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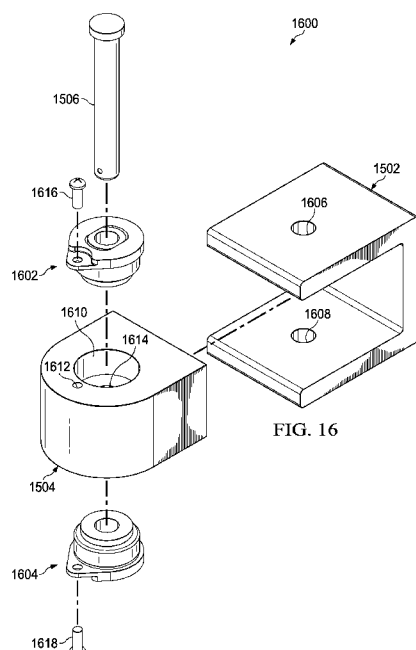
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(57) Abstract: An apparatus comprising an outer sleeve and an inner sleeve. The outer sleeve has a first channel with an inner wall with a first number of substantially planar surfaces. The inner sleeve has a second channel and an outer wall with a second number of substantially planar surfaces. The outer wall is configured to be received within the first channel. At least one of the second number of substantially planar surfaces on the outer wall of the inner sleeve is configured to slide against at least one of the first number of substantially planar surfaces.

VARIATION COMPENSATING ASSEMBLY**BACKGROUND INFORMATION****1. Field:**

The present disclosure relates generally to assembly of parts, particularly assembly of parts with holes. Still more particularly, the present disclosure relates to assemblies for compensating for variation in the placement of holes in parts in the assembly of parts.

Background:

During assembly, parts may be attached by placing elongate structures, such as bolts or pins, through holes in the parts. Anticipated manufacturing variation in the location of the holes of each part necessitates clearances between the elongate structures and the holes in the parts. If the clearances are not sufficient to accommodate the manufacturing variation, an elongate structure may not be able to be inserted through both parts. Further, if the clearances are not sufficient to accommodate the manufacturing variation, deformation of the elongate structures and the parts may be required to insert elongate structures.

One solution is to locate the holes in one part from the holes in the other part. This technique may be known as "match drilling." Another solution is to drill a slotted hole in one of the parts or use a slotted bushing rather than a circular hole. Yet another solution is to use an elongate structure having only a partial full diameter. Such an elongate structure may be referred to as a "diamond pin."

However, these solutions may be undesirable for use in manufacturing. For example, the parts still may not mate properly and may require rework or scrap. Further, these solutions may require additional time or additional elements.

Still further, these solutions may increase the cost or weight of the system undesirably.

Therefore, it would be desirable to have a method and apparatus that takes into account at least some of the issues
5 discussed above, as well as other possible issues.

SUMMARY

In one illustrative embodiment, an apparatus is presented.
10 The apparatus comprises an outer sleeve and an inner sleeve. The outer sleeve has a first channel with an inner wall with a first number of substantially planar surfaces. The inner sleeve has a second channel and an outer wall with a second number of substantially planar surfaces. The outer wall is configured to
15 be received within the first channel. At least one of the second number of substantially planar surfaces on the outer wall of the inner sleeve is configured to slide against at least one of the first number of substantially planar surfaces.

In another illustrative embodiment, a system comprises a
20 first part, a second part, an elongate structure connecting the first part and the second part, and an apparatus positioned in one of the first part and the second part. The elongate structure is inserted through the apparatus. The apparatus comprises an outer sleeve and an inner sleeve. The outer sleeve
25 has a first channel with an inner wall with a first number of substantially planar surfaces. The inner sleeve has a second channel and an outer wall with a second number of substantially planar surfaces. The outer wall is configured to be received within the first channel. At least one of the second number of
30 substantially planar surfaces on the outer wall of the inner sleeve is configured to slide against at least one of the first number of substantially planar surfaces.

In yet another illustrative embodiment, a method is provided. An aircraft is operated. A stress is transferred

from an elongate structure to a first part during operation of the aircraft with an apparatus comprising an outer sleeve and an inner sleeve. The outer sleeve has a first channel with an inner wall with a first number of substantially planar surfaces.

5 The inner sleeve has a second channel and an outer wall with a second number of substantially planar surfaces. The outer wall is configured to be received within the first channel. At least one of the second number of substantially planar surfaces on the outer wall of the inner sleeve is configured to slide against at least one of the first number of substantially planar surfaces. The features and functions 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.

15 According to an aspect of the present disclosure there is provided a system comprising: a first part;

a second part; an elongate structure connecting the first part and the second part; and an apparatus positioned in one of the first part and the second part, wherein the elongate

20 structure is inserted through the apparatus, the apparatus comprising: an outer sleeve having a first channel with an inner wall with a first number of substantially planar surfaces; and

an inner sleeve having a second channel and an outer wall with a second number of substantially planar surfaces, wherein

25 the outer wall is configured to be received within the first channel, and at least one of the second number of substantially planar surfaces on the outer wall of the inner sleeve is configured to slide against at least one of the first number of substantially planar surfaces. Advantageously, the first part

30 is a payload structure and the second part is a payload.

Further advantageously, the inner sleeve is configured to transmit shear forces from the elongate structure through the at least one of the second number of substantially planar surfaces. Yet further advantageously, the outer sleeve has an outer

diameter configured to be a transition fit with a hole in one of the first part and the second part, and further wherein the inner sleeve comprises a keeper feature located on a first side of the inner sleeve, the keeper feature configured to prevent removal of the inner sleeve from the outer sleeve in a first direction, wherein the one of the first part and the second part prevents removal of the inner sleeve from the outer sleeve in a second direction opposite of the first direction. Further advantageously, the system is selected from at least one of an aircraft, a surface ship, a tank, a personnel carrier, a train, a spacecraft, a space station, a satellite, a submarine, an automobile, a power plant, a bridge, a dam, a house, a manufacturing facility, and a building.

