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(71) Applicant (for all designated States except US): **THE BOEING COMPANY** [US/US]; 100 North Riverside Plaza, Chicago, Illinois 60606-2016 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **KATZENBERGER, Michael D** [US/US]; 2124 Coldbrook Court, Florissant, Missouri 63031 (US). **CZESCHIN, Ralph D** [US/US]; 26 Brookside Lane, Washington, Missouri 63090 (US). **SLADE, Anthony P** [US/US]; 10 Green Garden Drive, St. Ann, Missouri 63074 (US).

(74) Agents: **HALPERIN, Brett L** et al.; The Boeing Company, P.O. Box 2515, MC 110-SD54, Seal Beach, California 90740-1515 (US).

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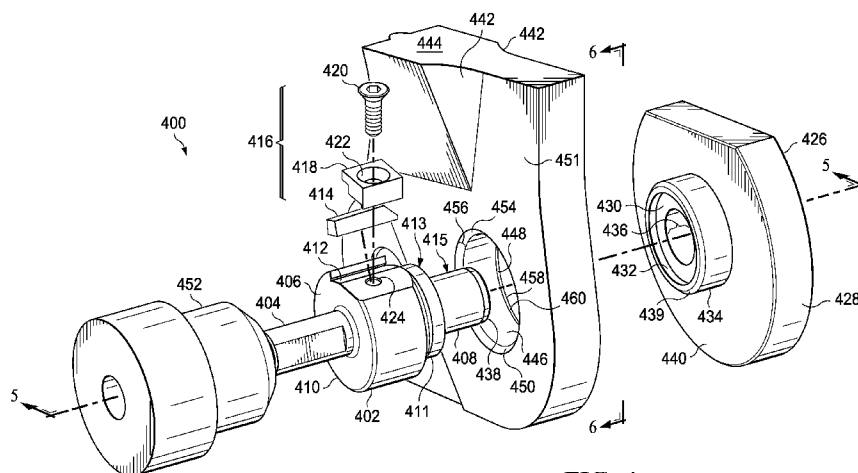


FIG. 4

(57) Abstract: An apparatus may comprise a body, a pilot, a blade, a shaft, and a guide. The body may have a first end and a second end. The pilot may extend from the first end of the body and the blade may be attached to the body and positioned longitudinally on the body at the first end. The shaft may extend from the second end of the body, and the guide may be capable of receiving the pilot.



CHAMFER TOOL

BACKGROUND INFORMATION

5 **1. Field:**

The present disclosure relates generally to manufacturing and, in particular, to cutting tools. Still more particularly, the present disclosure relates to a method and apparatus for producing a chamfer on a part using a cutting tool.

10 **2. Background:**

In manufacturing objects, holes may be formed and/or drilled into and/or through an object. For example, without limitation, a hole may be formed through a wing panel and a spar, such that a fastener may be placed through the hole to secure these parts together. In yet another example, a hole may be formed through a lug in a structure, such as, for example, without
15 limitation, a rib of an aircraft wing. A bearing may be placed into the hole for rotatably attaching other components, such as, for example, without limitation, control surfaces, like flaps.

In forming these types of holes, a chamfer may be created at and/or around one or both ends of the hole. A chamfer may be a bevel and/or groove and may have a flat surface. A chamfer may be created by cutting off an edge of a structure such as, for example, without
20 limitation, an edge of a hole. For example, a chamfer may be created to form a counter-sink for a hole for use in receiving a fastener. A chamfer also may be created in a hole used to receive a part, such as, for example, without limitation, a bearing.

The shape, size, angle, and/or other suitable parameters of a chamfer may be important to provide a proper fit for parts.

25 Accordingly, there is a need for a method and apparatus for increasing the precision at which a chamfer can be made, which overcomes the problems described above.

SUMMARY

In one advantageous embodiment, an apparatus may comprise a body, a pilot, a blade, a shaft, and a guide. The body may have a first end and a second end. The pilot may extend from the first end of the body and the blade may be attached to the body and positioned longitudinally on the body at the first end. The shaft may extend from the second end of the body, and the guide may be capable of receiving the pilot.

In another advantageous embodiment, a chamfer forming system may comprise a body, a pilot, a blade, a shaft, a guide, a clamp, a screw, a drill, and a lug. The body may have a first end, a second end, and a slot formed in the body. The pilot may extend from the first end of the body. The blade may be capable of being secured in the slot and positioned longitudinally on the body at the first end and may be capable of being moved to a selected position of the blade with respect to the first end of the body. The shaft may extend from the second end of the body. The guide may have a housing with a cavity and a ring capable of being placed in the cavity and providing a positive stop, wherein the ring may be capable of receiving an end of the pilot and may be capable of controlling a depth of a chamfer formed by the blade. The clamp and the screw may be capable of securing the blade in the slot. The drill may have a tool holder, wherein the shaft may be capable of being secured in the tool holder. The lug for an aircraft hinge may have a hole, wherein the hole may be capable of receiving the guide at a first end of the hole and the first end of the body with the pilot at a second end of the hole and wherein the pilot may engage the guide.

In yet another advantageous embodiment, a method may be present for forming a chamfer. A guide may be placed into a first end of a hole. A first end of a body having a pilot extending from the end into a first end of the hole may be moved, wherein the pilot may engage the guide and wherein the body may have a blade. The body may be rotated to form the chamfer in the second end of the hole.

In still yet another advantageous embodiment, a method may be present for forming chamfers in a hole in a lug for an aircraft hinge. The method may identify a depth for the chamfer, and select a ring capable of being placed into a cavity in a housing of a guide. The ring may be selected to limit how far a pilot can move into the hole to limit cutting of the chamfer by a blade to a desired depth. The ring may be placed into the cavity in the housing of the guide. The guide having the cavity may be placed into a first end of the hole, and a shaft may be

secured in a tool holder. An end of a body having a pilot extending from the end into a second end of the hole may be moved, wherein the pilot may engage the guide and wherein the body may have the blade. The body may be rotated after the pilot may engage the guide. Rotation of the body may be halted when the guide limits further movement of the guide into the hole to form a first chamfer in the second end of the hole. The guide may be placed into the second end of the hole after forming the first chamfer. The body having the pilot may be moved to the first end of the hole, wherein the pilot may engage the guide placed into the second end of the hole. The body may be rotated after the pilot may engage the guide after moving the body to form a second chamfer in the first end of the hole.

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1. An apparatus comprising:
 - a body having a first end and a second end;
 - a pilot extending from the first end of the body;
 - a blade attached to the body and positioned longitudinally on the body at the first end;
 - 15 a shaft extending from the second end of the body; and
 - a guide capable of receiving the pilot.
2. The apparatus of claim 1, wherein the guide has a stop element capable of controlling a depth of a chamfer formed by the blade.
3. The apparatus of claim 1, wherein the guide comprises:
 - 20 a housing having a cavity; and
 - a positive stop located within the cavity, wherein the positive stop is capable of engaging the stop feature on the body.
4. The apparatus of claim 3, wherein the positive stop is a ring capable of receiving an end of the pilot.
- 25 5. The apparatus of claim 1 further comprising:
 - a slot formed in the body, wherein the slot is capable of receiving the blade.
6. The apparatus of claim 5 further comprising:
 - a fastening system capable of securing the blade within the slot.
7. The apparatus of claim 6, wherein the fastening system comprises:
 - 30 a clamp; and
 - a screw, wherein the clamp and the screw are capable of securing the blade in the slot.
8. The apparatus of claim 1, wherein the blade is capable of being moved to a selected position with respect to the first end of the body.

9. The apparatus of claim 1 further comprising:

a drill having a tool holder, wherein the shaft is capable of being secured in the tool holder.

10. The apparatus of claim 1 further comprising:

a structure having a hole, wherein the hole is capable of receiving the guide at a first end of the hole and the first end of the body with the pilot at a second end of the hole and wherein the pilot engages the guide.

11. The apparatus of claim 10, wherein the structure is a lug for an aircraft hinge.

12. A chamfer forming system comprising:

a body having a first end, a second end, and a slot formed in the body;

a pilot extending from the first end of the body;

a blade capable of being secured in the slot and positioned longitudinally on the body at the first end and capable of being moved to a selected position with respect to the first end of the body;

a shaft extending from the second end of the body;

a guide having a housing with a cavity and a ring capable of being placed in the cavity and providing a positive stop, wherein the ring is capable of receiving an end of the pilot and is capable of controlling a depth of a chamfer formed by the blade;

a clamp;

a screw, wherein the clamp and the screw are capable of securing the blade in the slot;

a drill having a tool holder, wherein the shaft is capable of being secured in the tool holder; and

a lug for an aircraft hinge having a hole, wherein the hole is capable of receiving the guide at a first end of the hole and the first end of the body with the pilot at a second end of the hole and wherein the pilot engages the guide.

