool. Additionally or alternatively, the disclosure could be implemented in relation to elements other than bushings that project from a structural surface, *e.g.* nail heads, screw heads, *etc.* Although such projections could be circular and/or spherical, they could have other or additional shapes.

[0033] One configuration of a machine plate is indicated generally in Figure 2 by reference number 100. One configuration of a nosepiece is indicated generally in Figure 3 by reference number 102. As further described below, the nosepiece 102 may be used to guide a distal end 104 of a machine tool 108 through the machine plate 100 to a target drilling location 28 on the structure 20. The machine tool 108 is, *e.g.*, a cutting tool operable via an orbital drill unit (not shown in Figure 3). The terms “proximal” and “distal” are used with reference to a user of the machine tool 108.

[0034] Referring now to Figure 2, the machine plate 100 may be positioned on and attached to the structure surface 54. The machine plate 100 has a body 112 made, for example, of solid aluminum that may be elevated from the surface 54, *e.g.*, by a plurality of supports 116. A plurality of plate bushings 120 are mounted in the machine plate body 112 to provide a plurality of holes 118 through the body 112. Each bushing 120 may be

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positioned over a corresponding target drilling location on the structure 20. In the present exemplary configuration, the bushings 120 are configured to establish normality of a machine tool relative to a target location as further described below. In some other configurations, however, plate bushings may
 5 be configured to establish an approach angle for a machine tool at other than ninety degrees. It should be noted generally that machine plate configurations of various shapes and having various dimensions and numbers of holes, including configurations having a single hole, are contemplated.

[0035] In the present configuration, each plate bushing 120 has a
 10 distal portion 122 fixedly mounted in the machine plate body 112 and a proximal portion 124 extending above a proximal surface 126 of the machine plate body 112. A plate bushing 120 may be made, *e.g.*, of hardened tool steel and is shown in greater detail in Figures 3 and 4. The plate bushing proximal portion 124 has a projecting rim 128 that is graspable by the
 15 nosepiece 102 as further described below. In the present configuration, the bushing rim 128 includes a plurality of lobes 130.

[0036] Referring now to Figures 3, 5, 6 and 7, the nosepiece 102 includes a plurality of substantially concentric components, *e.g.*, a housing 132 having a proximal portion 134 and a distal portion 136, a collet 138, a
 20 collet clamp 140, a piston 142 and piston cylinder 144. The housing 132 may be made from one solid piece of steel, *e.g.*, heat treatable stainless or tool steel. The piston 142 and cylinder 144 may be fabricated, *e.g.*, of stainless steel.

[0037] In the present configuration and as shown in Figures 4 and
 25 5, the distal portion 136 of the nosepiece housing 132 is configured to mate with lobes 130 of the plate bushing 120. Specifically, an end 146 of the distal portion 136 has a hole 148 shaped to fit over the lobes 130 when a user positions the nosepiece relative to the plate bushing 120. As further described below, a user may cause the nosepiece housing 132 to be locked onto the
 30 lobes 130 through slots 152 and to be pressed against a distal surface 150 (shown in Figure 7) provided by the lobes 130.

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[0038] Referring now to Figures 3 and 6, the cutting tool 108 is held by a tool holder 154 configured for attachment to an orbital drill unit 156. The orbital drill unit 156 and attached cutting tool 108 may be rigidly connected with the nosepiece housing 132 at a plurality of housing flanges 158, two of which are shown in Figure 6. In various configurations the tool holder 154 provides a standard interface, *e.g.*, a HSK mount and heat shrink tool holder interface, between the tool 108 and the orbital drilling unit 156. In other configurations in which machining modules other than the present exemplary orbital drill unit are used, other or additional types of tool holder interfaces, *e.g.*, CAT, SK, BT interfaces, may be used. The nosepiece housing 132 includes lateral holes 160 for chip evacuation via an external vacuum system and duct (not shown).

[0039] A proximal portion 162 of the collet 138 is rigidly fixed to the nosepiece housing 132 through the piston cylinder 144. As shown in Figure 7, a slotted distal portion 164 of the collet extending from the housing 132 includes a lip 166. The collet may be made of a single piece of material, *e.g.*, of heat treatable stainless or tool steel. Slots 178 allow the machined diameter of the contacting surface of the lip 166 to contract as the collet clamp 140 slides over the distal portion 164 of the collet. The lip 166 is configured to fit over the protruding flange 50 of the bushing 32. In other implementations, a collet could be configured to fit over an element of a different type and/or having a different shape projecting from a work piece surface.

[0040] The nosepiece 102 with integral collet 138 is configured for radial movement in the plate bushing 120 to allow centering of the collet 138 with fixed nosepiece 102 on the target bushing flange 50. Accordingly, dimensions of the plate bushing 120 are based on dimensions of the target bushing 32 and collet 138, *e.g.*, as shown in Figure 8. Figure 8 is a top plan view of the plate bushing 120 centered over the target bushing 32. An inner diameter 168 of the plate bushing 120 may be established by adding twice the wall thickness of the collet 138 to an amount of leeway to a diameter 170 of the target bushing flange 50. For example, where a leeway of 0.050 inches is added to twice the collet wall thickness, the resulting plate bushing inner

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diameter 168 allows radial displacement of the collet 138 by 0.025 inches from a nominal drill location when the collet 138 is moved in the plate bushing 120 to center the nosepiece 102 on the target bushing flange 50. Thus, in the present configuration, leeway for radial movement of the collet 138 is a function of the difference in diameters 168 and 170 and the outside dimension of the collet clamp 140 divided by two.

[0041] An outer diameter 172 of the plate bushing 120 may be, *e.g.*, a standard size used in drill plate fabrication. In the present exemplary configuration, the machine plate 100 and plate supports 116 are fabricated to provide a machine plate height that allows each plate bushing 120 to be at an appropriate height from the work piece surface 54 to ensure sufficient contact by the collet 138 over the target bushing flange 50.

[0042] The collet clamp 140 has a distal end 174 configured to be extended over the collet 138 to clamp the collet 138 onto the target bushing flange 50. The clamp 140 may be made from a highly elastic material, *e.g.*, acetal copolymer. Such material allows the collet 138 to close around a target bushing flange within a predetermined vicinity of, *e.g.*, plus or minus 0.010 inch diametric from, a nominal target bushing flange outside dimension and still substantially close a gap 176 (shown in Figure 7) between the nosepiece housing, plate bushing 120 and collet clamp 140.

[0043] An air hose 180 (shown in Figure 6) extending from an air pressure/vacuum system (not shown) into the housing 132 pneumatically connects the pressure/vacuum system with a space 182 defined in the piston cylinder 144. The piston 142 is rigidly attached to the clamp 140 and operable to push the clamp 140 at least partially through the housing 132 to clamp the collet 138 onto the target bushing flange 50 and the housing 132 onto the plate bushing 120. The housing 132 may be clamped onto the plate bushing 120 and against the lobe distal surface 150 to establish normality of the tool 108 relative to the target bushing flange 50.

[0044] A machine assembly that includes the foregoing aligning apparatus may be combined with an orbital drill unit and used in the following manner. A user installs the tool 108 in the tool holder 154 and installs the tool

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holder 154 in the orbital drill unit 156. The user then affixes the orbital drill unit to the proximal flanges 158 of the nosepiece housing 132 so that the tool 108 is extendable through the nosepiece 102. The machine plate 100 is positioned over the structure 20 so that one or more plate bushings 120 are positioned over one or more target drilling locations 28, *e.g.*, over one or more target bushing flanges 50 projecting from the structure surface 54. Placement of the machine plate may be in accordance with nominal drilling location specifications.

[0045] The user inserts the nosepiece 102 into a plate bushing 120 so that distal ends of the collet 138 and clamp 140 extend through the plate bushing 120 toward a target bushing flange 50. To position the collet lip 166 around the target bushing flange 50, the user may “float” the drill unit motor, keeping the tool distal end 104 retracted from the plate bushing 120, and may move the collet 138 longitudinally and/or sideward in the plate bushing until the collet 138 is centered on the bushing flange 50. To position the nosepiece 102 relative to the plate bushing 120, the user may rotate the nosepiece, *e.g.*, up to about 60 degrees to mate the nosepiece hole 148 with the lobes 130 of the plate bushing 120. When the nosepiece and lobes have been mated, the piston 142 can be actuated toward the distal end of the housing 132 to lock the plate bushing lobes 130 into the distal end 146 of the nosepiece housing 132. It should be noted that unless the collet 138 is positioned over and onto the target bushing flange 50, the nosepiece 102 cannot be rotated and therefore cannot be locked onto the plate bushing lobes 130. In such manner, incorrect positioning of the collet onto the flange 50 can be avoided.