BRIEF DESCRIPTION OF THE DRAWINGS

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

Figure 1 is an illustration of an aircraft in accordance with an illustrative embodiment;

Figure 2 is an illustration of a block diagram of a platform in accordance with an illustrative embodiment;

Figure 3 is an illustration of a perspective view of an assembly in accordance with an illustrative embodiment;

Figure 4 is an illustration of an exploded view of an assembly in accordance with an illustrative embodiment;

Figure 5 is an illustration of a side view of an assembly in accordance with an illustrative embodiment;

Figure 6 is an illustration of a front view of an assembly in accordance with an illustrative embodiment;

Figure 7 is an illustration of a back view of an assembly in accordance with an illustrative embodiment;

5 **Figure 8** is an illustration of a cross-section of an assembly in accordance with an illustrative embodiment;

Figure 9 is an illustration of a perspective view of an assembly in accordance with an illustrative embodiment;

10 **Figure 10** is an illustration of an exploded view of an assembly in accordance with an illustrative embodiment;

Figure 11 is an illustration of a side view of an assembly in accordance with an illustrative embodiment;

Figure 12 is an illustration of a front view of an assembly in accordance with an illustrative embodiment;

15 **Figure 13** is an illustration of a back view of an assembly in accordance with an illustrative embodiment;

Figure 14 is an illustration of a cross-section of an assembly in accordance with an illustrative embodiment;

20 **Figure 15** is an illustration of a location of a platform in accordance with an illustrative embodiment;

Figure 16 is an illustration of an exploded view of a location of a platform in accordance with an illustrative embodiment;

25 **Figure 17** is an illustration of a cross-sectional view of a location of a platform in accordance with an illustrative embodiment;

Figure 18 is an illustration of a flowchart of a process for operating an assembly in accordance with an illustrative embodiment;

30 **Figure 19** is an illustration of an aircraft manufacturing and service method in accordance with an illustrative embodiment; and

Figure 20 is an illustration of an aircraft in the form of a block diagram in accordance with an illustrative embodiment.

DETAILED DESCRIPTION

The illustrative embodiments recognize and take into
5 account one or more different considerations. For example, the
illustrative embodiments recognize and take into account that
"match drilling" may be inefficient or undesirable in assembling
parts. For example, "match drilling" is performed on a part by
part basis. Accordingly, "match drilling" is inconsistent with
10 interchangeability which may be desirable in manufacturing.
Further, "match drilling" may require more time and resources
than drilling parts prior to assembly.

The illustrative embodiments recognize and take into
account that to keep the price of parts low an assembling party
15 must allow manufacturing variation in the detail parts. As a
result, the assembling party may not control the placement of
holes or the variation in the placement of holes to the
precision required for immediate assembly.

The illustrative embodiments recognize and take into
20 account that as clearances between elongate structures and holes
are increased, the amount of shear force that the resulting
joint can withstand is decreased. As a result, accommodating
manufacturing variation by changing clearances can limit the
amount of shearing force transferred between two parts. As a
25 result, the amount of shearing force transferred between two
parts may require additional material at the joint.

The illustrative embodiments recognize and take into
account that currently available solutions may not be able to
transfer force at a desired level. For example, in slotted
30 holes, when an elongate structure is inserted, a theoretical
line contact is formed. This theoretical line contact is formed
by a cylindrical surface contacting a planar surface. The
theoretical line contact is the load path to transfer forces

from the elongate structure to the slotted hole. A theoretical line contact is not an effective means to transfer high forces.

As another example, "diamond pins" may result in a small contact area between a "diamond pin" and the holes. Like a theoretical line contact, a small contact area may not be an effective means to transfer high forces.

The illustrative embodiments recognize and take into account that compensating for variations may produce a cost savings. For example, compensating for variations may enable the creation of simpler assembly designs. Simpler assembly designs may require less manufacturing touch time which may produce a cost savings as well as a weight savings. Further, compensation for variations may result in cost savings by not having to scrap or rework parts that do not fit.

With reference now to the figures, and in particular, with reference to **Figure 1**, an illustration of an aircraft is depicted in accordance with an illustrative embodiment. In this illustrative example, aircraft **100** has wing **102** and wing **104** attached to body **106**. Aircraft **100** includes engine **108** attached to wing **102** and engine **110** attached to wing **104**.

Body **106** has tail section **112**. Horizontal stabilizer **114**, horizontal stabilizer **116**, and vertical stabilizer **118** are attached to tail section **112** of body **106**.

Aircraft **100** is an example of an aircraft in which tolerance compensating assembly may be implemented in accordance with an illustrative embodiment. For example, tolerance compensating assembly may be used in connecting a payload structure to a payload. The payload structure may be attached to wing **102**, wing **104**, body **106**, a wheel, or other suitable portion of aircraft **100**. Further, tolerance compensating assembly may be used to connect parts in the manufacture of portions of the aircraft such as wing **102** and wing **104**.

With reference now to **Figure 2**, an illustration of a block diagram of a platform is depicted in accordance with an

illustrative embodiment. In **Figure 2**, platform **200** may be one implementation of aircraft **100**. Although the illustrative examples for an illustrative embodiment are described with respect to an aircraft, an illustrative embodiment may be

5 applied to other types of platforms. Platform **200** may be, for example, without limitation, a mobile platform, a stationary platform, a land-based structure, an aquatic-based structure, and a space-based structure. More specifically, platform **200** may be a surface ship, a tank, a personnel carrier, a train, a
10 spacecraft, a space station, a satellite, a submarine, an automobile, a power plant, a bridge, a dam, a house, a manufacturing facility, a building, and other suitable platforms.

As depicted, platform **200** has first part **202**, second part
15 **204**, assembly **206**, and elongate structure **208**. First part **202** has number of holes **210**. Second part **204** has number of holes **212**. As used herein, a "number of" items means one or more items. For example, number of holes **210** means one or more holes.

20 As used herein, a hole is a channel in a part regardless of shape. The shape of a hole may be selected from at least one of circular, rectangular, elliptical, triangular, a slot, or any other suitable hole. In some illustrative examples, a hole may go through a part or through a portion of the part.

25 First part **202** and second part **204** may be connected using elongate structure **208**, number of holes **210**, and number of holes **212**. For example, elongate structure **208** may be inserted through at least one hole of number of holes **210** of first part **202** and at least one hole of number of holes **212** of second part
30 **204**. In one illustrative example, elongate structure **208** may be inserted through one hole of number of holes **210** of first part **202** and one hole of number of holes **212** of second part **204**. In another illustrative example, elongate structure **208** may be inserted through one hole of number of holes **210** of first part

202 and two holes of number of holes **212** of second part **204**. In yet another illustrative example, elongate structure **208** may be inserted through two holes of number of holes **210** of first part **202** and one hole of number of holes **212** of second part **204**.

5 In these illustrative examples, elongate structure **208** is configured to join first part **202** and second part **204**. In one or more illustrative examples, elongate structure **208** may be configured to hold first part **202** and second part **204** relative to each other in one or more positions. Elongate structure **208**
10 may be selected from one of a fastener, a screw, a bolt, a pin, and any other suitable structure that may be used with first part **202** and second part **204**.

Assembly **206** is configured to compensate for a variation in the placement of at least one hole in number of holes **210** and
15 number of holes **212**. Assembly **206** may be manufactured in a variety of sizes. Considerations may be used to determine a desirable size for assembly **206**. Considerations may include at least one of the size of first part **202**, the size of second part **204**, the size of elongate structure **208**, degree of force,
20 anticipated degree of variation, or other suitable considerations. The diameter of the assembly may range from several nanometers to several feet. In one illustrative embodiment, assembly **206** may have a diameter between 1.5 and 2 inches.