13. A method for forming a chamfer, the method comprising:

placing a guide into a first end of a hole;

moving an end of a body having a pilot extending from the end into a first end of the hole, wherein the pilot engages the guide and wherein the body has a blade; and

rotating the body to form the chamfer in the second end of the hole.

14. The method of claim 13, wherein the guide comprises a housing with a cavity and further comprising:

identifying a depth for the chamfer;

selecting a ring capable of being placed into the cavity, wherein the ring is selected to limit how far the pilot can move into the hole to limit cutting of the chamfer by the blade to a desired depth; and

placing the ring into the cavity of the housing.

- 5 15. The method of claim 13, wherein the chamfer is a first chamfer and further comprising:
placing the guide into the second end of the hole after forming the first chamfer;
moving the end of the body having the pilot extending from the end into the first end of the hole, wherein the pilot engages the guide; and
rotating the body to form a second chamfer in the first end of the hole.

- 10 16. The method of claim 13, wherein the rotating step comprises:
rotating the body after the pilot engages the guide.

17. The method of claim 16, wherein the rotating step further comprises:
halting rotation of the body when the guide limits further movement of the guide into the hole to form the chamfer in the second end of the hole.

- 15 18. The method of claim 13, wherein the body has a shaft at an opposite end from the pilot and further comprising:
securing the shaft in a tool holder.

19. The method of claim 13, wherein the hole is located in an aircraft part.

- 20 20. A method for forming chamfers in a hole in a lug for an aircraft hinge, the method comprising:

identifying a depth for the chamfer;

selecting a ring capable of being placed into a cavity in a housing of a guide, wherein the ring is selected to limit how far a pilot can move into the hole to limit cutting of the chamfer by a blade to a desired depth;

- 25 placing the ring into the cavity in the housing of the guide;

placing the guide having the cavity into a first end of the hole;

securing a shaft in a tool holder;

moving an end of a body having a pilot extending from the end into a first end of the hole, wherein the pilot engages the guide and wherein the body has the blade;

- 30 rotating the body after the pilot engages the guide;

halting rotation of the body when the guide limits further movement of the guide into the hole to form a first chamfer in the second end of the hole;

placing the guide into the second end of the hole after forming the first chamfer;

moving the body having the pilot to the first end of the hole, wherein the pilot engages the guide placed into the second end of the hole; and

rotating the body after the pilot engages the guide after moving the body to form a second chamfer in the first end of the hole.

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The features, functions, and advantages can be achieved independently in various embodiments of the present disclosure or may be combined in yet other embodiments in which further details can be seen with reference to the following description and drawings.

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BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the advantageous embodiments are set forth in the appended claims. The advantageous embodiments, however, as well as a preferred mode of use, further objectives and advantages thereof, will best be understood by reference to the following detailed description of an advantageous embodiment of the present disclosure when read in conjunction with the accompanying drawings, wherein:

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Figure 1 is a diagram illustrating an aircraft manufacturing and service method in which an advantageous embodiment may be implemented;

Figure 2 is a diagram of an aircraft in accordance with an advantageous embodiment;

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Figure 3 is a diagram illustrating a chamfer forming system in accordance with an advantageous embodiment;

Figure 4 is a diagram illustrating a chamfer forming system in accordance with an advantageous embodiment;

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Figure 5 is a side view of a chamfer forming system in accordance with an advantageous embodiment;

Figure 6 is a diagram illustrating a front view of a chamfer forming system in accordance with an advantageous embodiment;

Figure 7 is a diagram illustrating a chamfer in accordance with an advantageous embodiment;

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Figure 8 is a diagram illustrating a bearing secured within a hole in accordance with an advantageous embodiment;

Figure 9 is a diagram illustrating setting a chamfer forming system in accordance with an advantageous embodiment; and

Figure 10 is a flowchart of a process for forming chamfers in a hole in accordance with an advantageous embodiment.

DETAILED DESCRIPTION

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Referring more particularly to the drawings, embodiments of the disclosure may be described in the context of aircraft manufacturing and service method **100** as shown in **Figure 1** and an aircraft **102** as shown in **Figure 2**. During pre-production, aircraft manufacturing and service method **100** may include specification and design **104** of aircraft **102** and material procurement **106**.

10

During production, component and subassembly manufacturing **108** and system integration **110** of aircraft **102** takes place. Thereafter, aircraft **102** may go through certification and delivery **112** in order to be placed in service **114**. While in service by a customer, aircraft **102** is scheduled for routine maintenance and service **116** (which may also include modification, reconfiguration, refurbishment, and so on).

15

Each of the processes of aircraft manufacturing and service method **100** 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 include, without limitation, any number of aircraft manufacturers and major system subcontractors; a third party may include, for example, 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.

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As shown in **Figure 2**, aircraft **102** produced by aircraft manufacturing and service method **100** may include airframe **118** with a plurality of systems **120** and interior **122**.

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Examples of systems **120** include one or more of propulsion system **124**, electrical system **126**, hydraulic system **128**, and environmental system **130**. Any number of other systems may be included in this example. Although an aerospace example is shown, the principles of the disclosure may be applied to other industries, such as the automotive industry.

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Apparatus and methods embodied herein may be employed during any one or more of the stages of aircraft manufacturing and service method **100**. For example, without limitation, components or subassemblies corresponding to component and subassembly manufacturing **108** may be fabricated or manufactured in a manner similar to components or subassemblies produced while aircraft **102** is in service.

Also, one or more apparatus embodiments, method embodiments, or a combination thereof may be utilized during component and subassembly manufacturing **108** and system integration **110**, for example, without limitation, by substantially expediting assembly of or reducing the cost of aircraft **102**.

5 Similarly, one or more of apparatus embodiments, method embodiments, or a combination thereof may be utilized while aircraft **102** is in service, for example, without limitation, to maintenance and service **116**. As a specific example, an advantageous embodiment may be implemented during component and sub-assembly manufacturing **108** to create chamfers in holes in lugs for receiving bearings for use in trailing edge flaps for aircraft **102**.

10 The different advantageous embodiments recognize and take into account that some buildups between parts may have large tolerances. In some cases, however, the tolerance may need to be tighter and/or more stringent to provide for a proper fit. For example, without limitation, bearings used for trailing edge flaps in an aircraft may require a higher tolerance than other components. For example, without limitation, the chamfer for a hole may have a tolerance
15 of around plus or minus 0.0020 of an inch (20/1,000's) for a bearing that is to be placed into the hole.

The different advantageous embodiments recognize and take into account that variables and tolerances may require depths of chamfers and holes to be checked for each individual piece in a structure on which chamfers are used. When large production runs are required, the
20 different advantageous embodiments recognize and take into account that this type of process may become a tedious and time-consuming operation. The different advantageous embodiments recognize and take into account that currently used tool systems may precisely set depths for chamfers, but these depths may be based on a measurement of the depth with respect to the part.

Thus, the different advantageous embodiments provide a method and apparatus for
25 forming chamfers and parts. In one advantageous embodiment, a body may have a first end and a second end. A pilot may extend from the first end of the body. Further, the apparatus may include a blade attached to the body and positioned on the body at the first end. A shaft may extend from a second end.

A guide also may be present that may be capable of receiving the pilot. In these
30 examples, the guide may be capable of providing a positive stop for controlling the depth of a chamfer formed by the blade in a hole. The guide also may be used to set a position for the blade positioned on the body.

These different advantageous embodiments may not require adjusting the depth relative to a part. Instead, the depth may be pre-set once using the guide to provide a fixed and repeatable depth for multiple numbers of chamfers formed in different holes.

With reference now to **Figure 3**, a diagram illustrating a chamfer forming system is depicted in accordance with an advantageous embodiment. In this example, chamfer forming system **300** includes body **302** with shaft **304** extending from second end **306** of body **302**. Pilot **308** extends from first end **310** of body **302**.

Body **302**, shaft **304**, and pilot **308** may be formed integrally as a single component. In other advantageous embodiments, shaft **304** and/or pilot **308** may be attached to body **302**. This attachment may be performed using various processes such as, for example, without limitation, welding, fasteners, adhesives, and/or some other suitable process for attaching components to each other.

In these examples, body **302**, shaft **304**, and pilot **308** may be constructed from various materials. The selected material for these components may be one that provides a capability to hold up during a chamfer forming process. The material may be, for example, without limitation, steel, aluminum, titanium, plastic, or some other suitable material.