[0046] When the nosepiece 102 has been rotated into position over the plate bushing lobes 130, the user may activate the clamp 140 by introducing gas or hydraulic pressure, *e.g.*, air from the air pressure system through the air hose 180 into the piston cylinder 144. Air pressure may be supplied in the piston cylinder at between about 100 and 200 pounds per square inch. In some configurations, air pressure as high as about 400 pounds per square inch could be supplied in the cylinder 144. The pressure causes the piston 142 to push the clamp 140 distally in the piston cylinder

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144. The clamp 140 closes the collet 138 around the flange 50 of the target bushing 32, centering the machine tool 108 and drill unit 156 over the target bushing 32. The clamp also clamps the nosepiece 102 against the plate bushing lobes 130. The nosepiece is forced against the lobe surface 150, thereby bringing the machine tool 108 and drill unit 156 into normality with the target bushing 32. This double clamping action, caused by a single stroke of the piston 142, restrains the nosepiece 102 and drill unit in the machine plate 100 in six degrees of freedom. The drill unit 156 can then be used to drill through the target bushing 32. The nosepiece 102 is shown in Figure 9 in clamped position.

[0047] To remove the drill unit and nosepiece 102 from the machine plate 100, the user activates the air system to create a vacuum in the piston cylinder 144, thereby causing the piston 142 to withdraw the clamp 140 and allow the nosepiece 102 to be removed from the target bushing flange 50 and plate bushing lobes 130. It should be noted generally that the clamp 140 could be operated in other or additional ways. For example, manual operation of a collet clamp is contemplated in some implementations. It also should be noted that many different types of grasping mechanisms could be used in place of the rim 128 and lobes 130. For example, the rim and/or nosepiece distal end could include various contours instead of or in addition to flat surfaces.

[0048] A flow diagram of a method of aligning a machine tool with a target location on a structure in accordance with one implementation of the disclosure is indicated generally in Figure 13 by reference number 300. In step 304 the distal end of the machine tool is inserted into a nosepiece for guiding a distal end of the tool. The nosepiece has a housing and a collet attached to and extending distally from the housing. In step 308, a distal end of the collet is inserted through a plate bushing in a machine plate positioned over an element projecting from the structure at the target location. In step 312 the collet is moved radially in the plate bushing to center the collet distal end over the element projecting from the structure. In step 316 the centered

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collet distal end is affixed to the projecting element. In step 320, a distal end of the housing is affixed to the plate bushing.

[0049] The foregoing apparatus and methods make it possible to use nominal specifications to position a drill plate over a work piece and then to perform drilling based on the location of a “landmark” on the underlying structure. Configurations of the machine plate and nosepiece interface make it possible to achieve both concentricity and normality in hole processing. It is possible for drilling to deviate from nominal locations while ensuring that a final hole is processed concentric with a required target location, e.g., an installed bushing. After a one-time installation of a drilling tool in the nosepiece, the drill unit and nosepiece can be inserted into a plurality of plate bushings to drill a plurality of hole locations without having to reinstall the tool in the nosepiece or perform other time consuming steps.

[0050] A single-acting cylinder provides the force sufficient to close the collet that finds the center of an installed work piece bushing and provides normality and rigidity for an orbital drill unit to process a hole. The center line of a hole is not determined by a drill bushing but rather by the location of an installed bushing or other projecting element on the structure. Using the foregoing apparatus and methods can increase productivity and lower production cycle times to produce high-quality holes.

[0051] The above aligning apparatus can be used in orbital drilling, the benefits of which can include the ability to obtain a plurality of hole diameters from a single cutter, low cutting forces, high surface-feet-per-minute machining of carbon fiber composite, stainless steel and/or titanium structure, minimal entry and/or exit burr and virtually no composite delamination. A simple interface with an orbital drill motor is provided, along with the ability to quickly locate the centerline of a fastener. The “insert, rotate, and lock” process to be followed by an operator is simple and quick to perform. The process is highly visible to an operator, and since there is a dedicated plate bushing size for each fastener diameter, errors can be reduced or eliminated.

[0052] While various embodiments have been described, those skilled in the art will recognize modifications or variations which might be

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made without departing from the present disclosure. The examples illustrate the various embodiments and are not intended to limit the present disclosure. Therefore, the description and claims should be interpreted liberally with only such limitation as is necessary in view of the pertinent prior art.

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CLAIMS

What is claimed is:

1. A method of aligning a machine tool with a target location on a
5 structure, the method comprising: inserting a distal end of the machine tool
into a nosepiece for guiding a distal end of the tool, the nosepiece having a
housing and a collet attached to and extending distally from the housing;
inserting a distal end of the collet through a plate bushing in a machine plate
positioned over an element projecting from the structure at the target location;
10 moving the collet radially in the plate bushing to center the collet distal end
over the element projecting from the structure; affixing the centered collet
distal end to the projecting element; and affixing a distal end of the housing to
the plate bushing.
- 15 2. The method of claim 1, further comprising actuating a clamp in the
housing to clamp the distal end of the housing to the plate bushing and to
clamp the collet distal end to the projecting element.
3. The method of claim 1, further comprising operating the tool through
20 the housing and collet.
4. The method of claim 3, performed using a machining module that
controls a proximal end of the tool.
- 25 5. The method of claim 4, wherein the machining module includes an
orbital drill.
6. The method of claim 1, further comprising rotating the housing to
mate the distal end of the housing with a plurality of lobes of a proximal rim of
30 the plate bushing.

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7. The method of claim 1, further comprising causing the distal end of the housing to grasp the plate bushing.

8. A method of aligning a machine tool with a target location on a structure, the method comprising: inserting a distal end of the machine tool into a nosepiece for guiding the tool, the nosepiece having a housing and a collet attached to and extending distally from the housing; inserting a distal end of the collet through a plate bushing positioned over an element projecting from the structure at the target location; centering the collet distal end over the element projecting from the structure; and actuating a piston in the housing to clamp the collet distal end over the projecting element and to lock a distal end of the housing onto the plate bushing.

9. The method of claim 8, further comprising establishing an approach angle of the tool predefined relative to the projecting element.

10. The method of claim 8, the actuating and centering performed to bring the tool into normality with the projecting element.

11. The method of claim 8, further comprising: positioning a machine plate including the plate bushing on the structure in accordance with a nominal machining location; and aligning the tool relative to the target location.

12. The method of claim 11, wherein the target location deviates from the nominal machining location.

13. The method of claim 8, further comprising mating the distal end of the housing with one or more protrusions of the plate bushing.

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14. The method of claim 8, wherein the piston is actuated to push an elastic clamp against the plate bushing to lock the housing distal end onto the plate bushing.

5 15. A method of aligning a machine tool with a target location on a structure, the method comprising: positioning a plate bushing over the target location; configuring the tool with a nosepiece such that the tool is extendible at least partially through a distal end of the nosepiece; inserting a collet of the
10 distal end of the nosepiece through the plate bushing to center the collet over an element projecting from the structure at the target location; clamping the collet onto the projecting element and a distal end of the nosepiece onto the plate bushing; and extending the tool through the nosepiece distal end to the target location.

15 16. The method of claim 15, wherein clamping a distal end of the nosepiece onto the plate bushing comprises affixing a housing of the nosepiece to one or more protuberances of the plate bushing.

 17. The method of claim 15, the clamping comprising actuating a piston
20 in a housing of the nosepiece to push an elastic clamp onto the collet and plate bushing.

 18. The method of claim 15, further comprising moving the collet
25 radially relative to the plate bushing to center the collet.

 19. The method of claim 15, the inserting and clamping performed to bring the tool into normality with the projecting element.

 20. The method of claim 15, wherein at least the inserting is performed
30 while the tool is retracted from at least the plate bushing.