25 As depicted, assembly **206** has outer sleeve **214** and inner sleeve **216**. Outer sleeve **214** and inner sleeve **216** may be made of any appropriate material. Materials may be selected from at least one of metals, composites, plastics, ceramics and any other suitable material. Outer sleeve **214** and inner sleeve **216**
30 of assembly **206** may be made from the same material or from different materials. In some illustrative examples, outer sleeve **214** and inner sleeve **216** of assembly **206** may be manufactured from materials configured to resist deformation under high loads and to transfer high loads. In one

illustrative example, at least one of outer sleeve **214** and inner sleeve **216** is manufactured from a material selected from the group of machineable metals. In another illustrative example, at least one of outer sleeve **214** and inner sleeve **216** is made of hardened steel.

As depicted, outer sleeve **214** has first channel **218**, orientation feature **220**, keeper feature **222**, and outer diameter **224**. First channel **218** is configured to accept portions of inner sleeve **216**. In one illustrative example, first channel **218** is configured to accept all of inner sleeve **216**.

First channel **218** has inner wall **226**, first diameter **228**, and second diameter **230**. Inner wall **226** has number of substantially planar surfaces **232**. In one illustrative example, first channel **218** is similar to an ellipse having two substantially circular sides and number of substantially planar surfaces **232** wherein number of substantially planar surfaces **232** is two substantially planar surfaces.

First diameter **228** is configured to accept portions of inner sleeve **216**. In one illustrative example, first diameter **228** is the distance between number of substantially planar surfaces **232**.

Second diameter **230** is configured to allow movement of inner sleeve **216** within outer sleeve **214**. In the above illustrative example, second diameter **230** may be the distance between the two substantially circular sides.

Number of substantially planar surfaces **232** is configured so that at least one of number of substantially planar surfaces **232** may slideably engage at least one of number of substantially planar surfaces **234** of outer wall **236** of inner sleeve **216**. As used herein, the phrase "at least one of," when used with a list of items, means different combinations of one or more of the listed items may be used and only one of each item in the list may be needed. For example, "at least one of item A, item B, and item C" may include, without limitation, item A or item A

and item B. This example also may include item A, item B, and item C or item B and item C.

Orientation feature **220** is configured to orient outer sleeve **214** in relation to a structure such as one of first part **202** and second part **204**. In one illustrative example, orientation feature **220** is a groove machined into outer sleeve **214**. In this illustrative example, a fastener head may contact orientation feature **220**. Specifically, a portion of a fastener head may sit within the groove and prevent outer sleeve **214** from rotating relative to one of first part **202** and second part **204**.

In another illustrative example, orientation feature **220** is a hole configured to accept a fastener, such as a screw, bolt, pin, or other suitable fastener. A fastener may be placed into the hole and one of first part **202** and second part **204**. In this way, orientation feature **220** prevents outer sleeve **214** from rotating relative to one of first part **202** and second part **204**. In this illustrative example, orientation feature **220** may also be referred to as a securing feature. In this illustrative example orientation feature **220** is configured to secure outer sleeve **214** to a structure such as one of first part **202** and second part **204**.

In yet another illustrative example, orientation feature **220** is a groove machined into the outer wall of outer sleeve **214**. A second groove may be machined into one of first part **202** and second part **204**. The assembly **206** may be placed in a hole in one of first part **202** and second part **204**, so that the groove in outer sleeve **214** and the second groove in one of first part **202** and second part **204** are adjacent. When adjacent, the groove in outer sleeve **214** and the second groove in one of first part **202** and second part **204** may form a channel which is configured to accept a pin. A pin may then be placed within the channel to prohibit rotation of outer sleeve **214**. In this way, orientation feature **220** prevents outer sleeve **214** from rotating relative to one of first part **202** and second part **204**.

Keeper feature **222** is configured to retain inner sleeve **216** within outer sleeve **214** in one axis. Keeper feature **222** may prevent removal of inner sleeve **216** from outer sleeve **214** along one direction of this axis. In one illustrative example, keeper
5 feature **222** may be a lip configured to retain inner sleeve **216** within outer sleeve **214**. Keeper feature **222** may be desirable for ease of assembly, maintenance, and other operations.

Outer diameter **224** is configured to sit within a hole of one of first part **202** and second part **204**. In one illustrative
10 example, outer diameter **224** is configured to be a transition fit in a hole of one of first part **202** and second part **204**. As used herein, a transition fit is a mechanical fit in which a clearance or interference fit may be obtained within the
15 diameter **224** is configured to be a clearance fit in a hole of one of first part **202** and second part **204**. In yet another illustrative example, outer diameter **224** is configured to be an interference fit in a hole of one of first part **202** and second part **204**. In another illustrative example, the hole of one of
20 first part **202** and second part **204** is a counterbore connected to a hole in number of holes **210** of first part **202** or number of holes **212** of second part **204**.

Inner sleeve **216** has outer wall **236** and second channel **238**. Second channel **238** is configured to receive elongate structure
25 **208**. Second channel **238** has diameter **240**. In one illustrative example, diameter **240** of second channel **238** is configured to be a transition fit into elongate structure **208**. As a result, in this illustrative example, elongate structure **208** may transfer high forces to inner sleeve **216**.

Outer wall **236** is configured to fit within outer sleeve
30 **214**. In one illustrative example, outer wall **236** is configured to slideably engage outer sleeve **214**.

Outer wall **236** has number of substantially planar surfaces **234**, first diameter **242**, and second diameter **244**. Number of

substantially planar surfaces **234** is configured to engage outer sleeve **214**. In one illustrative example, number of substantially planar surfaces **234** comprises two substantially planar surfaces configured to slideably engage outer sleeve **214**.

5 First diameter **242** is configured to fit within first channel **218** of outer sleeve **214**. In one illustrative example, first diameter **242** is the distance between number of substantially planar surfaces **234**. In this illustrative example, first diameter **242** is configured to allow number of
10 substantially planar surfaces **234** to slideably engage number of substantially planar surfaces **232** of outer sleeve **214**.

Second diameter **244** of outer wall **236** is configured to fit within first channel **218** of outer sleeve **214**. Second diameter **244** may be configured to be smaller than second diameter **230** of
15 outer sleeve **214**. In one illustrative example, second diameter **244** is configured to allow inner sleeve **216** to slide within outer sleeve **214**.

The illustrative examples may be used to compensate for variations in the position of holes in parts. For example, a
20 hole in number of holes **210** of first part **202** may be farther to the right than designed. As a result, the hole in number of holes **210** may not align with a hole in number of holes **212** as desired. To compensate for the variation in the position of the hole in number of holes **210**, inner sleeve **216** may move relative
25 to outer sleeve **214** in assembly **206**.

By compensating for variations in the position of holes in parts, the illustrative embodiments may produce a cost savings. For example, compensating for variations may enable the creation of simpler assembly designs. Simpler assembly designs may
30 incorporate fewer components, which may produce a cost savings as well as a weight savings. Further, compensation for variations may result in cost savings by not having to scrap or rework parts that do not fit.