Further, body **302** may have slot **312**. Blade **314** may be a removable blade that may fit within slot **312**. Blade **314** may be secured within slot **312** in a particular position using fastening system **315**. In these examples, fastening system **315** may include clamp **316** and screw **318**. Additionally, chamfer forming system **300** also may include guide **320**. Guide **320** may have housing **322** and ring **324**. Ring **324** may fit into cavity **326** of housing **322**. In these examples, end **328** of pilot **308** may fit into hole **323** in ring **324**. Ring **324** may provide stop element **329** to limit movement of pilot **308** into ring **324**. Stop feature **333** in body **302** may engage stop element **329** as shown by arrow **327** in limiting movement of pilot **308** into ring **324**.

Ring **324** may have depth **330**. Depth **330** may be selected to determine when stop element **329** engages stop feature **333** in these examples, as illustrated by arrow **327**. Depth **330** may correspond to depth **331** forming first chamfer **332** within hole **334** of structure **336**. Hole **334** may have first end **335** and second end **337**. Stop element **329** takes the form of positive stop **325** in these examples.

Depending on the desired depth for first chamfer **332**, depth **330** of ring **324** may be changed by selecting another ring for ring **324**. By changing depth **330**, the distance pilot **308** travels through hole **334** before stop feature **333** engages stop element **329** may be changed. In

other advantageous embodiments, ring **324** may be fixed within housing **322**. In this type of embodiment, a new guide in place of guide **320** may then be selected for a different chamfer.

Structure **336** in this example may be lug **338** for an aircraft part. In particular, lug **338** may be, for example, without limitation, a lug for an aircraft hinge.

5 Guide **320** may be placed against side **340** of structure **336**. First end **310** with pilot **308** extending from first end **310** may be placed into hole **334** from side **342**, opposite side **340**, through first end **335** of hole **334**. In this manner, pilot **308** may engage and/or be received into ring **324** of guide **320**.

10 Shaft **304** may be placed into tool holder **344** in drill **346**. Tool holder **344** may be attached to spindle **343**, which may be attached to motor **350**. Tool holder **344** may be, for example, without limitation, a chuck. Drill **346** may rotate body **302** with blade **314** in a manner to cut and slash or form first chamfer **332**. As first chamfer **332** is being cut for hole **334**, pilot **308** may move further into ring **324**.

15 At some point, stop feature **333** in body **302** may engage stop element **329** in ring **324**. This engagement may occur when pilot **308** moves a distance of depth **330** into ring **324**. At this point, first chamfer **332** may be complete and body **302** with pilot **308** may be disengaged from guide **320** and used to form another chamfer in another hole. In some advantageous embodiments, guide **320** may then be placed against side **340** to form a second chamfer. A second chamfer, such as second chamfer **351** with angle **353** may be formed in structure **336** on
20 side **340** by rotating body **302** with pilot **308** to engage guide **320** from side **340**.

In these different advantageous embodiments, blade **314** may be set to an appropriate position within slot **312** using setting ring **352**. Setting ring **352** may have depth **354**, which may be around the same distance as depth **331** for hole **334** in structure **336**. Further, setting ring **352** also may include chamfer **356**, which may have a shape, position, size, and/or orientation that
25 may be around the same as first chamfer **332**.

Pilot **308** may be placed through setting ring **352** into guide **320**. Blade **314** may be set into selected position **358** within slot **312** in this configuration. Angle **303** in first chamfer **332** may be controlled by selecting angle **301** for blade **314**. Further, setting ring **352** may be used to check the position of blade **314** between and/or during chamfer forming operations to ensure that
30 a change in the position of blade **314** has not occurred to make first chamfer **332** out of tolerance. Also, this check may be made to determine whether blade **314** has worn from use such that first chamfer **332** may differ in size, depth, orientation, or some other suitable parameter from the desired settings.

The illustration of chamfer forming system **300** in **Figure 3** is provided for purposes of illustrating different features for different advantageous embodiments. This illustration is not meant to imply physical or architectural limitations in a manner in which different advantageous embodiments may be implemented. For example, in other advantageous embodiments, guide
5 **320** may not use ring **324**. Instead, cavity **326** may be configured to receive end **328** of pilot **308** and have depth **330** for controlling the depth of first chamfer **332**.

In yet other advantageous embodiments, blade **314** may be adjusted to aid in setting depth **331** for first chamfer **332**. The adjustment of blade **314** may be performed using guide **320** to set blade **314** at the desired location within spot **312** to cut depth **331** for first chamfer **332**. As
10 yet another example, stop feature **333** may be on pilot **308** rather than body **302**.

With reference now to **Figure 4**, a diagram illustrating a chamfer forming system is depicted in accordance with an advantageous embodiment. In this example, chamfer forming system **400** is an example of one implementation of chamfer forming system **300** in **Figure 3**. In this example, chamfer forming system **400** includes body **402**. Body **402** may have shaft **404**
15 extending from end **406**. In this example, pilot **408** extends from end **410** of body **402**. Body **402** may include stop feature **411**. Stop feature **411** may be a portion of pilot **408** having a wider diameter at section **413** of body **402** as compared to section **415** of pilot **408**.

In this example, shaft **404** and pilot **408** may be formed as an integral part of body **402**. In other advantageous embodiments, these components may be attached to body **402** through
20 various processes, such as, for example, without limitation, bonding, welding, and some other suitable attachment process. Body **402**, shaft **404**, and/or pilot **408** may be made from various materials. The particular material selected may depend on the hardness needed for these components. These materials may be, for example, without limitation, formed from steel, titanium, aluminum, alloy tool steels, or some other suitable materials.

In this example, body **402** may have slot **412** which may be formed radially into body **402**. Blade **414** may be placed into slot **412** such that blade **414** may be positioned
25 longitudinally along body **402**.

Blade **414** may be formed from various materials. For example, without limitation, blade **414** may be formed using steel, titanium, high speed steel, carbide, or some other suitable
30 material. Further, blade **414** may be tempered, case hardened, diamond coated, or otherwise treated. The particular material selected for blade **414** may differ depending on the particular material into which a chamfer may be formed.

In this example, fastening system **416** may secure blade **414** within slot **412**. Fastening system **416** may be comprised of clamp **418** and screw **420**. Screw **420** may secure clamp **418** to blade **414** on body **402** when screw **418** may be placed through hole **422** in clamp **418** and secured within hole **424** in body **402**. In this illustrated example, hole **424** may be a threaded hole.

Chamfer forming system **300** also may include guide **426**. Guide **426** may include housing **428** and ring **430**. In this example, ring **430** fits within cavity **432** of housing **426**. Cavity **432** may be formed through extension **434** in housing **428**. In this example, ring **430** may be a bushing and may have depth **436**. Ring **430** may receive end **438** of pilot **408**. Surface **439** of ring **430** forms stop element **329** in these examples. Surface **439** may engage section **413** of body **402** to prevent pilot **408** from moving further into ring **430**. Section **413** in pilot **408** may be an example of stop feature **333** in **Figure 3**.

In operation, side **440** of guide **426** may be placed against side **442** of structure **444**. This placement results in extension **434** of guide **426** being placed into hole **446**. In this manner, extension **434** of guide **426** may be placed into end **448** of hole **446**. End **438** of pilot **408** may be placed into end **450** of hole **446** on side **451** of structure **444** and **438 of pilot 408** may engage ring **430** within cavity **432**.

Shaft **404** may be secured or engaged in tool holder **454**. Rotation of shaft **404** causes body **402** with blade **414** to cut chamfer **454** within hole **446**. Chamfer **454** may have depth **456**, which may be controlled by depth **436** in ring **430**. In these examples, depth **436** and depth **456** may have the same value. As blade **414** cuts into end **450** of hole **446**, end **438** of pilot **408** moves farther into ring **430**. Once pilot **408** may have traveled depth **436**, section **413** of body **402** engages surface **439**, and pilot **408** no longer moves deeper into hole **446**. In this manner, depth **456** for chamfer **454** may be controlled.

If a new value is needed for depth **456**, a new ring **430** may replace ring **430** and have a new depth, and may be placed into cavity **432**.

In a similar fashion, guide **426** may be placed into end **450** of hole **446** and end **410** with pilot **408** extending from end **410** may be placed into end **448** of hole **446** to cut and form chamfer **458** with depth **460**.

With reference now to **Figure 5**, a side view of a chamfer forming system is depicted in accordance with an advantageous embodiment. In this figure, chamfer forming system **400** is shown in a cutaway and/or partially exposed view taken along lines **5-5** in **Figure 4**.