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21. A method of using an aligning apparatus to align a machine tool with a target location on a structure, the tool configurable with a machining module to control a proximal end of the tool, the aligning apparatus including a machine plate having a plate bushing, the plate bushing having a hole therethrough and one or more protrusions, the aligning apparatus further including a nosepiece having a housing, a collet attached to and extending from the housing in a distal direction relative to the housing, and an annular piston in a piston cylinder in the housing, the piston attached to an elastic clamp positioned at least partially around the collet, the piston actuatable to push the clamp in the distal direction, the method comprising: affixing the machining module to the nosepiece housing to allow extension of a distal end of the tool through a hole in a distal end of the nosepiece housing and through the collet; positioning the hole of the plate bushing of the machine plate over a target projection projecting from the structure at the target location; inserting a distal end of the collet into the plate bushing hole so that the collet distal end extends through the plate bushing toward the target projection; moving the collet longitudinally and/or radially in the plate bushing to center the collet on the target projection; mating the distal hole of the nosepiece housing with the protrusions of the plate bushing; and actuating the piston to push the clamp against the plate bushing, to lock the housing distal end onto the plate bushing protrusions and to close the collet around the target projection.

22. A method for aligning a component of a machine tool with a target location on a structure, the target location having a first component projecting therefrom, and a plate positioned over the target location, the plate having a second component with an opening, the method comprising: arranging a collet at least partially within a nosepiece, with the nosepiece being secureable to the component of the machine tool; inserting a portion of the collet through the opening in the second component and into alignment with the first component at the target location; using a single motion of a piston within the nosepiece to simultaneously tighten the collet over the first component and to clamp the nosepiece to the second component.

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23. The method of claim 22, further comprising inserting a distal end of the machine tool into the nosepiece, wherein the nosepiece guides the distal end of the tool.

5 24. The method of claim 22, further comprising moving the collet radially in the opening in the second component to center the collet over the first component.

10 25. The method of claim 22, wherein the inserting a portion of the collet through the opening in the second component comprises inserting a portion of the collet through a plate bushing in a machine plate.

15 26. The method of claim 22, further comprising operating the tool through the collet after the collet has been secured to the first component.

 27. The method of claim 26, wherein the operation of operating the tool comprises operating an orbital drill unit.

20 28. The method of claim 22, wherein the inserting a portion of the collet through the opening in the second component and into alignment with the first component at the target location comprises moving the collet radially to align a hole in a distal end of the nosepiece with a plurality of lobes formed on the second component.

25 29. The method of claim 22, wherein the inserting a portion of the collet through the opening in the second component and into alignment with the first component at the target location comprises moving the collet centered on a flange projecting from said first component.

30 30. The method of claim 29, further comprising preventing the nosepiece from becoming locked to the second component unless the collet is positioned over and onto the first component.

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31. The method of claim 22, wherein the operation of using a single motion of a piston within the nosepiece to cause a clamp to move linearly and simultaneously tighten the collet over the first component and to clamp the nosepiece to the second component comprises using air from an air pressure
5 system.

32. A method for aligning a component of a machine tool with a target location on a structure, the target location having a first component projecting therefrom with the first component including a flange, and a plate positioned
10 over the target location, the plate having a second component with an opening, the method comprising: arranging a collet within a nosepiece; securing the nosepiece to the component of the machine tool; inserting a portion of the collet through the opening in the second component such that said collet is positioned over and on said first component; and simultaneously
15 tightening the collet over the first component and clamping the nosepiece to the second component.

33. The method of claim 32, wherein the operation of simultaneously tightening the collet over the first component and clamping the nosepiece to
20 the second component is caused by motion of a piston that urges a clamp linearly within the nosepiece to effect said simultaneous tightening.

34. The method of claim 32, further comprising inserting a distal end of the machine tool into the nosepiece, wherein the nosepiece guides the distal
25 end of the tool.

35. The method of claim 32, wherein the operation of inserting a portion of the collet through the opening in the second component comprises aligning a hole of said nosepiece with a plurality of lobes formed on said
30 second component.

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36. The method of claim 32, further comprising preventing the nosepiece from becoming locked to the second component unless the collet is positioned over and onto the first component.

5 37. The method of claim 32, wherein said operation of simultaneously tightening the collet over the first component and clamping the nosepiece to the second component comprises restraining the nosepiece and the machine tool in the plate in six degrees of freedom.

10 38. The method of claim 33, further comprising driving the piston with one of hydraulic pressure and air pressure.

39. A method for aligning a component of a machine tool with a target location on a structure, the target location having a first component projecting therefrom with the first component including a flange, and a plate positioned over the target location, the plate having a second component with an opening, the method comprising: arranging a collet within a nosepiece; securing the nosepiece to the component of the machine tool; inserting a portion of the collet through the opening in the second component such that
15 said collet is in axial alignment with said first component; and using a piston within the nosepiece to drive a clamp linearly within the nosepiece, the clamp urging the collet and nosepiece to become affixed to the first component and the second component, respectively.

25 40. The method of claim 39, wherein the piston causes the collet and nosepiece to be simultaneously affixed to the first component and the second component, respectively.

41. The method of claim 39, further comprising preventing the
30 nosepiece from becoming locked to the second component unless the collet is first positioned over and onto the first component, before said piston is actuated.