One or more illustrative embodiments may allow for high forces to be transferred from an elongate structure to an assembly. Further, the illustrative embodiments may be used in any type of part.

5 The illustrative embodiments may require less time or resources than "mate drilling." Further, the illustrative embodiments may be used in parts of different sizes, shapes, and designs. This interchangeability may produce a cost savings.

10 The illustration of platform **200** in **Figure 2** is not meant to imply physical or architectural limitations to the manner in which an illustrative embodiment may be implemented. Other components in addition to or in place of the ones illustrated may be used. Some components may be unnecessary. Also, the blocks are presented to illustrate some functional components.
15 One or more of these blocks may be combined, divided, or combined and divided into different blocks when implemented in an illustrative embodiment.

For example, outer sleeve **214** may not have keeper feature **222**. In this illustrative example, inner sleeve **216** may have a
20 keeper feature, such as a lip. In another illustrative example, outer sleeve **214** may have keeper feature **222** and inner sleeve **216** may have a second keeper feature configured to function in combination with keeper feature **222**. In this illustrative example, keeper feature **222** may be a counterbore while the
25 second keeper feature may be a lip.

In yet another illustrative example, neither outer sleeve **214** nor inner sleeve **216** have a keeper feature. In this illustrative example, inner sleeve **216** may be retained within outer sleeve **214** by at least one structure selected from first
30 part **202**, second part **204**, and any other suitable structure. This illustrative example may reduce the height of assembly **206** relative to assembly **206** having keeper feature **222**. Designing assembly **206** without keeper feature **222** could also reduce the cost and weight of assembly **206**.

With reference now to **Figure 3**, an illustration of a perspective view of an assembly is depicted in accordance with an illustrative embodiment. As depicted, assembly **300** is an example of a physical implementation of assembly **206** shown in block form in **Figure 2**.

As depicted, assembly **300** has outer sleeve **302** and inner sleeve **304**. Inner sleeve **304** is configured to fit within first channel **306** of outer sleeve **302**.

First channel **306** has first substantially planar surface **308**, second substantially planar surface **310**, first curved surface **312**, and second curved surface **314**. As depicted first substantially planar surface **308** and second substantially planar surface **310** are parallel to each other.

Inner sleeve **304** has third substantially planar surface **316**, fourth substantially planar surface **318**, third curved surface **320**, and fourth curved surface **322**. As depicted, third substantially planar surface **316** of inner sleeve **304** is configured to engage first substantially planar surface **308** of outer sleeve **302**. As depicted, fourth substantially planar surface **318** of inner sleeve **304** is configured to engage second substantially planar surface **310** of outer sleeve **302**. In one illustrative embodiment, third substantially planar surface **316** and fourth substantially planar surface **318** of inner sleeve **304** are configured to slideably engage first substantially planar surface **308** and second substantially planar surface **310** of outer sleeve **302** respectively.

As depicted, first curved surface **312** and third curved surface **320** have complementary curvatures. In other words, first curved surface **312** of outer sleeve **302** is configured to engage third curved surface **320** of inner sleeve **304**. Likewise, second curved surface **314** and fourth curved surface **322** have complementary curvatures.

First curved surface **312** and third curved surface **320** are separated by distance **326**. Second curved surface **314** and fourth

curved surface **322** are separated by distance **328**. As inner sleeve **304** moves within first channel **306**, distance **326** and distance **328** may increase or decrease. For instance, in one illustrative example, inner sleeve **304** may move within first channel **306** so that first curved surface **312** engages third curved surface **320**. In this illustrative example, distance **326** is decreased to zero and distance **328** is increased.

Inner sleeve **304** is configured to move within outer sleeve **302**. In one illustrative example, inner sleeve **304** may be configured to move along a single axis. In this illustrative example, the single axis may be parallel to at least one of first substantially planar surface **308**, second substantially planar surface **310**, third substantially planar surface **316** and fourth substantially planar surface **318**. This movement may be referred to as translation movement. In some illustrative examples, inner sleeve **304** may be configured to move along two axes. In illustrative examples in which inner sleeve **304** is configured to move along two axes, assembly **300** may accommodate orientation variation between holes in parts in addition to distance variations in the holes. In one illustrative example, one of the two axes may be perpendicular to at least one of first substantially planar surface **308**, second substantially planar surface **310**, third substantially planar surface **316** and fourth substantially planar surface **318**. In these illustrative examples, this movement may be referred to as rotation movement.

In one illustrative example, inner sleeve may rotatably move about an axis perpendicular to at least one of first substantially planar surface **308**, second substantially planar surface **310**, third substantially planar surface **316** and fourth substantially planar surface **318** separate from movement along a first axis. In another illustrative example, inner sleeve may rotatably move about an axis perpendicular to at least one of first substantially planar surface **308**, second substantially planar surface **310**, third substantially planar surface **316** and

fourth substantially planar surface **318** simultaneously with regard to movement along a first axis.

Inner sleeve **304** also has second channel **324**. Second channel **324** is configured to receive an elongate structure.

5 The illustration in **Figure 3** is only an example of a physical implementation for assembly **206** shown in block form in **Figure 2** and is not meant to limit the manner in which assembly **206** may be implemented. For example, although inner sleeve **304** is described as moving along one axis or two axes within first
10 channel **306**, in some illustrative examples, inner sleeve **304** may be configured to allow movement along three axes and in six degrees of freedom.

With reference now to **Figure 4**, an illustration of an exploded view of an assembly is depicted in accordance with an
15 illustrative embodiment. As depicted, assembly **400** is an example of a physical implementation of assembly **206** shown in block form in **Figure 2**, and an exploded view of assembly **300** of **Figure 3**.

As depicted, assembly **400** has outer sleeve **302** and inner
20 sleeve **304**. Outer sleeve **302** has first channel **306**. First channel **306** has inner wall **402** which has first substantially planar surface **308**, second substantially planar surface **310**, first curved surface **312**, and second curved surface **314**.

First channel **306** also has first diameter **404** and second
25 diameter **406**. As depicted, first diameter **404** is the distance from first substantially planar surface **308** to second substantially planar surface **310**. First diameter **404** is configured to receive inner sleeve **304**. Second diameter **406** is the distance from the center of first curved surface **312** to the
30 center of second curved surface **314**. Second diameter **406** is configured to allow inner sleeve **304** to move within first channel **306**.

Outer sleeve **302** also has keeper feature **408**. Keeper feature **408** is configured to retain inner sleeve **304** in one direction. As depicted, keeper feature **408** is a lip.

Inner sleeve **304** has outer wall **410** which has third substantially planar surface **316**, fourth substantially planar surface **318**, third curved surface **320**, and fourth curved surface **322**. Outer wall **410** is configured to fit into first channel **306** of outer sleeve **302**.