In this example, pilot **408** in chamfer forming system **400** may have hole **500**. Hole **500** may receive and engage engaging member **504**, which may extend from wall **506** of cavity **432** in housing **428** of guide **426**. In this view, pilot **408** may be fully engaged into ring **430** within housing **428**. As can be seen, ring **430** may provide a positive stop through surface **439** (not shown on **Figure 5**) to control depth **456** in **Figure 4** in chamfer **454**.

Chamfer forming system **400** in **Figures 4** and **5** illustrate shaft **404**, body **402**, pilot **408**, and guide **426**, each of which may have any of a number of possible lengths, depending on the particular implementation. In these examples, shaft **404** may have a length of around one inch and body **402** also may have a length of around one inch. In addition, pilot **408** may be received by and housed in guide **426**. Guide **426** may have a total length of around 0.7 inches. Chamfer forming system **400** may have a total length of around 2.7 inches. These examples are not intended to provide limitations to the manner in which other advantageous embodiments may be implemented. For example, in other advantageous embodiments, chamfer forming system **400** may have other suitable sizes contemplated for a particular chamfer, structure, or other suitable consideration in forming chamfers.

The illustration of chamfer forming system **400** in **Figures 4** and **5** have been presented for purposes of illustrating one manner in which an advantageous embodiment may be implemented. This illustration is not meant to imply physical or architectural limitations to the manner in which other advantageous embodiments may be implemented.

For example, without limitation, surface **439** may function as stop element **329** in ring **430**, while section **413** functions as stop feature **333** that engages stop element **329**. In other advantageous embodiments, other features may be used to implement stop feature **333** and stop element **329**. Also, rather than using surface **439**, a wall in housing **428** may provide stop element **329**, while end **438** on pilot **408** may function as stop feature **333**. When end **438** reaches a wall within housing **428**, pilot **408** may stop moving through hole **446**. Of course, other advantageous embodiments may employ other types of stop features and/or stop elements. In yet another advantageous embodiment, a blade in addition to blade **414** may be used and positioned on body **402** in any suitable location by any suitable means.

With reference now to **Figure 6**, a diagram illustrating a front view of a chamfer forming system is depicted in accordance with an advantageous embodiment. In **Figure 6**, the front view of chamfer forming system **400** is taken along lines **6-6**. In this example, pilot **408**, stop feature **411**, and body **402** in chamfer forming system **400** in **Figures 4** and **6** may be seen. Each of these components may have any of a number of possible diameters.

For example, without limitation, pilot **408** may have diameter **602** which may be around 0.625 inches; section **413** of pilot **408** may have diameter **604** which may be around 1.0 inches; and body **402** may have diameter **606** which may be around 1.31 inches. These exemplary diameters are provided for purposes of illustrating one implementation of chamfer forming system **400**. For example, without limitation, the diameter of section **413** of pilot **408** may be varied depending on the diameter of hole **446**. Other advantageous embodiments may have other suitable sizes and/or diameters contemplated for creating chamfers for other sizes of hole **446**.

In these illustrative examples, length **507** in **Figure 5** of pilot **408** may vary depending on the thickness of structure **444** and/or diameter **602** of pilot **408** may vary depending on the diameter of hole **446**. For example, without limitation, a diameter of around 0.625 inches for section **413** may be used in hole **446** having a diameter of around 0.625 inches. In some advantageous embodiments, pilot **408** may have more than one diameter to allow for pilot **408** to be used with different sized holes.

With reference now to **Figure 7**, a diagram illustrating a chamfer is depicted in accordance with an advantageous embodiment. In this example, hole **446** includes chamfer **454** on end **450** and chamfer **458** on end **448**. Bearing **700** may be placed into end **458** of hole **446**. In this example, bearing **600** may be a mono-ball bearing, which may be part of a structure such as, for example, without limitation, a trailing edge flap assembly and/or any type of flanged bearing which may require staking to provide a positive location for installation.

With reference now to **Figure 8**, a diagram illustrating a bearing **700** secured within hole **446** is depicted in accordance with an advantageous embodiment. In this example, bearing **700** may be at least partially retained within hole **446** by forming lip **800** of bearing **700** over chamfer **454**. Lip **800** may be formed over chamfer **454** by crimping, staking, or otherwise forming lip **800** over chamfer **454**. This process may prevent migration of bearing **700** within hole **446**.

If chamfer **454** does not have a desired value for depth **456** (not shown), then bearing **700** may not form a fit within tolerance to structure **444**. The desired value of chamfer **454** may include, for example, without limitation, angle **303**, which may correspond to angle **301** for blade **314**. In these examples, structure **444** may take various forms. For example, without limitation, structure **444** may be, for example, a lug, a clevis, or some other suitable structure for receiving bearing **700**.

With reference now to **Figure 9**, a diagram illustrating setting a chamfer forming system is depicted in accordance with an advantageous embodiment. In this example, blade **414** in chamfer forming system **400** may be set to an appropriate depth to cut a desired chamfer within a

part. In this example, setting ring **900** provides a capability to set blade **414**. Setting ring **900** may have chamfer **902** and depth **904**. Depth **904** may be a depth that may be around the same depth as structure **444** (not shown) at which hole **446** (not shown) is located. Chamfer **902** may mimic or may be around the same depth and orientation as chamfer **454** (not shown). Pilot **408** may be placed through setting ring **900** into guide **426** to set blade **414**.

In addition to being used to set blade **414**, setting ring **900** also may be used to check blade **414** during chamfer forming operations. This check may be made to ensure that the position of blade **414** and/or wear that may occur on blade **414** does not change a chamfer that may be formed using chamfer system **400**. In these examples, the position may be relative to setting ring **900**.

With reference now to **Figure 10**, a flowchart of a process for forming chamfers in a hole is depicted in accordance with an advantageous embodiment. The process illustrated in **Figure 10** may be implemented using chamfer forming system **300** in **Figure 3**.

The process may begin by identifying a depth for first chamfer **332** for hole **334** (operation **1000**). Thereafter, the process may select setting ring **352** (operation **1002**). Setting ring **352** may have a depth that may be used to control the depth of the chamfer. Setting ring **352** may be used to set the position of blade **314** (operation **1004**).

Guide **320** may be placed into second end **337** of hole **334** (operation **1006**). Shaft **304** may be secured to tool holder **344** for drill **346** (operation **1008**). The process then may move first end **310** of body **302** having pilot **308** extending from first end **310** into first end **335** of hole **334** (operation **1010**).

Body **302** may be rotated after pilot **308** engages guide **320** (operation **1012**). In operation **1012**, pilot **308** may engage ring **334** placed into cavity **326** of guide **320**. The process may then move pilot **308** further into hole **334** (operation **1014**). The movement of pilot **308** further into hole **334** causes blade **314** to cut first chamfer **332** into the side of hole **338**. The rotation of body **302** may be halted when guide **320** limits further movement of pilot **308** into hole **334** (operation **1016**).

When pilot **308** is no longer capable of being moved further into hole **334**, first chamfer **332** may be complete with the desired depth and chamfer angle. The process may then place guide **320** into first end **335** of hole **334** after forming first chamfer **332** (operation **1018**). The process may move first end **310** of body **302** having pilot **308** extending from first end **310** into second end **337** of hole **334** (operation **1020**). Body **302** is rotated after pilot **308** engages guide **320** to form second chamfer **351** in second end **337** of hole **334** (operation **1022**).

The process may move pilot **308** further into hole **334** while body **302** rotates (operation **1024**). Guide **320** may then halt rotation of body **302** by limiting further movement of pilot **308** into hole **334** (operation **1026**), with the process terminating thereafter. When pilot **308** is no longer capable of being moved further into hole **334**, first chamfer **332** may be complete with the
5 desired depth and chamfer angle.

The illustration of the different operations in **Figure 10** are provided as an example of one manner in which a chamfer may be created using a chamfer forming system in accordance with an advantageous embodiment. In other implementations, other operations may be used in addition to or in place of the ones illustrated. Further, operations also may be performed in a
10 different order.

For example, without limitation, operation **1008** may be performed after operation **1010** or may be performed prior to operation **1006** in these examples. As yet another example, operations **1006**, **1010**, **1012**, **1014**, and **1016** may be performed on an opposite end of the hole to create a second chamfer such that the hole may have a chamfer on either end. Further,
15 operations **1000**, **1002**, and **1004** may be performed for the second chamfer if a different depth is desired.

Thus, the different advantageous embodiments provide a method and apparatus for forming a chamfer. In the different advantageous embodiments, a replaceable blade may allow an operator to quickly replace a cutting edge during the forming of a chamfer and/or between
20 forming chamfers. Further, the guide provided in the different advantageous embodiments may have a set depth allowing an operator to set the proper depth of a cut whenever a blade replacement may be needed. Further, this feature also allows for a quick setting of the blade without having to perform measurements.