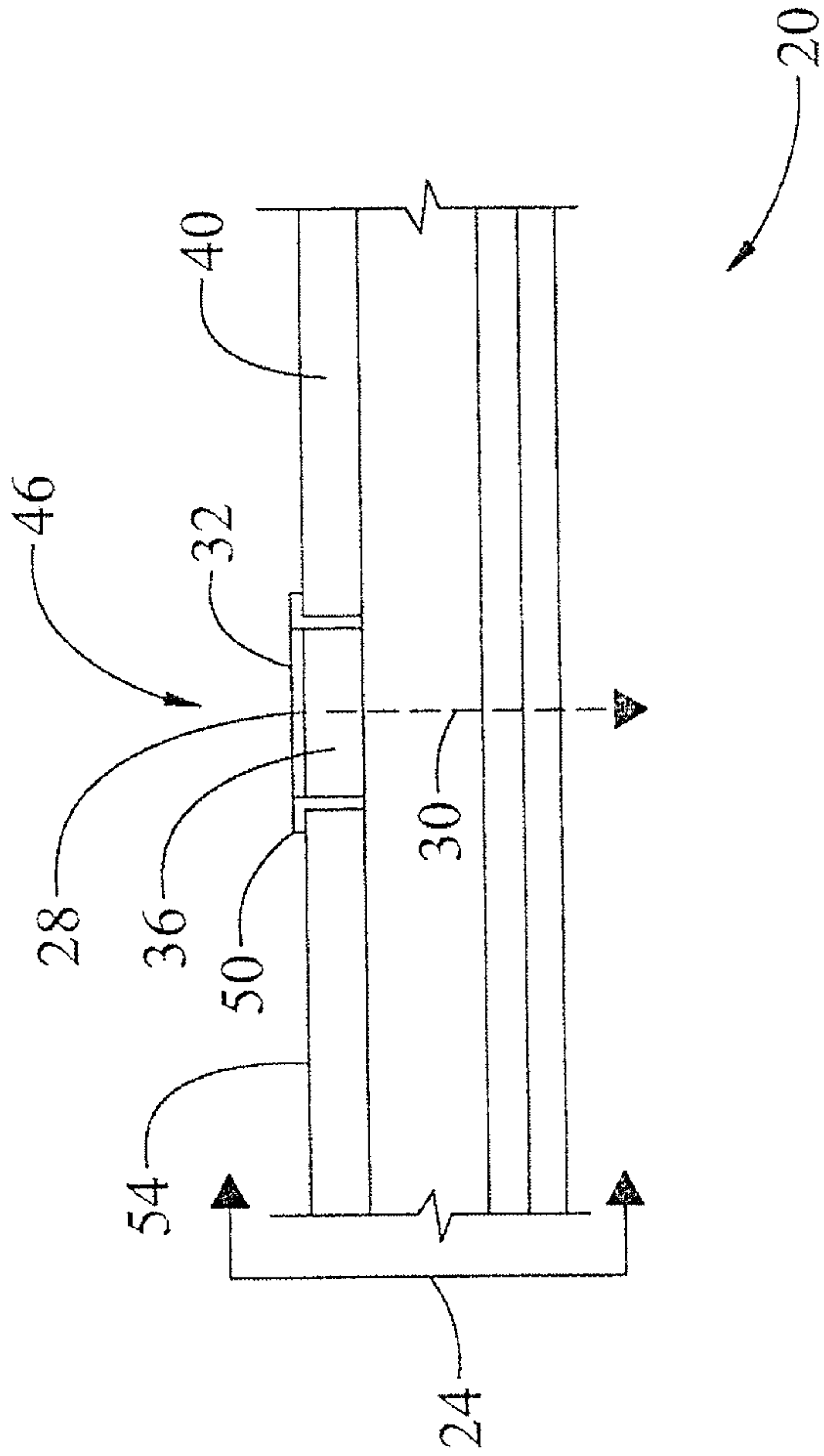


Fig. 1

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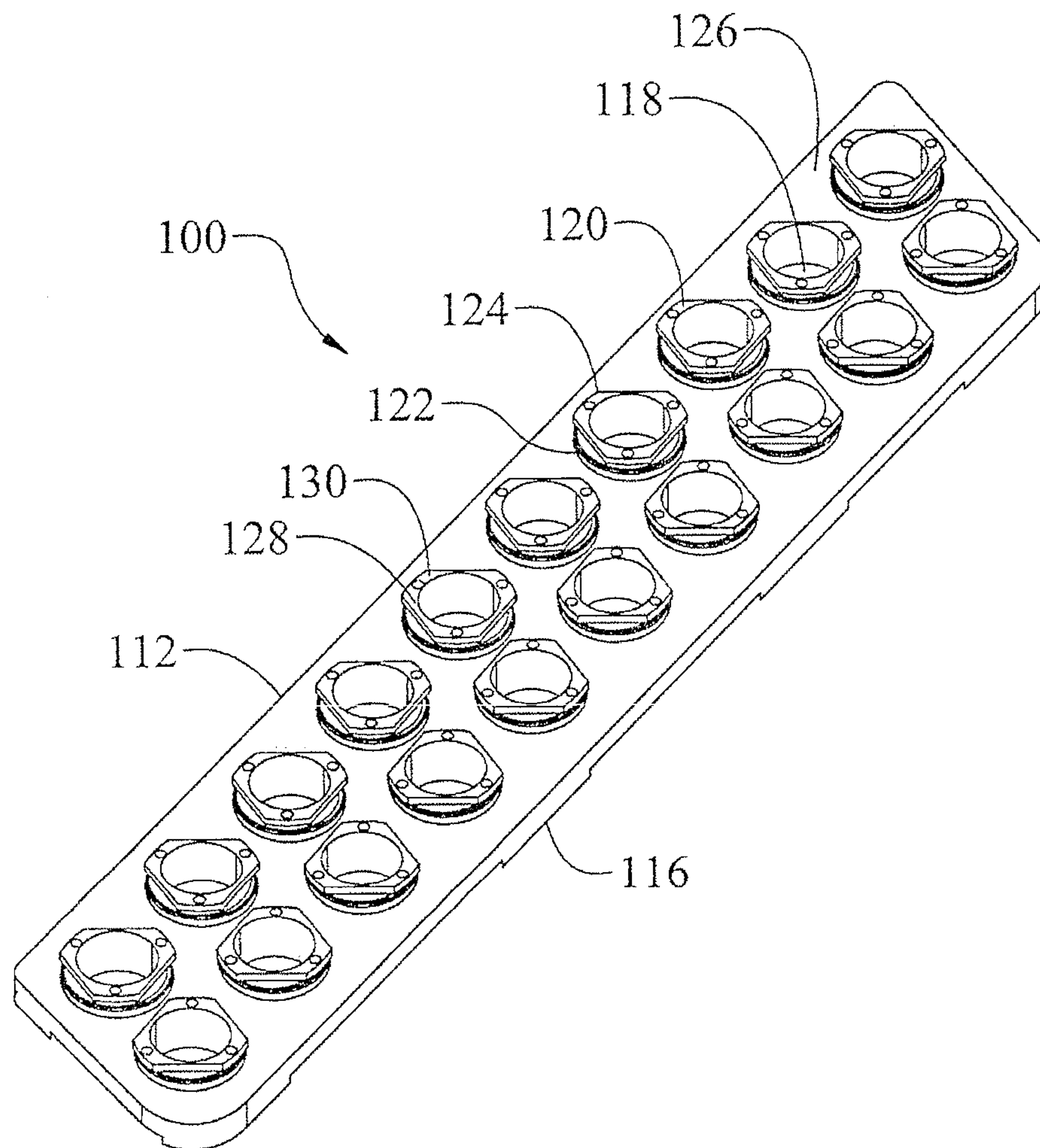