Inner sleeve **304** also has third diameter **412** and fourth diameter **414**. As depicted, third diameter **412** is the distance between third substantially planar surface **316** and fourth substantially planar surface **318**. Third diameter **412** is configured to fit within first diameter **404**. In one illustrative example, third diameter **412** is configured so that inner sleeve **304** is slideably engageable with outer sleeve **302**. In this illustrative example, third substantially planar surface **316** and fourth substantially planar surface **318** are slideably engageable with first substantially planar surface **308** and second substantially planar surface **310** respectively.

Fourth diameter **414** is configured to fit within second diameter **406**. As depicted, fourth diameter **414** is the distance from the center of third curved surface **320** to the center of fourth curved surface **322**. As depicted, fourth diameter **414** is shorter than second diameter **406** so that inner sleeve **304** may move within outer sleeve **302** along a first axis parallel to first substantially planar surface **308** and second substantially planar surface **310**.

With reference now to **Figure 5**, an illustration of a side view of an assembly is depicted in accordance with an illustrative embodiment. As depicted, assembly **500** is an example of a physical implementation of assembly **206** shown in block form in **Figure 2**, and a side view of assembly **300** of **Figure 3**.

Assembly **500** has outer sleeve **302**. Outer sleeve **302** has outer diameter **502**. Outer diameter **502** is configured to fit within a hole in a part. In one illustrative example, outer diameter **502** is configured to be a transition fit in a hole within a part. In one illustrative example, the hole is a counterbore connected to a hole in the part configured to receive an elongate structure.

With reference now to **Figure 6**, an illustration of a front view of an assembly is depicted in accordance with an illustrative embodiment. As depicted, assembly **600** is an example of a physical implementation of assembly **206** shown in block form in **Figure 2**, and a front view of assembly **300** of **Figure 3**.

Assembly **600** comprises outer sleeve **302** and inner sleeve **304**. As depicted, inner sleeve **304** is positioned within first channel **306** of outer sleeve **302**.

As depicted, outer sleeve **302** has first substantially planar surface **308** and second substantially planar surface **310**. Inner sleeve **304** has third substantially planar surface **316** and fourth substantially planar surface **318**.

In one illustrative example, assembly **600** may be used to join a first part to a second part. In this illustrative example, assembly **600** may be placed in a hole of the first part. Assembly **600** may be oriented in relation to the first part using an orientation feature of outer sleeve **302**.

An elongate structure may then be placed through a hole of the second part and through second channel **324** of inner sleeve **304**. While the first part and the second part are joined, external forces may be applied to the parts. These external forces may encourage the first part and the second part to shift relative to each other. This may cause shear forces to be applied to the elongate structure while elongate structure is within second channel **324**.

Assembly **600** may effectively transfer shear forces from the elongate structure to the first part. In this illustrative example, the elongate structure may transfer the shear forces into inner sleeve **304** through the walls of second channel **324**.

5 In an illustrative example, second channel **324** may be configured to transition fit the elongate structure to effectively transmit high forces.

Next, inner sleeve **304** transfers the shear forces into outer sleeve **302**. Inner sleeve **304** may transfer forces through
10 at least one of third substantially planar surface **316** and fourth substantially planar surface **318**. For example, inner sleeve **304** may transfer forces through third substantially planar surface **316** into first substantially planar surface **308**. As third substantially planar surface **316** and first
15 substantially planar surface **308** are parallel to each other, force may be transferred across the length of third substantially planar surface **316**. The area transferring a force may be referred to as a load path. The load path created by third substantially planar surface **316** and first substantially
20 planar surface **308** can carry high forces due to the large surface area of the load path.

Although in this illustrative example the forces are described as being transferred through third substantially planar surface **316** and first substantially planar surface **308**,
25 in other illustrative examples the forces may instead transfer through fourth substantially planar surface **318** and second substantially planar surface **310**. In other illustrative examples, forces may be transferred through third substantially planar surface **316** and fourth substantially planar surface **318**
30 to first substantially planar surface **308** and second substantially planar surface **310** respectively.

With reference now to **Figure 7**, an illustration of a back view of an assembly is depicted in accordance with an illustrative embodiment. As depicted, assembly **700** is an

example of a physical implementation of assembly **206** shown in block form in **Figure 2**, and a back view of assembly **300** of **Figure 3**.

Assembly **700** comprises outer sleeve **302** and inner sleeve **304**. Outer sleeve **302** has keeper feature **702**, opening **704**, and orientation feature **706**. As depicted, keeper feature **702** is a lip. Keeper feature **702** retains inner sleeve **304** within outer sleeve **302** in one direction.

Opening **704** is configured to receive an elongate structure. Further, opening **704** may be configured to allow an elongate structure to move within opening **704** as inner sleeve **304** moves within outer sleeve **302**.

As depicted, orientation feature **706** is a groove. Orientation feature **706** may be configured to accept a portion of a head of a fastener. In one illustrative example, the head of a screw engages outer sleeve **302** within orientation feature **706**. Orientation feature **706** is configured to prevent rotation of outer sleeve **302** relative to a part.

With reference now to **Figure 8**, an illustration of a cross-section of an assembly is depicted in accordance with an illustrative embodiment. As depicted, assembly **800** is an example of a physical implementation of assembly **206** shown in block form in **Figure 2**, and a cross-section view of assembly **300** of **Figure 3**.

Assembly **800** comprises outer sleeve **302** and inner sleeve **304**. Inner sleeve **304** is configured to slideably engage outer sleeve **302**.

Outer sleeve has first channel **306**, keeper feature **702**, and opening **704**. Inner sleeve **304** is configured to fit within first channel **306**. Keeper feature **702** is configured to retain inner sleeve **304** within first channel **306** in one direction. Opening **704** is configured to receive an elongate member and allow movement of elongate member within opening **704** in the axis of movement of inner sleeve within outer sleeve **302**. As a result,

opening **704** is larger in diameter than second channel **324** of inner sleeve **304**. Outer sleeve **302** also has beveled edge **802** and beveled edge **804**. Beveled edge **802** and beveled edge **804** may allow for outer sleeve **302** to fit within holes which are not perfectly cylindrical. In other words, beveled edge **802** and beveled edge **804** may allow outer sleeve **302** to fit into holes with rounded corners. A hole with rounded corners may have a radius rather than a 90 degree angle at the intersection of the walls and base of the hole.

With reference to **Figure 9**, an illustration of a perspective view of an assembly is depicted in accordance with an illustrative embodiment. As depicted assembly **900** is an example of a physical implementation of assembly **206** shown in block form in **Figure 2**. Assembly **900** has outer sleeve **902** and inner sleeve **904**. As depicted, outer sleeve **902** has first channel **906** and orientation feature **908**. First channel **906** is configured to receive portions of inner sleeve **904**. First channel **906** has first substantially planar surface **916** and second substantially planar surface **918**. Inner sleeve **904** has third substantially planar surface **920** and fourth substantially planar surface **922**. First substantially planar surface **916** and third substantially planar surface **920** are configured to slideably engage. Likewise, second substantially planar surface **918** and fourth substantially planar surface **922** are configured to slideably engage.