Thus, the different advantageous embodiments may not require checking a blade prior to
25 cutting a chamfer. With the use of the ring and the removable blade, the different advantageous embodiments provide a capability to ensure that a proper depth is set for a blade whenever a blade replacement may occur or to just check the depth of the current setting.

The description of the different advantageous embodiments has been presented for purposes of illustration and description, and is not intended to be exhaustive or limited to the
30 embodiments in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art. For example, without limitation, other different advantageous embodiments have been shown with respect to creating chamfers in a hole for a bearing in an

aircraft part. Other advantageous embodiments may be applied to other manufacturing processes for other types of structures.

For example, without limitation, the different advantageous embodiments may be applied to creating chamfers and/or countersinks for holes for fasteners used to join parts to each other.

- 5 These chamfers may be for parts in structures such as, for example, without limitation, a car, a building, a car plant, a spacecraft, or some other suitable structure. Further, different advantageous embodiments may provide different advantages as compared to other advantageous embodiments.

- 10 The embodiment or embodiments selected are chosen and described in order to best explain the principles of the embodiments, the practical application, and to enable others of ordinary skill in the art to understand the disclosure for various embodiments with various modifications as are suited to the particular use contemplated.

CLAIMS:

What is claimed is:

5

1. An apparatus comprising:
a body having a first end and a second end;
a pilot extending from the first end of the body;
a blade attached to the body and positioned longitudinally on the body at the first end;
10 a shaft extending from the second end of the body; and
a guide capable of receiving the pilot.

15

2. The apparatus of claim 1, wherein the guide has a stop element capable of controlling a depth of a chamfer formed by the blade.

20

3. The apparatus of claim 1, wherein the guide comprises:
a housing having a cavity; and
a positive stop located within the cavity, wherein the positive stop is capable of engaging
the stop feature on the body.

25

4. The apparatus of claim 3, wherein the positive stop is a ring capable of receiving an end of the pilot.

5. The apparatus of claim 1 further comprising:
a slot formed in the body, wherein the slot is capable of receiving the blade.

6. The apparatus of claim 5 further comprising:
a fastening system capable of securing the blade within the slot.

30

7. The apparatus of claim 6, wherein the fastening system comprises:
a clamp; and
a screw, wherein the clamp and the screw are capable of securing the blade in the slot.

8. The apparatus of claim 1, wherein the blade is capable of being moved to a selected position with respect to the first end of the body.

9. The apparatus of claim 1 further comprising:

5 a structure having a hole, wherein the hole is capable of receiving the guide at a first end of the hole and the first end of the body with the pilot at a second end of the hole and wherein the pilot engages the guide.

10. A method for forming a chamfer, the method comprising:

10 placing a guide into a first end of a hole;

moving an end of a body having a pilot extending from the end into a first end of the hole, wherein the pilot engages the guide and wherein the body has a blade; and

rotating the body to form the chamfer in the second end of the hole.

15 11. The method of claim 10, wherein the guide comprises a housing with a cavity and further comprising:

identifying a depth for the chamfer;

selecting a ring capable of being placed into the cavity, wherein the ring is selected to limit how far the pilot can move into the hole to limit cutting of the chamfer by the blade to a

20 desired depth; and

placing the ring into the cavity of the housing.

12. The method of claim 10, wherein the chamfer is a first chamfer and further comprising:

placing the guide into the second end of the hole after forming the first chamfer;

25 moving the end of the body having the pilot extending from the end into the first end of the hole, wherein the pilot engages the guide; and

rotating the body to form a second chamfer in the first end of the hole.

13. The method of claim 10, wherein the rotating step comprises:

30 rotating the body after the pilot engages the guide.

14. The method of claim 13, wherein the rotating step further comprises:

halting rotation of the body when the guide limits further movement of the guide into the hole to form the chamfer in the second end of the hole.

15. The method of claim 10, wherein the body has a shaft at an opposite end from the pilot
5 and further comprising:
securing the shaft in a tool holder.

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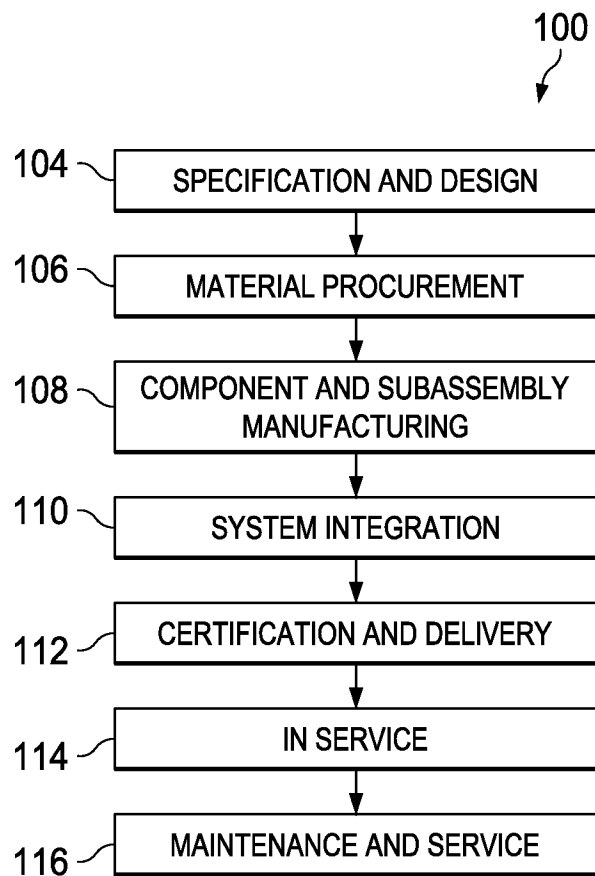