Fig. 2

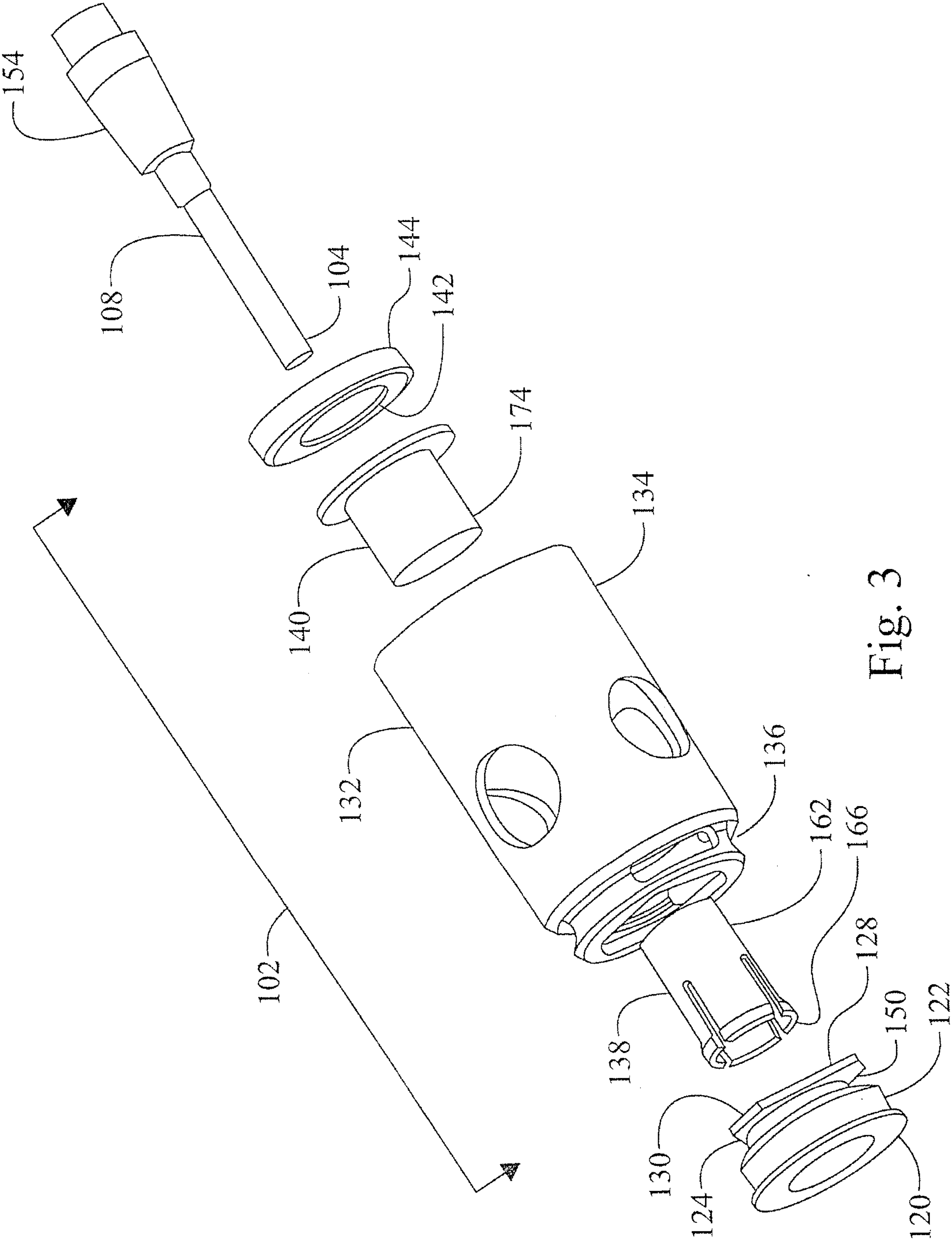


Fig. 3

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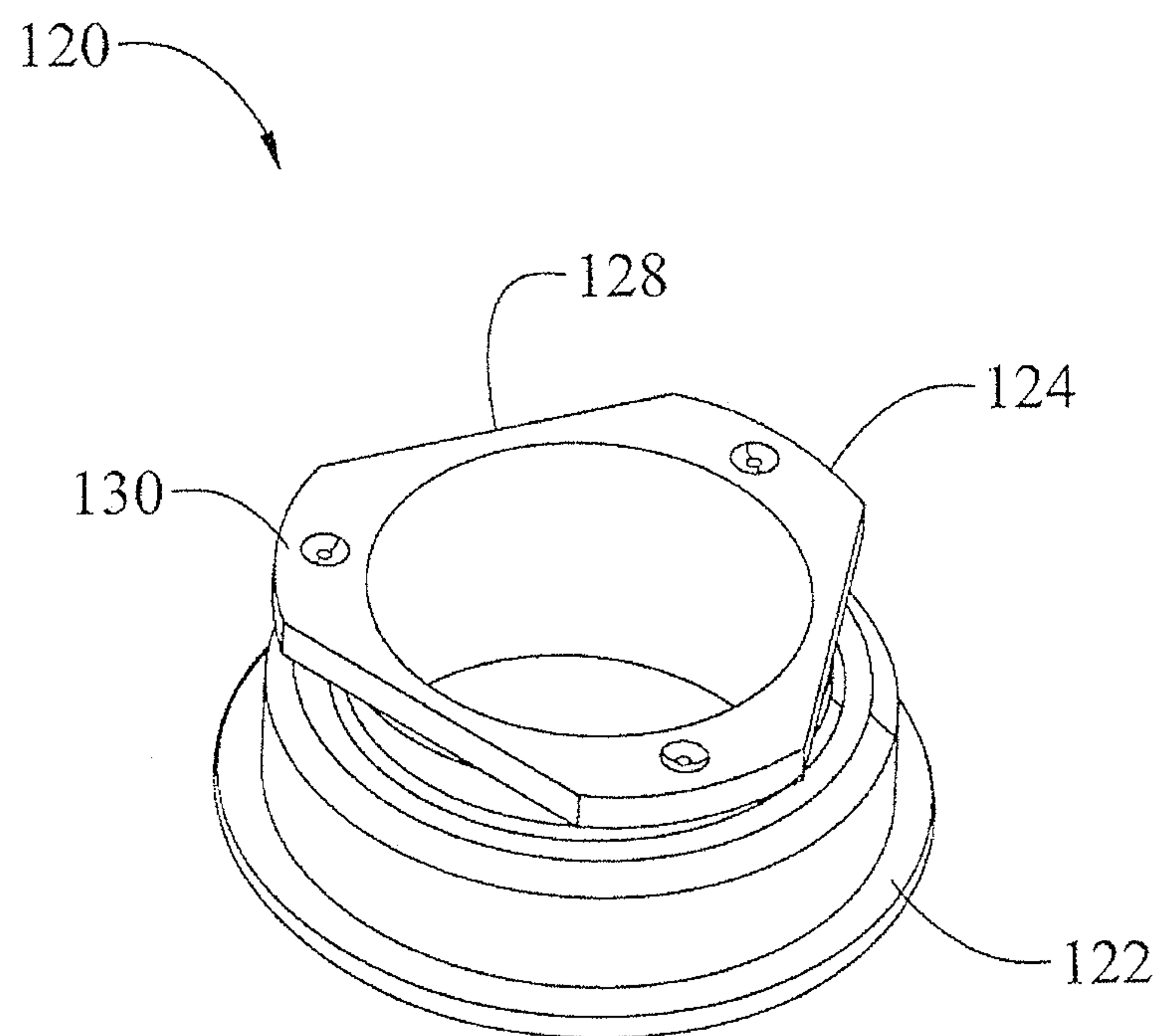


Fig. 4

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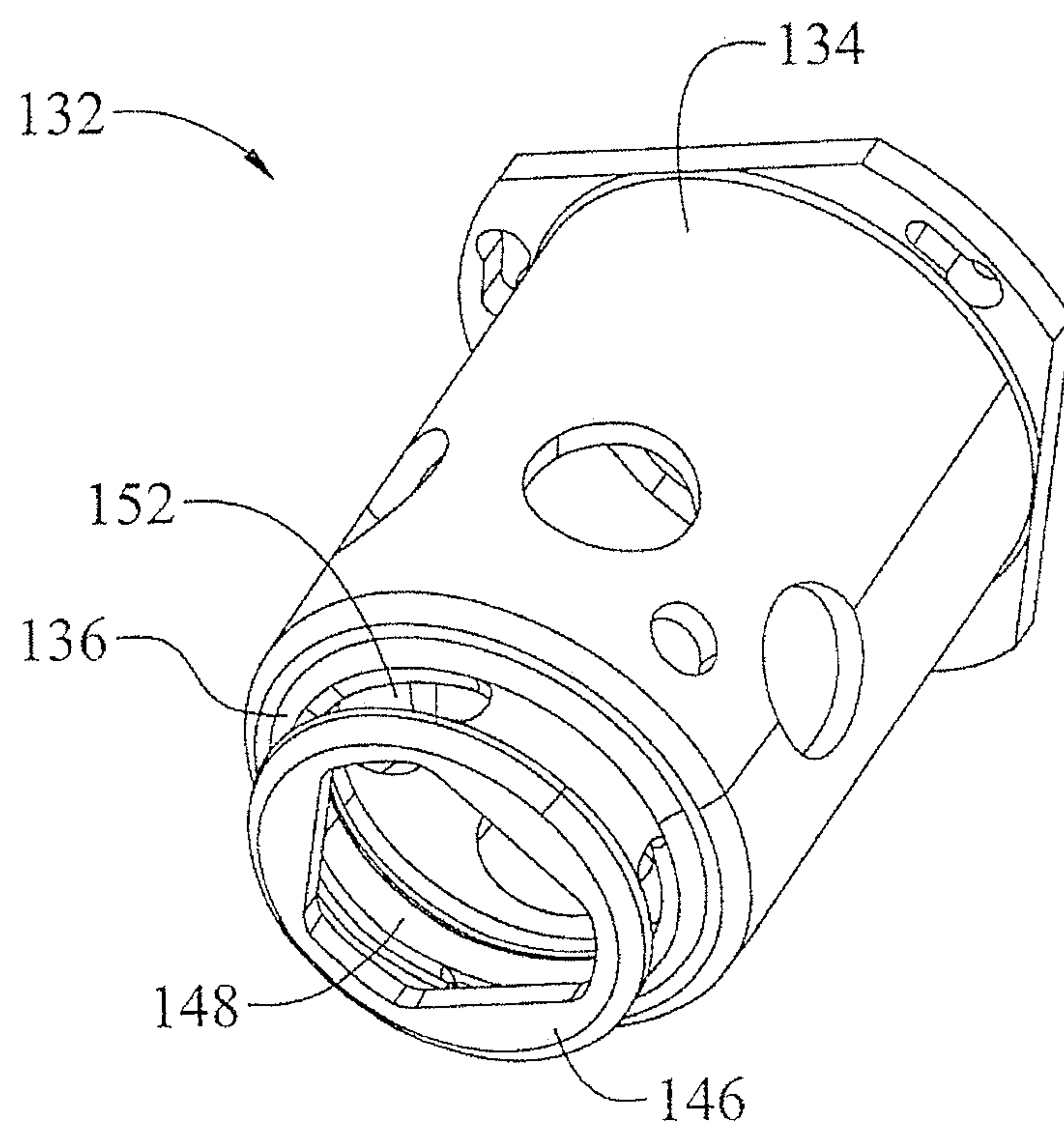