Orientation feature **908** has flange **910**, hole **912**, and groove **914**. Hole **912** is configured to receive a fastener. Flange **910** is configured to sit between the fastener and a part. Groove **914** is configured to receive a portion of the head of a fastener.

To orient assembly **900** with regard to a part, a fastener is placed through hole **912**. The fastener is also placed into a hole in the part. As a result, the fastener orients outer sleeve **902** in a position relative to the part.

Inner sleeve **904** has second channel **924**. Second channel **924** is configured to receive an elongate structure. In one illustrative example, second channel **924** is configured to be a transition fit with an elongate structure.

5 With reference to **Figure 10**, an illustration of an exploded view of an assembly is depicted in accordance with an illustrative embodiment. As depicted, assembly **1000** is an example of a physical implementation of assembly **206** shown in block form in **Figure 2**, and an exploded view of assembly **900** of
10 **Figure 9**.

Assembly **1000** comprises outer sleeve **902** and inner sleeve **904**. Outer sleeve **902** has first channel **906**. First channel **906** has inner wall **1002** which has first substantially planar surface **916**, second substantially planar surface **918**, first curved
15 surface **1004**, and second curved surface **1006**.

First channel **906** also has first diameter **1008** and second diameter **1010**. As depicted, first diameter **1008** is the distance from first substantially planar surface **916** to second substantially planar surface **918**. First diameter **1008** is
20 configured to receive inner sleeve **904**. Second diameter **1010** is the distance from the center of first curved surface **1004** to the center of second curved surface **1006**. Second diameter **1010** is configured to allow inner sleeve **904** to move within first channel **906**.

25 Inner sleeve **904** has keeper feature **1012** and outer wall **1014**. Keeper feature **1012** is on a first side of inner sleeve **904**, opposite the outer sleeve **902**, and retains inner sleeve **904** within outer sleeve **902** in a first direction. As depicted, keeper feature **1012** is a lip.

30 In some illustrative examples, at least a portion of assembly **900** may be inserted into a structure such as first part **202** or second part **204** of **Figure 2**. In these illustrative examples, inner sleeve **904** may be retained within outer sleeve **902** in a second direction, opposite to the first direction by

the structure. One illustrative example of this relationship may be seen in **Figure 17** below.

Outer wall **1014** has third substantially planar surface **920**, fourth substantially planar surface **922**, third curved surface **1016**, and fourth curved surface **1018**. Outer wall **1014** is configured to fit into first channel **906** of outer sleeve **902**.

Inner sleeve **904** also has third diameter **1020** and fourth diameter **1022**. As depicted, third diameter **1020** is the distance between third substantially planar surface **920** and fourth substantially planar surface **922**. Third diameter **1020** is configured to fit within first diameter **1008**. In one illustrative example, third diameter **1020** is configured so that inner sleeve **904** is slideably engageable with outer sleeve **902**. In this illustrative example, third substantially planar surface **920** and fourth substantially planar surface **922** are slideably engageable with first substantially planar surface **916** and second substantially planar surface **918** respectively.

Fourth diameter **1022** is configured to fit within second diameter **1010**. As depicted, fourth diameter **1022** is the distance from the center of third curved surface **1016** to the center of fourth curved surface **1018**. As depicted, fourth diameter **1022** is shorter than second diameter **1010** so that inner sleeve **904** may move within outer sleeve **902** along a single axis.

With reference to **Figure 11**, an illustration of a side view of an assembly is depicted in accordance with an illustrative embodiment. As depicted, assembly **1100** is an example of a physical implementation of assembly **206** shown in block form in **Figure 2**, and a side view of assembly **900** of **Figure 9**.

Assembly **1100** comprises outer sleeve **902** and inner sleeve **904**. Outer sleeve **902** has outer diameter **1102**, upper diameter **1104**, and orientation feature **908**. Outer diameter **1102** is configured to fit within a hole of a part. In one illustrative example, outer diameter **1102** is configured to be a transition fit in a hole within a part. In one illustrative example, the

hole is a counterbore connected to a hole in the part configured to receive an elongate structure.

Upper diameter **1104** is configured to be greater than outer diameter **1102**. As a result, only a portion of outer sleeve **902** resides within the hole in the part. This provides sufficient vertical space for inner sleeve **904** to move within outer sleeve **902** and within the hole. This may prevent outer sleeve **902** from placing an undesirable amount of pressure on inner sleeve **904**. If an undesirable amount of pressure is placed onto inner sleeve **904**, inner sleeve **904** might not be able to move.

Inner sleeve **904** has keeper feature **1012** which has diameter **1106**. As depicted, diameter **1106** is smaller than outer diameter **1102**. As diameter **1106** is smaller than outer diameter **1102**, inner sleeve **904** may move within a hole holding outer sleeve **902**. Diameter **1106** is larger than a first channel through outer sleeve **902**. As diameter **1106** is larger than a first channel through outer sleeve **902**, inner sleeve **904** is retained within outer sleeve **902** in one direction.

With reference to **Figure 12**, an illustration of a front view of an assembly is depicted in accordance with an illustrative embodiment. As depicted, assembly **1200** is an example of a physical implementation of assembly **206** shown in block form in **Figure 2**, and a front view of assembly **900** of **Figure 9**.

Assembly **1200** comprises outer sleeve **902** and inner sleeve **904**. As depicted, inner sleeve **904** is positioned within first channel **906** of outer sleeve **902**.

As depicted, outer sleeve **902** has first substantially planar surface **916** and second substantially planar surface **918**. Inner sleeve **904** has third substantially planar surface **920**, fourth substantially planar surface **922**, and second channel **924**.

In one illustrative example, assembly **1200** may be used to join a first part to a second part. In this illustrative example, assembly **1200** may be placed in a hole of the first

part. Assembly **1200** may be oriented in relation to the first part using orientation feature **908** of outer sleeve **902**.

An elongate structure may be placed through a hole of the second part and through second channel **924** of inner sleeve **904**.

5 While the first part and the second part are joined, external forces may be applied to the parts. These external forces may encourage the first part and the second part to shift relative to each other. This may cause shear forces to be applied to the elongate structure while elongate structure is within second
10 channel **924**.

Assembly **1200** may effectively transfer shear forces from the elongate structure to the first part. In this illustrative example, the elongate structure may transfer the shear forces into inner sleeve **904** through the walls of second channel **924**.

15 In an illustrative example, second channel **924** may be configured to transition fit the elongate structure to effectively transmit high forces.