FIG. 1

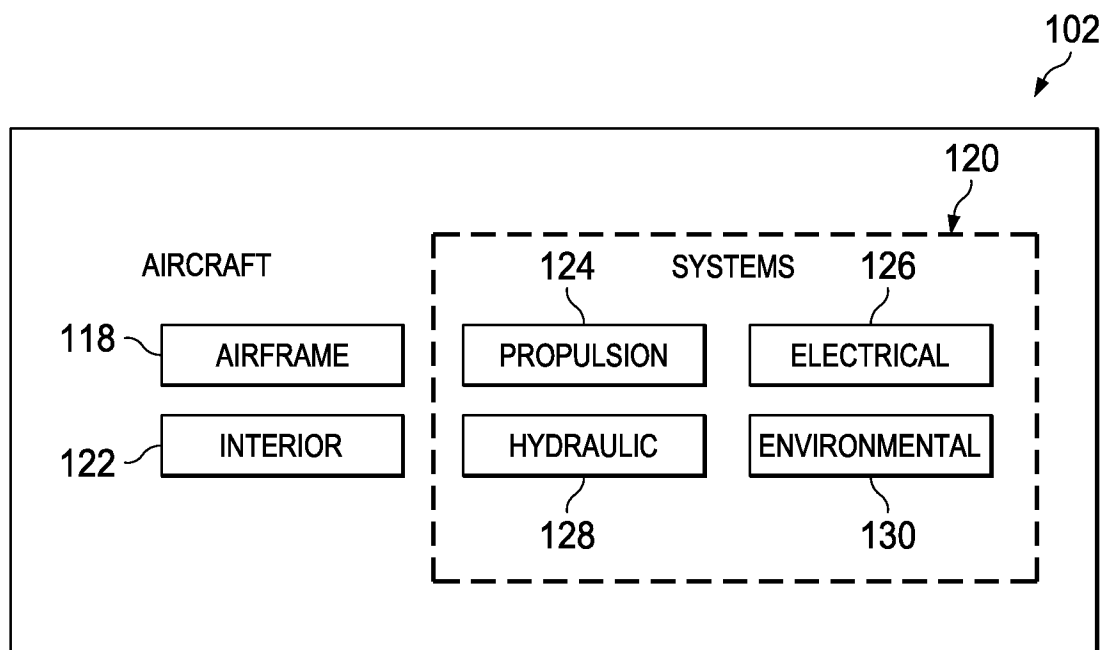
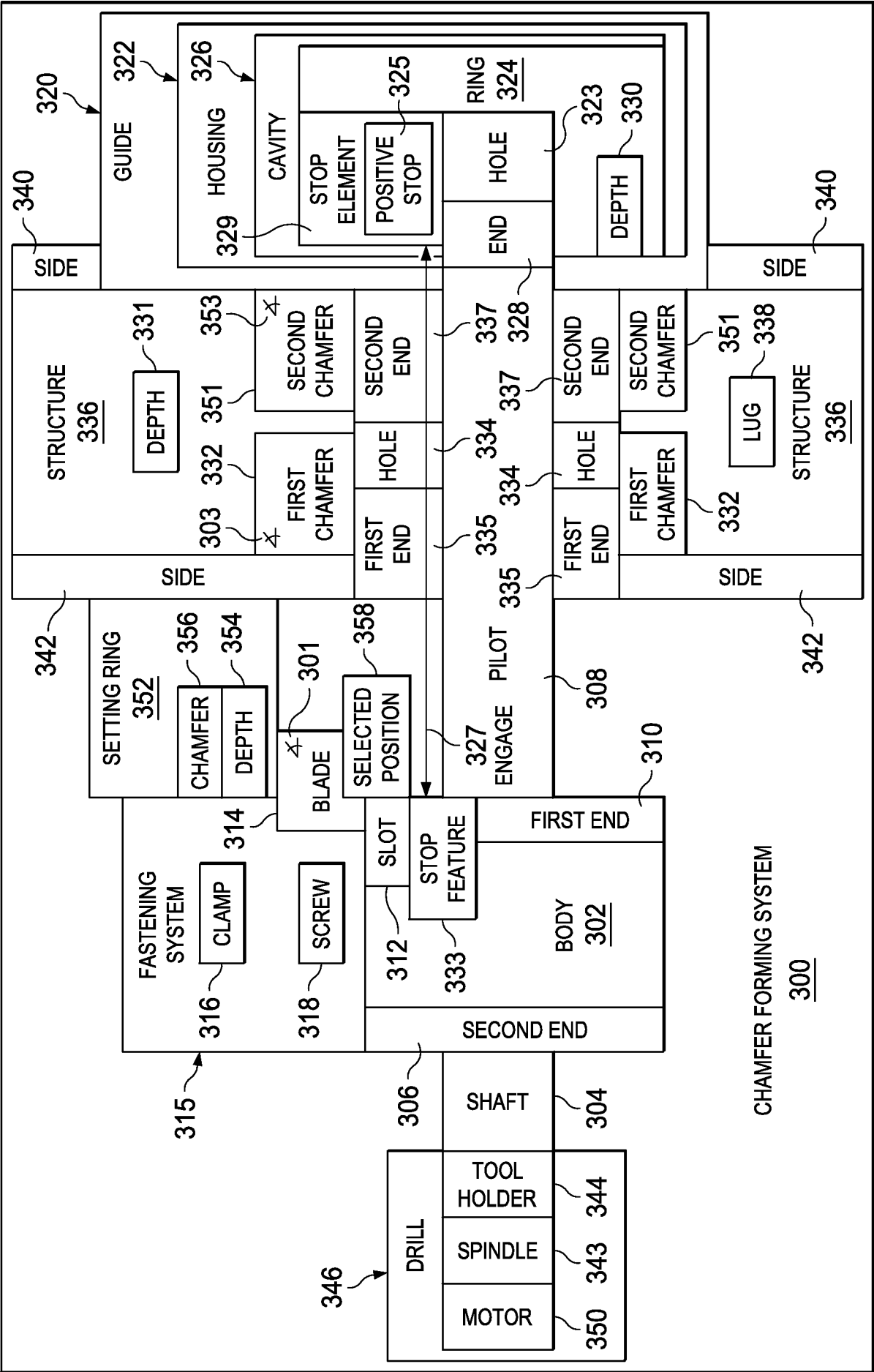


FIG. 2

FIG. 3



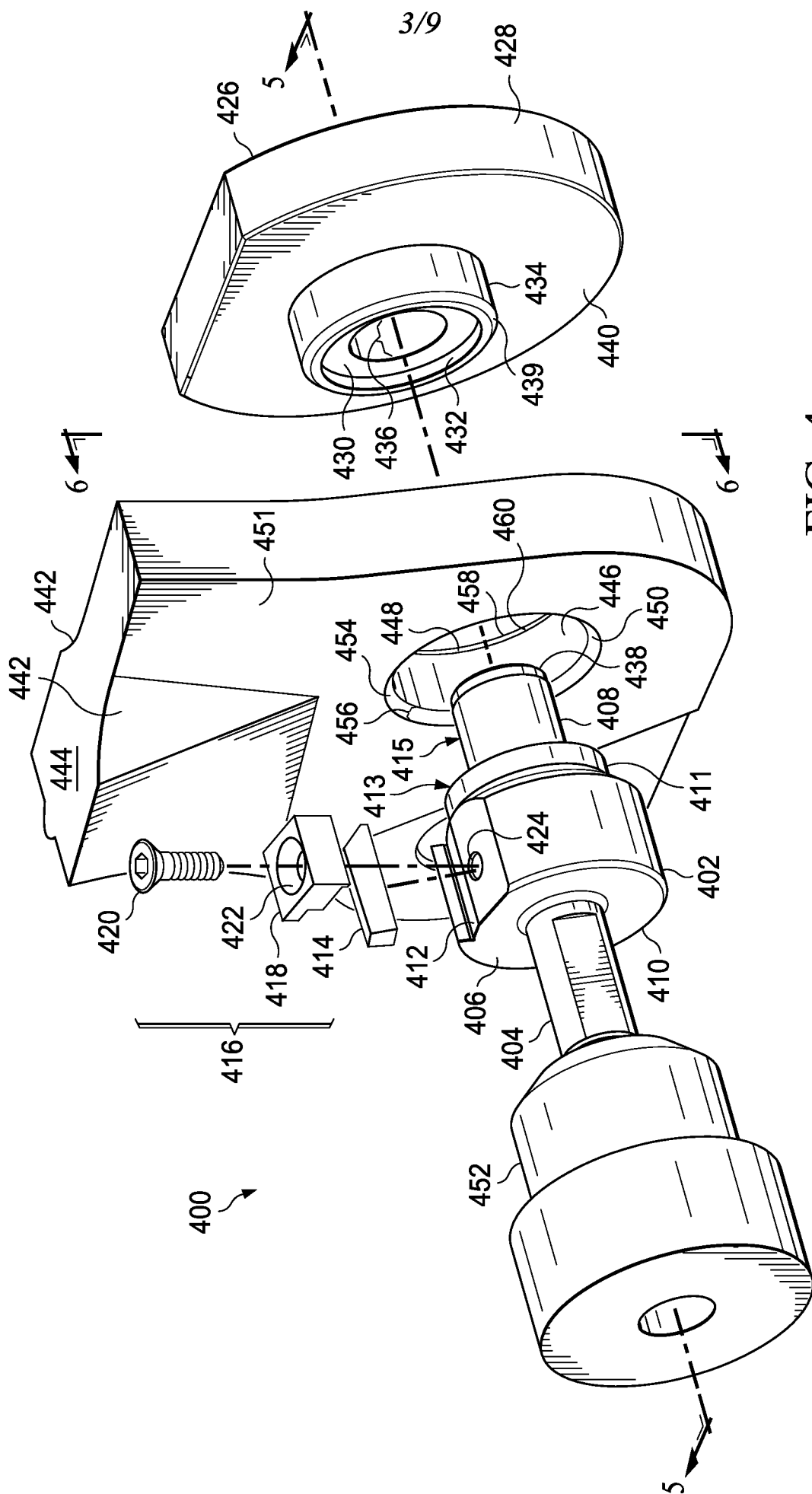
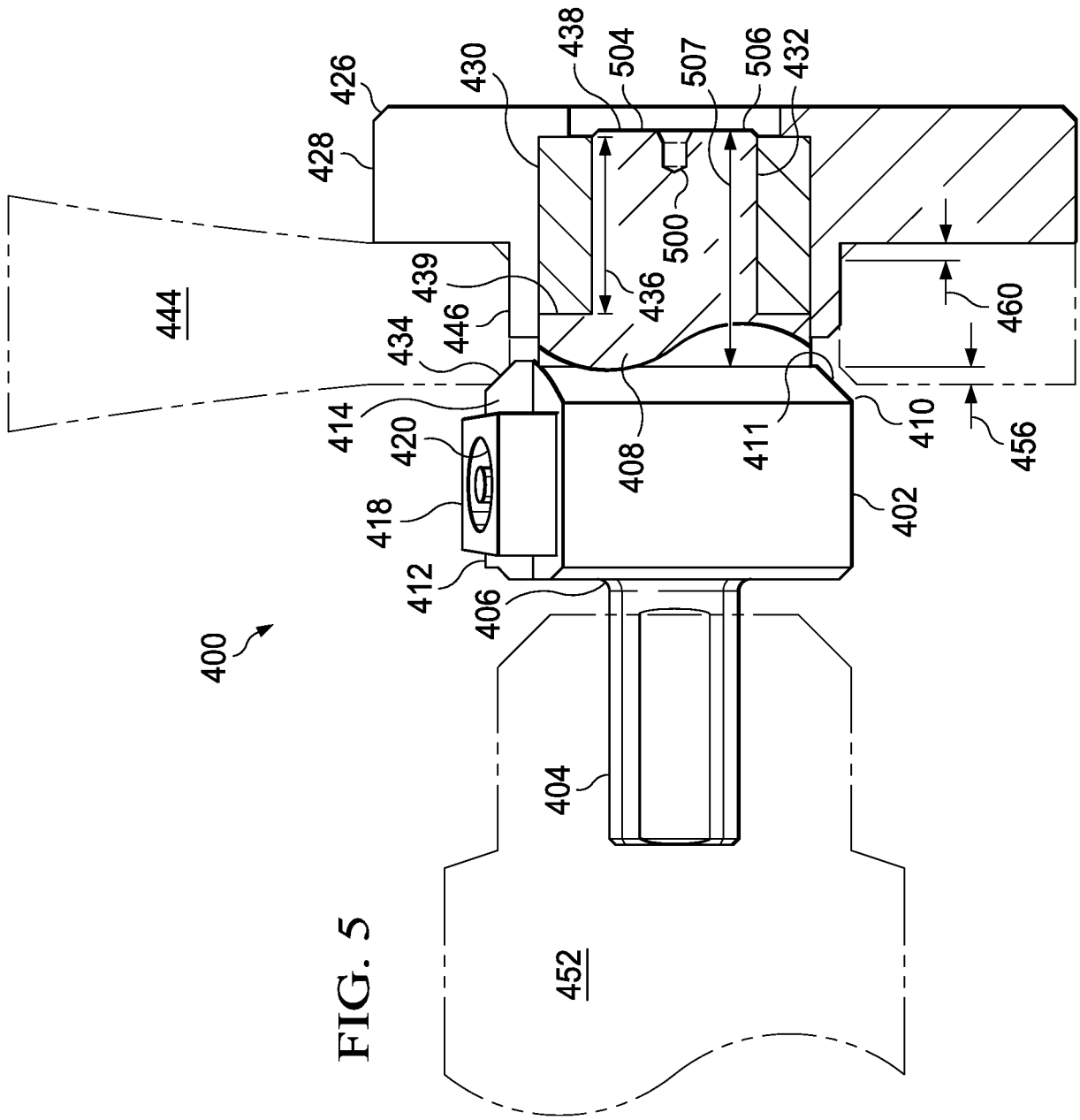