Fig. 5

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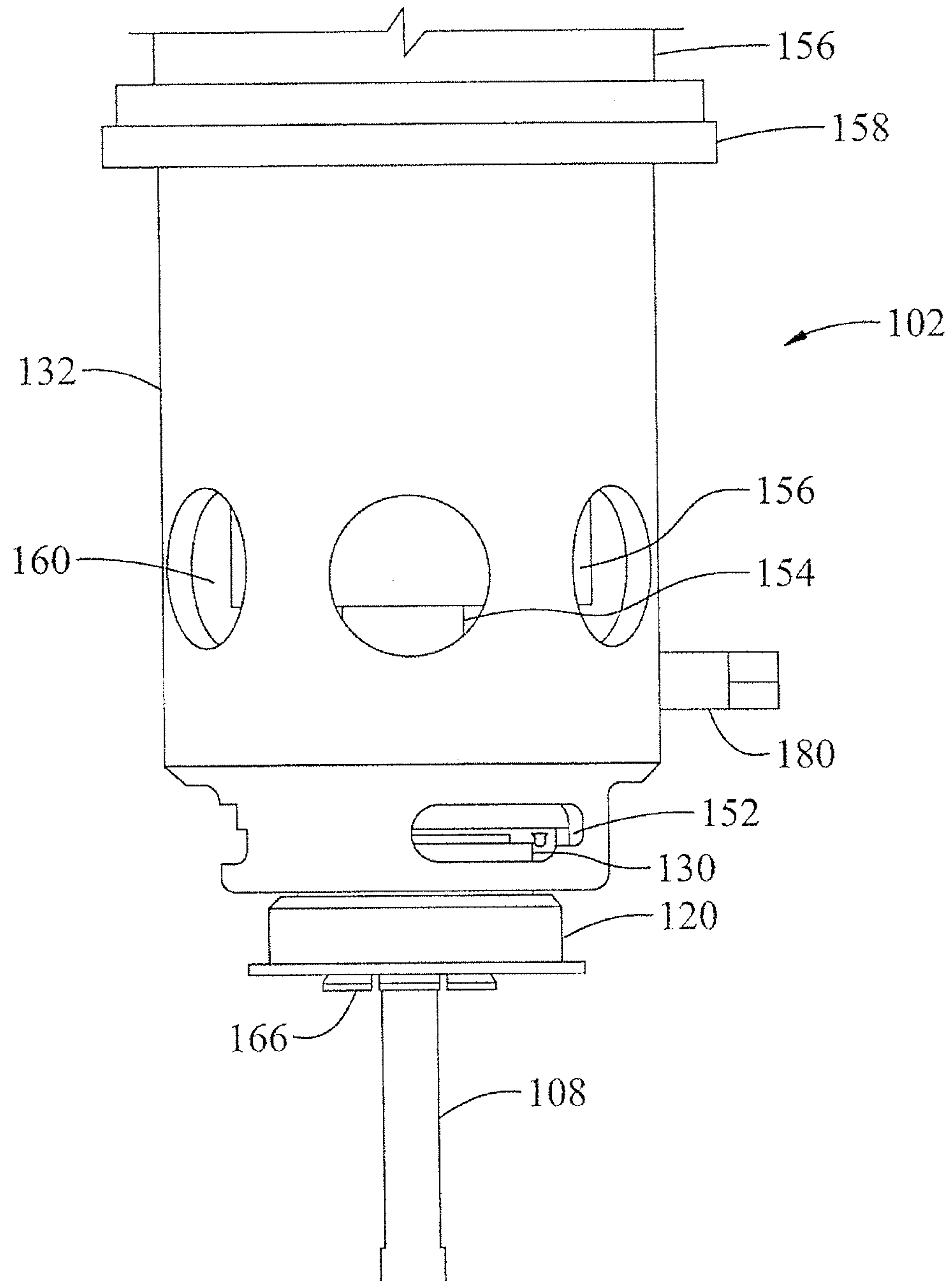


Fig. 6

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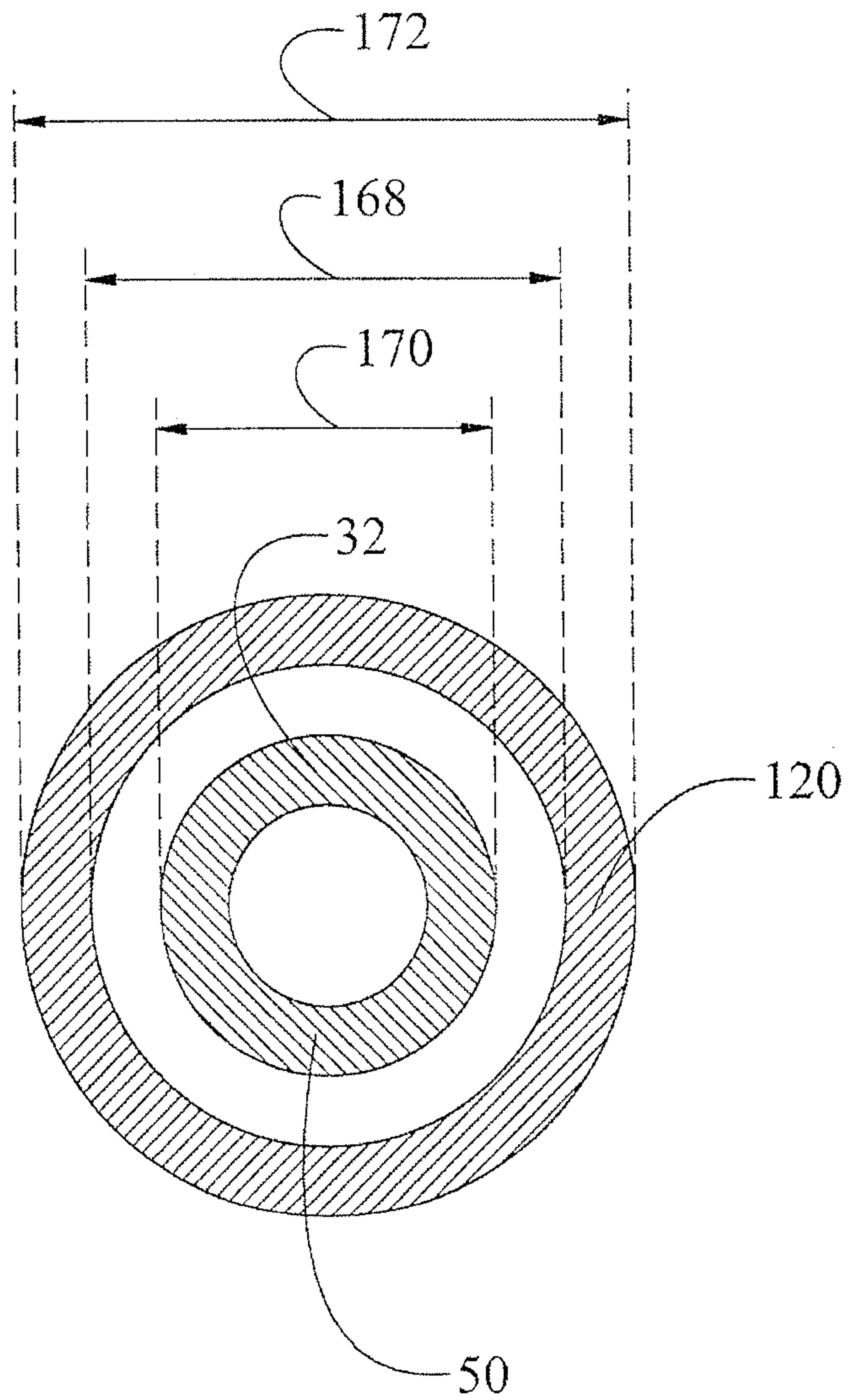