Next, inner sleeve **904** transfers the shear forces into outer sleeve **902**. Inner sleeve **904** may transfer forces through
20 at least one of third substantially planar surface **920** and fourth substantially planar surface **922**. For example, inner sleeve **904** may transfer forces through third substantially planar surface **920** into first substantially planar surface **916**. As third substantially planar surface **920** and first
25 substantially planar surface **916** are parallel to each other, force may be transferred across the length of third substantially planar surface **920**. The area transferring force may be referred to as a load path. The load path created by third substantially planar surface **920** and first substantially
30 planar surface **916** can carry high forces due to the large surface area of the load path.

Although in this illustrative example the forces are described as being transferred through third substantially planar surface **920** and first substantially planar surface **916**,

in other illustrative examples the forces may instead transfer through fourth substantially planar surface **922** and second substantially planar surface **918**. In other illustrative examples, forces may be transferred through third substantially planar surface **920** and fourth substantially planar surface **922** to first substantially planar surface **916** and second substantially planar surface **918** respectively.

With reference now to **Figure 13**, an illustration of a back view of an assembly is depicted in accordance with an illustrative embodiment. As depicted, assembly **1200** is an example of a physical implementation of assembly **206** shown in block form in **Figure 2**, and a back view of assembly **900** of **Figure 9**.

Assembly **1300** has outer sleeve **902** and inner sleeve **904**. As depicted, inner sleeve **904** resides within a first channel of outer sleeve **902**. Inner sleeve **904** has keeper feature **1012** and second channel **924**. Keeper feature **1012** is configured to retain inner sleeve **904** within the first channel of outer sleeve **902** in one direction. As depicted, keeper feature **1012** retains inner sleeve **904** by having diameter **1106**. Diameter **1106** is larger than the first channel of outer sleeve **902**.

With reference now to **Figure 14**, an illustration of a cross-section of an assembly is depicted in accordance with an illustrative embodiment. As depicted assembly **1400** is an example of a physical implementation of assembly **206** shown in block form in **Figure 2**, and a cross-section view of assembly **900** of **Figure 9**.

Assembly **1400** has outer sleeve **902** and inner sleeve **904**. Inner sleeve **904** is configured to fit within first channel **906** of outer sleeve **902**. Inner sleeve **904** has keeper feature **1012** and outer wall **1014**. As depicted, diameter **1402** of keeper feature **1012** is larger than second diameter **1404** of first channel **906**. As a result, keeper feature **1012** retains inner sleeve **904** within outer sleeve **902** in one direction. In other

words, keeper feature **1012** prevents inner sleeve **904** from moving all the way through first channel **906**.

Outer wall **1014** has fourth diameter **1406**. As depicted, fourth diameter **1406** is smaller than second diameter **1404** of first channel **906**, allowing inner sleeve **904** to move in one direction within outer sleeve **902**.

With reference now to **Figure 15**, an illustration of a location of a platform in which an illustrative embodiment may be implemented is depicted in accordance with an illustrative embodiment. Platform **1500** may be platform **200** of **Figure 2**. Platform **1500** may be a portion of aircraft **100**, such as a payload structure on the wing, body, wheel, or other suitable portion of aircraft **100**.

Platform **1500** comprises first part **1502**, second part **1504**, and elongate structure **1506**. As depicted, first part **1502** and second part **1504** are connected using elongate structure **1506**.

With reference now to **Figure 16**, an illustration of an exploded view of a location of a platform is depicted in accordance with an illustrative embodiment. Platform **1600** is an exploded view of platform **1500** of **Figure 15**.

Platform **1600** comprises first part **1502**, second part **1504**, elongate structure **1506**, first assembly **1602**, and second assembly **1604**. As depicted, first part **1502** has first hole **1606** and second hole **1608**. First hole **1606** and second hole **1608** are configured to receive elongate structure **1506**.

Second part **1504** has third hole **1614**, first counterbore **1610**, and first fastener hole **1612**. Third hole **1614** is configured to receive elongate structure **1506**. Third hole **1614** is configured to have sufficient clearance for elongate structure **1506** to move within third hole **1614**.

First counterbore **1610** is configured to receive first assembly **1602**. In one illustrative example, first counterbore **1610** is configured to be a transition fit with portions of first assembly **1602**. A second counterbore is configured to receive

second assembly **1604**. In one illustrative example, the second counterbore is configured to be a transition fit with portions of second assembly **1604**.

First assembly **1602** may be oriented in relation to second part **1504** using fastener **1616** and first fastener hole **1612**. Specifically, fastener **1616** may be placed through an orientation feature of first assembly **1602** and first fastener hole **1612**. As a result, first assembly **1602** is prevented from rotation within first counterbore **1610**.

Second assembly **1604** may be oriented in relation to second part **1504** using fastener **1618** and a second fastener hole. Specifically, fastener **1618** may be placed through an orientation feature of second assembly **1604** and a second fastener hole. As a result, second assembly **1604** is prevented from rotation within a second counterbore.

With reference now to **Figure 17**, an illustration of a cross-sectional view of a location of a platform is depicted in accordance with an illustrative embodiment. Platform **1700** is a cross-sectional view of platform **1500** of **Figure 15**.

Platform **1700** has first part **1502**, second part **1504**, elongate structure **1506**, first assembly **1602**, and second assembly **1604**. First part **1502** may be a payload structure in aircraft **100** of **Figure 1**. Second part **1504** may be a payload to be attached to the payload structure. Elongate structure **1506** passes through first hole **1606** of first part **1502**, first assembly **1602**, third hole **1614** of second part **1504**, second assembly **1604**, and second hole **1608** of first part **1502**.

As depicted, elongate structure **1506** has shaft diameter **1702**. Shaft diameter **1702** is smaller than diameter **1704** of third hole **1614** of second part **1504**. As a result, third hole **1614** may allow movement of elongate structure **1506** within third hole **1614**.

As depicted, lip diameter **1706** of first assembly **1602** is smaller than diameter **1708** of first counterbore **1610**. As a

result, inner sleeve **1710** of first assembly **1602** may move within first counterbore **1610**.

The illustrations in **Figures 3-17** are only examples of some physical implementations for assembly **206** shown in block form in **Figure 2** and not meant to limit the manner in which assembly **206** may be implemented. In one illustrative example, first part **1502** of **Figure 15** may instead only have a single hole to join first part **1502** to second part **1504** using elongate structure **1506**. In another illustrative example, an assembly may be associated with first part **1502** rather than second part **1504**. In one illustrative example, a single assembly, such as assembly **206**, may be within a counterbore associated with first hole **1606** of first part **1502**. In this illustrative example, conventionally known bushings may be used in second hole **1608** and third hole **1614**.