FIG. 4



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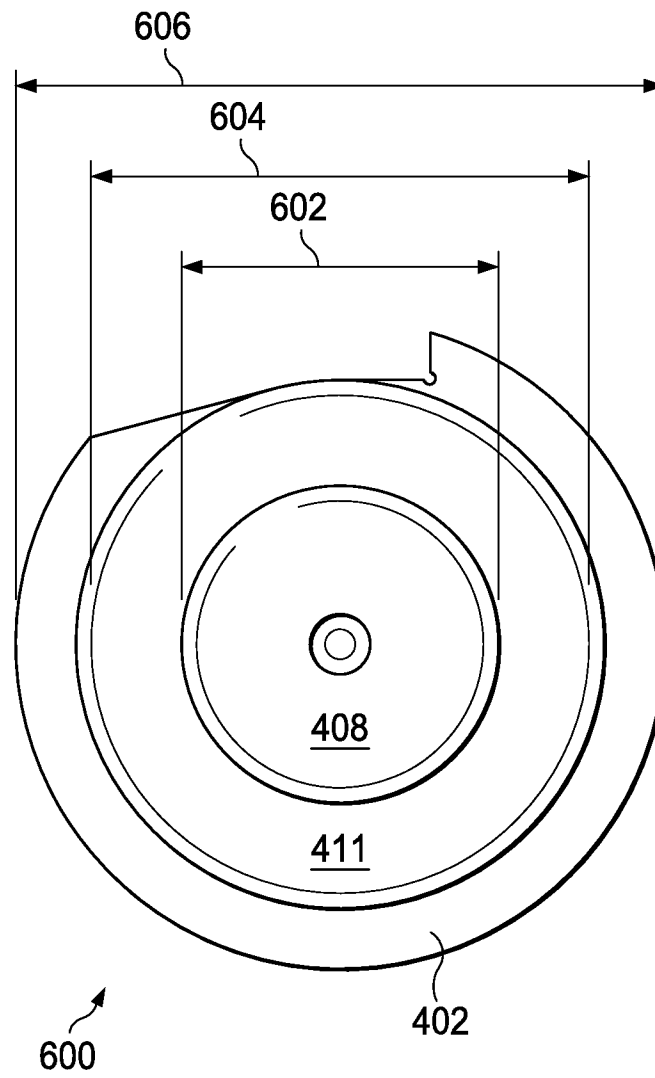