Fig. 8

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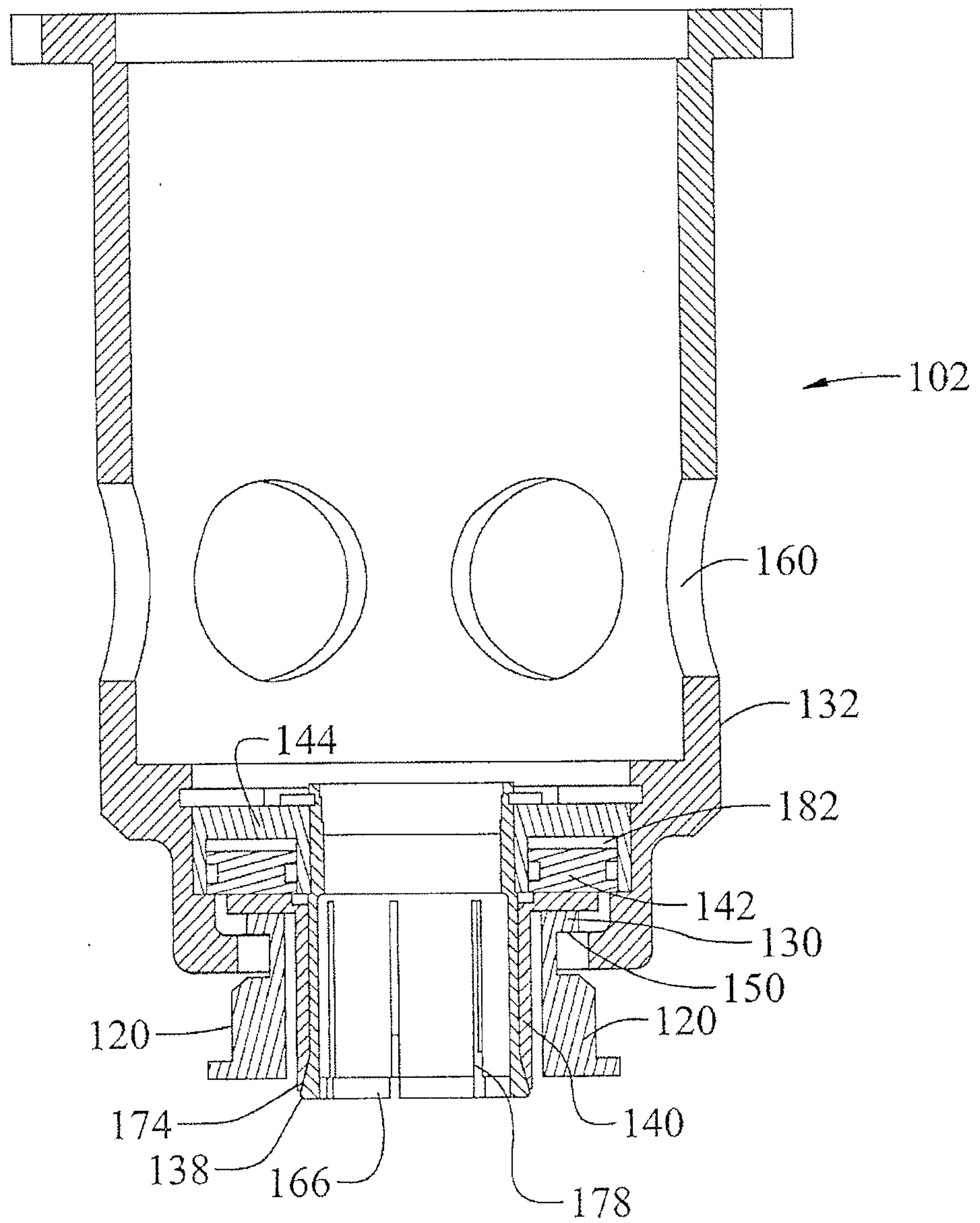


Fig. 9

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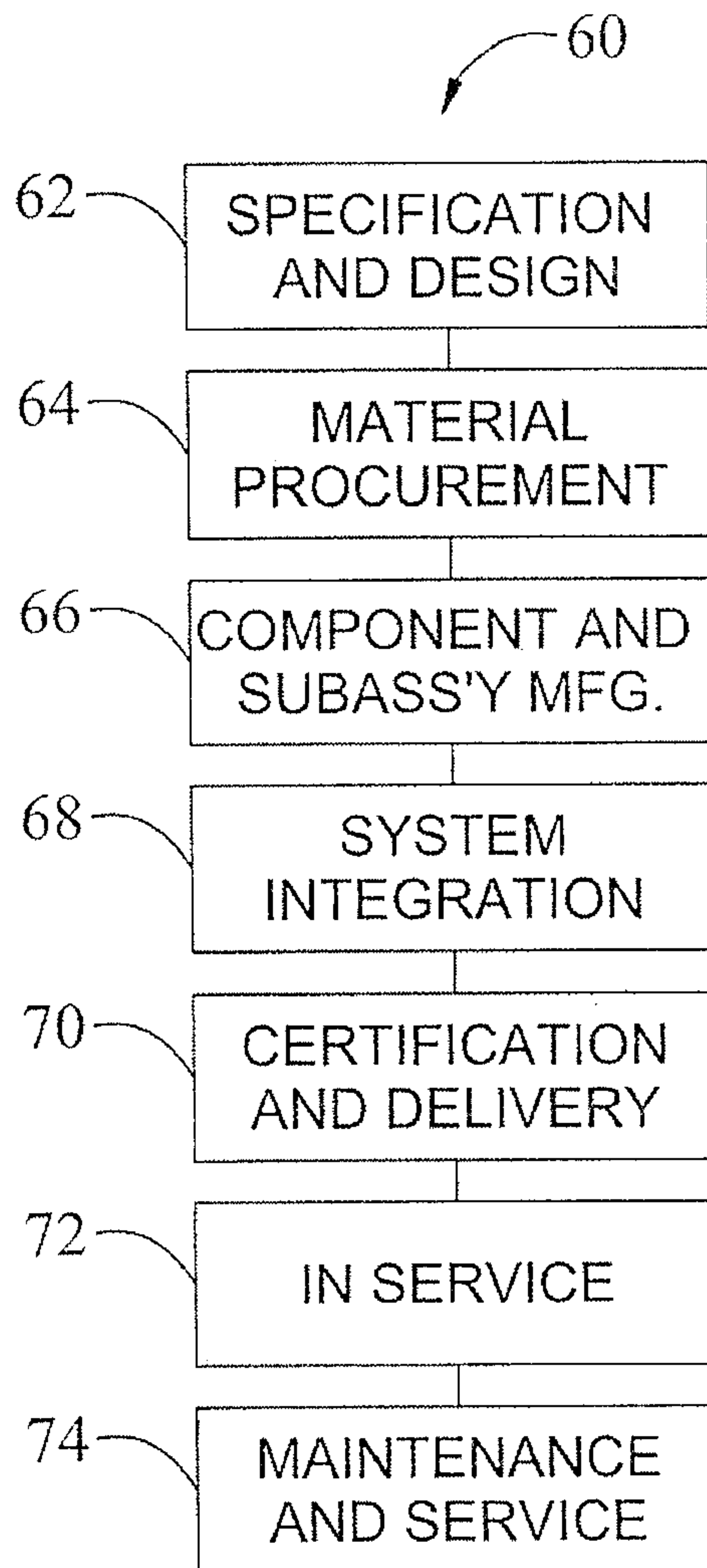


Fig. 10

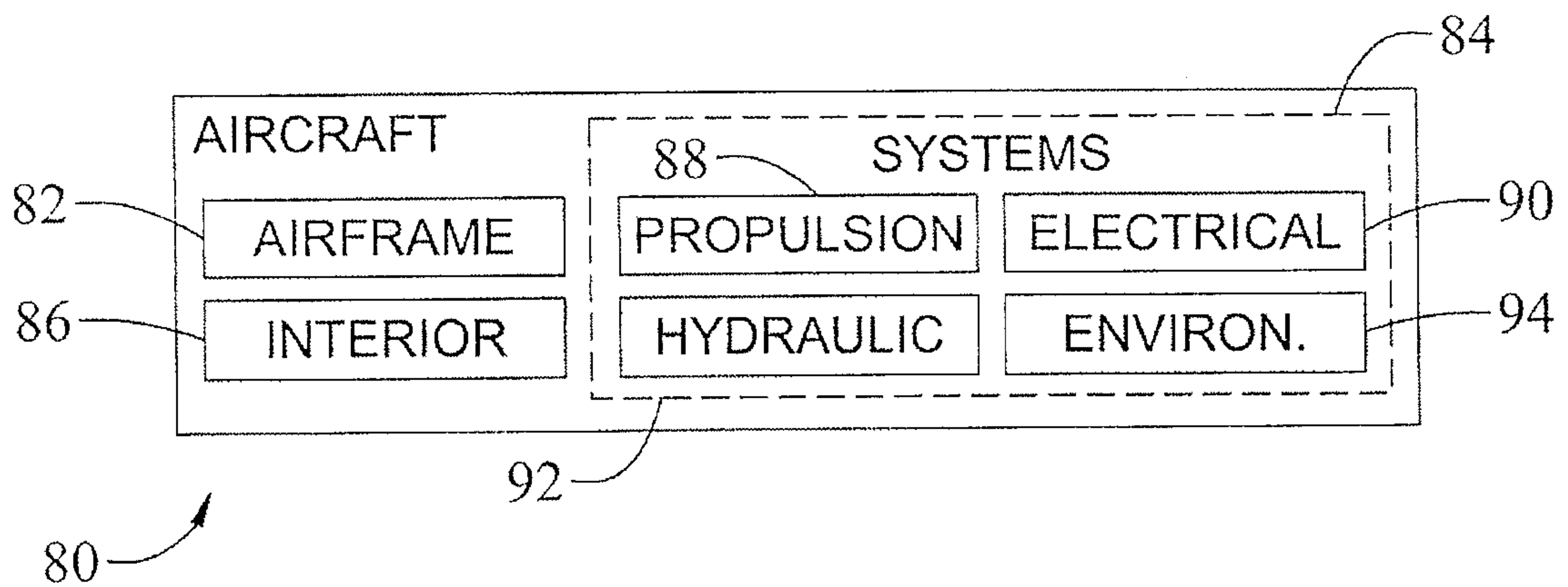


Fig. 11

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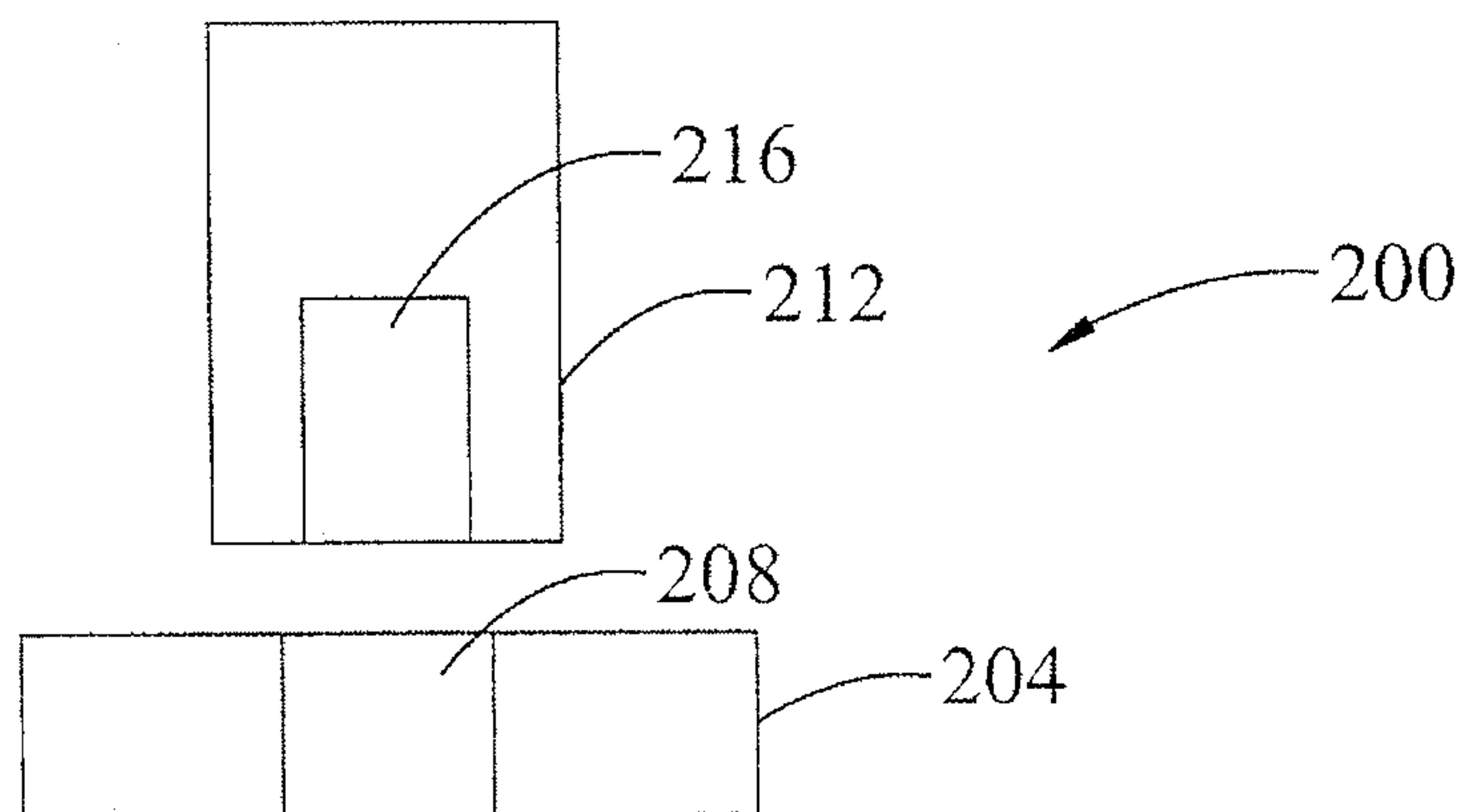


Fig. 12

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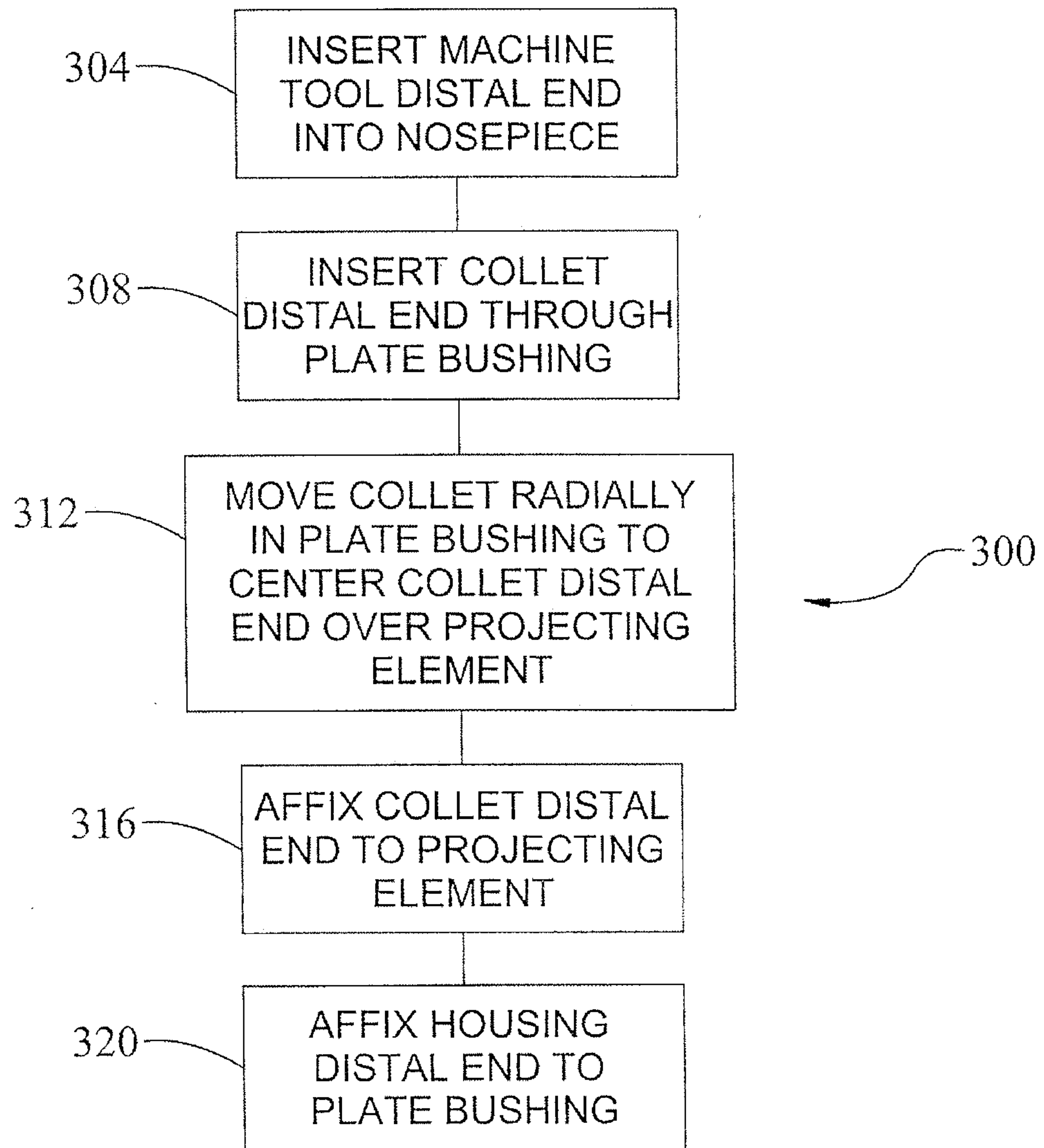


Fig. 13