FIG. 6

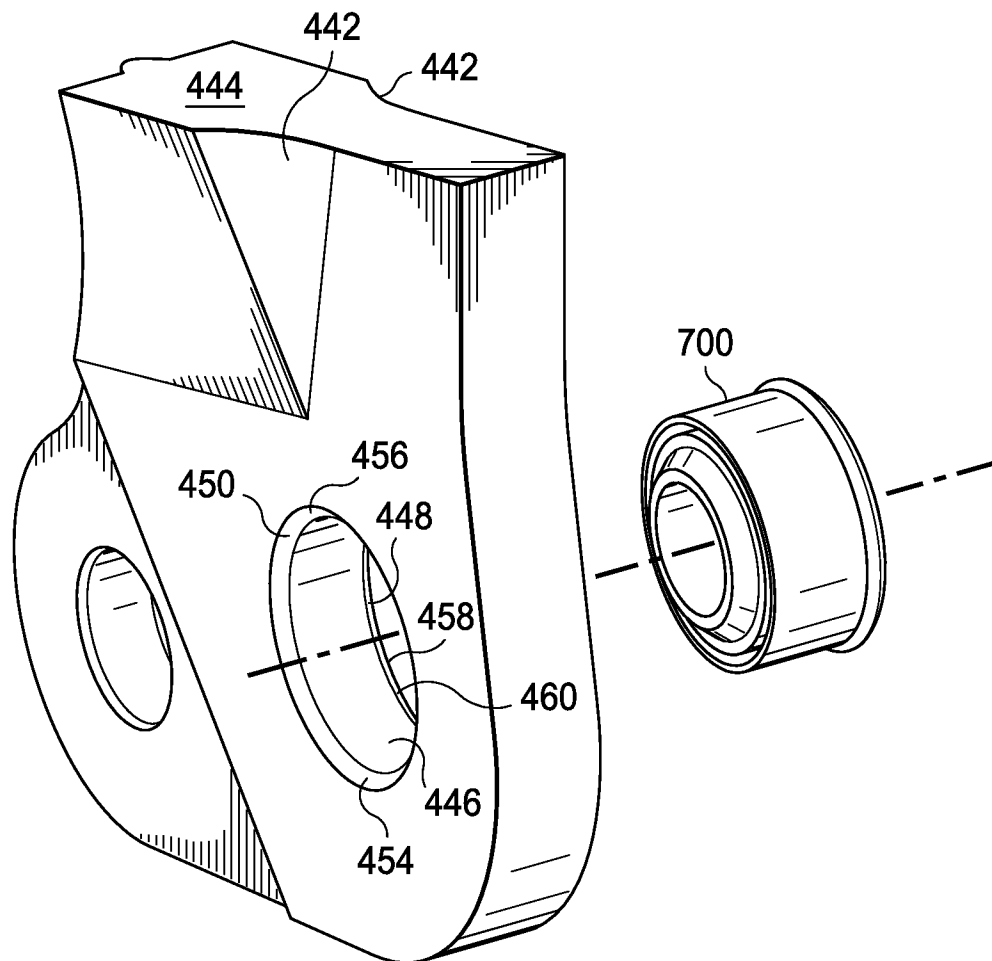


FIG. 7

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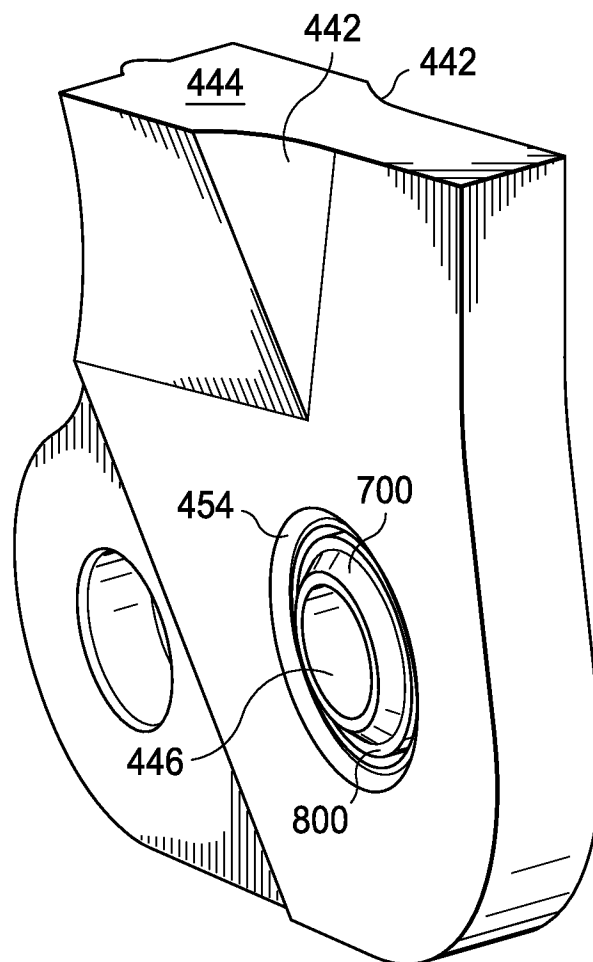
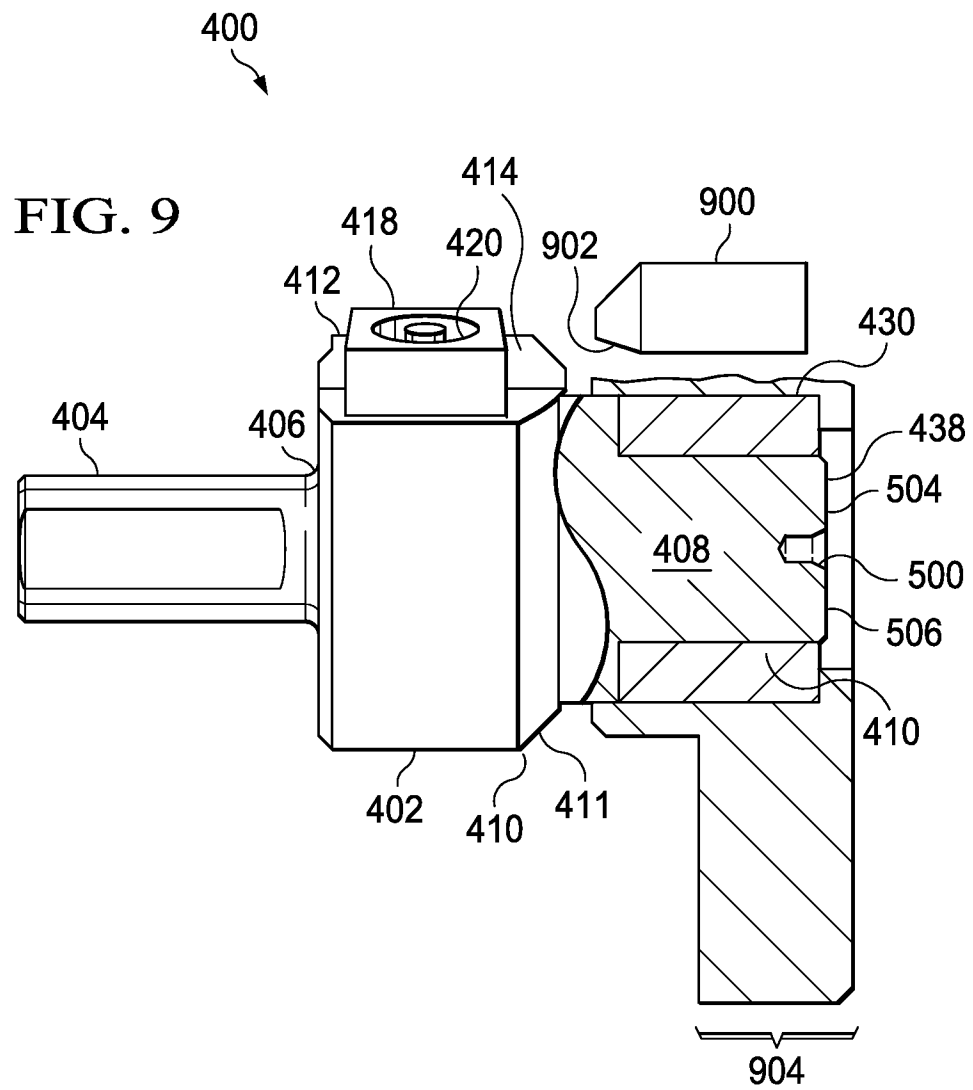


FIG. 8



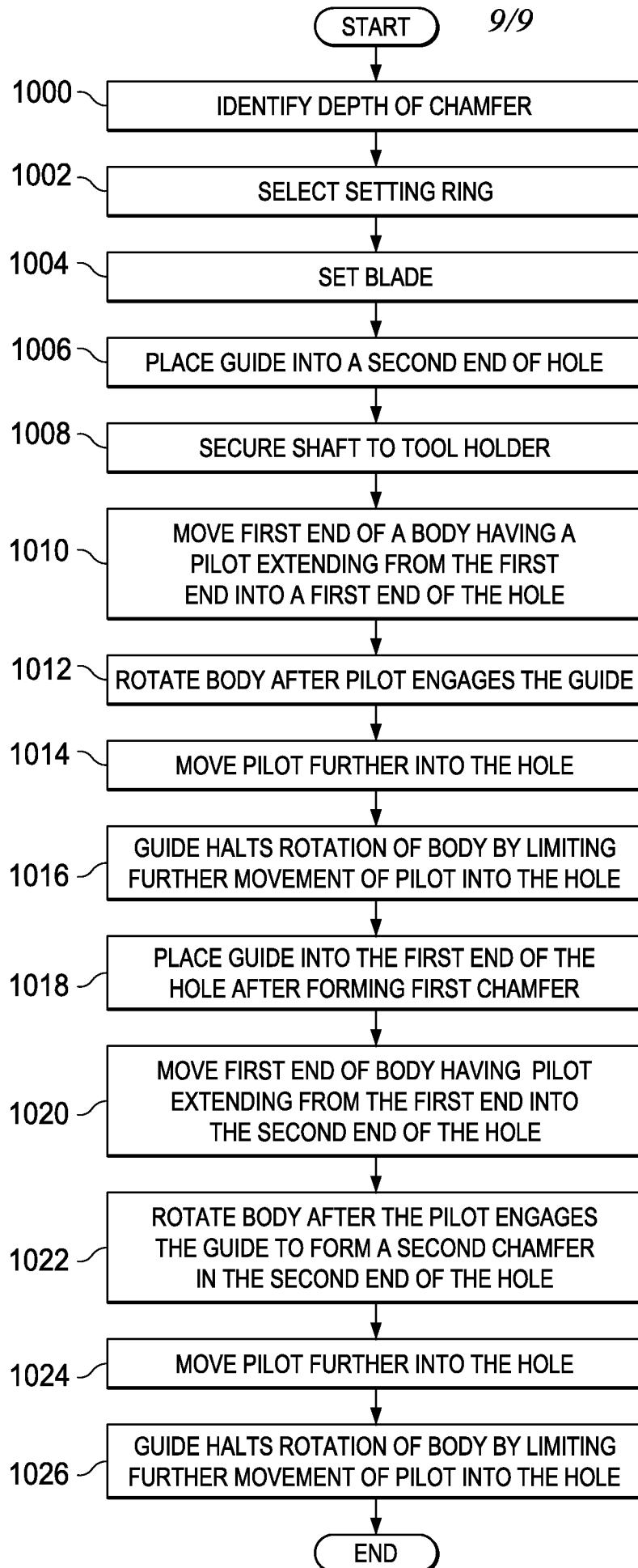


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2009/055307

A. CLASSIFICATION OF SUBJECT MATTER

INV. B23B51/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

B23B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 39 10 427 A1 (ABB TURBINEN NUERNBERG GMBH [DE]) 4 October 1990 (1990-10-04) the whole document	1-6,9-15
A	US 5 487 627 A (KASUTANI HIROSHI [JP] ET AL) 30 January 1996 (1996-01-30) figure 1	1,5,6,10

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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Date of the actual completion of the international search

4 November 2009

Date of mailing of the international search report

12/11/2009

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Fanti, Paolo

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2009/055307

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 3910427	A1	04-10-1990	NONE
US 5487627	A	30-01-1996	NONE