In yet another illustrative example, platform **1600** in **Figure 16** may not have fastener **1616** and fastener **1618**. In this illustrative example, first assembly **1602** and second assembly **1604** may be retained within second part **1504** by a structure selected from at least one of first part **1502** and any other suitable structure. First assembly **1602** and second assembly **1604** may be retained within second part **1504** by the same structure, or by different structures. This illustrative example may reduce the cost and weight of platform **1600** by potentially reducing the size of first assembly **1602** and second assembly **1604** and by eliminating fastener **1616** and fastener **1618**. This illustrative example may also simplify the process of assembling platform **1600**.

In other illustrative examples, platform **1700** may have larger clearances between at least one of first assembly **1602** and second assembly **1604** and at least one of first part **1502** and second part **1504** along the axis of elongate structure **1506**. In one illustrative example, this larger clearance creates a space between a keeper feature of inner sleeve **1710** of first assembly

1602 and outer sleeve **1712** of first assembly **1602**. In this illustrative example, there is also a space between first part **1502** and inner sleeve **1710** of first assembly **1602**. As a result, in this illustrative example, inner sleeve **1710** may move in a rotation movement relative to outer sleeve **1712** of first assembly **1602**. In another illustrative example, a number of additional structures, such as a spherical washer, may be used in platform **1600** to accommodate orientation differences between surfaces of inner sleeve **1710** and second part **1504**.

The different components shown in **Figure 1** and **Figures 3-16** may be combined with components in **Figure 2**, used with components in **Figure 2**, or a combination of the two.

Additionally, some of the components in **Figure 1** and **Figures 3-16** may be illustrative examples of how components shown in block form in **Figure 2** can be implemented as physical structures.

Turning now to **Figure 18**, an illustration of a flowchart of a process for transfer of stress in an assembly is depicted in accordance with an illustrative embodiment. In this illustrative example, process **1800** in **Figure 18** may be implemented in platform **200** using assembly **206** in **Figure 2**.

The process begins by an elongate structure receiving a shear stress from a first part (operation **1802**). An elongate structure may receive a shear stress based on external forces working on at least one of the first part and a second part joined to the first part by the elongate structure. Such external forces may include wind, acceleration, deceleration, gravity, and other suitable forces.

Next, the elongate structure transfers stress from the first part to an inner sleeve through the intersection of the cylindrical shape of the elongate structure and a second channel of the inner sleeve (operation **1804**). In one illustrative example, the second channel of the inner sleeve may be a transition fit to the elongate structure. In this illustrative

example, the elongate structure may transfer high forces through the walls of the second channel.

Next, the inner sleeve transfers stress from the elongate structure to an outer sleeve through at least one of a number of substantially planar surfaces of the inner sleeve (operation **1806**). In one illustrative example, the inner sleeve transfers stress from the elongate structure to at least one of a number of substantially planar surfaces of the outer sleeve. In this illustrative example, the at least one of a number of substantially planar surfaces of the inner sleeve and the at least one of a number of substantially planar surfaces of the outer sleeve are parallel to each other.

Last, the outer sleeve transfers shear stress from the inner sleeve to the second part through an outer diameter of the outer sleeve and a hole of the second part (operation **1808**). The hole may be a counterbore or other type of hole in the second part. The outer sleeve is configured so that at least a portion of the outer sleeve may be received in the hole in the second part. In one illustrative example, at least a portion of the outer sleeve is configured to be transition fit with the hole in the second part.

The flowcharts and block diagrams in the different depicted embodiments illustrate the architecture, functionality, and operation of some possible implementations of the apparatus and methods in an illustrative embodiment. In this regard, each block in the flowcharts or block diagrams may represent a module, a segment, a function, and/or a portion of an operation or step.

In some alternative implementations of an illustrative embodiment, the function or functions noted in the blocks may occur out of the order noted in the figures. For example, in some cases, two blocks shown in succession may be executed substantially concurrently, or the blocks may sometimes be performed in the reverse order, depending upon the functionality

involved. Also, other blocks may be added in addition to the illustrated blocks in a flowchart or block diagram.

For example, the assembly may instead transfer stresses from the second part to the first part through the elongate structure. In other words, the functions would be performed in the reverse order, with the outer sleeve transferring stress from the second part to the inner sleeve, and the inner sleeve transferring stress to the elongate structure.

Illustrative embodiments of the disclosure may be described in the context of aircraft manufacturing and service method **1900** as shown in **Figure 19** and aircraft **2000** as shown in **Figure 20**. Turning first to **Figure 19**, an illustration of an aircraft manufacturing and service method is depicted in accordance with an illustrative embodiment. During pre-production, aircraft manufacturing and service method **1900** may include specification and design **1902** of aircraft **2000** in **Figure 20** and material procurement **1904**.

During production, component and subassembly manufacturing **1906** and system integration **1908** of aircraft **2000** in **Figure 20** takes place. Thereafter, aircraft **2000** in **Figure 20** may go through certification and delivery **1910** in order to be placed in service **1912**. While in service **1912** by a customer, aircraft **2000** in **Figure 20** is scheduled for routine maintenance and service **1914**, which may include modification, reconfiguration, refurbishment, and other maintenance or service.

Each of the processes of aircraft manufacturing and service method **1900** may be performed or carried out by a system integrator, a third party, and/or an operator. In these examples, the operator may be 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, without limitation, any number of vendors, subcontractors, and

suppliers, and an operator may be an airline, a leasing company, a military entity, a service organization, and so on.

With reference now to **Figure 20**, an illustration of an aircraft is depicted in accordance with an illustrative embodiment. In this example, aircraft **2000** is produced by aircraft manufacturing and service method **1900** in **Figure 19** and may include airframe **2002** with plurality of systems **2004** and interior **2006**. Examples of systems **2004** include one or more of propulsion system **2008**, electrical system **2010**, hydraulic system **2012**, and environmental system **2014**. Any number of other systems may be included. Although an aerospace example is shown, different illustrative embodiments may be applied to other industries, such as the automotive industry.

Apparatuses and methods embodied herein may be employed during at least one of the stages of aircraft manufacturing and service method **1900** in **Figure 19**.

One or more illustrative embodiments may be used during component and subassembly manufacturing **1906**. For example, assembly **206** in **Figure 2** may be used to join parts during component and subassembly manufacturing **1906**. Further, assembly **206** may also be used to perform replacements during maintenance and service **1914**. For example, aircraft **2000** may be inspected during scheduled maintenance for aircraft **2000**.

The illustrative embodiments may be used to compensate for variations in the position of holes in parts. One or more illustrative embodiments may allow for high forces to be transferred from an elongate structure to an assembly. Further, the illustrative embodiments may be used in any type of part.

Further, the illustrative embodiments may produce a cost savings. For example, compensating for variations may enable the creation of simpler assembly designs. Simpler assembly designs may incorporate fewer separate major structural parts, which may produce a cost savings as well as a weight savings.

Further, compensation for variations may result in cost savings by not having to scrap or rework parts that do not fit.

The description of the different illustrative embodiments has been presented for purposes of illustration and description,
5 and is not intended to be exhaustive or limited to the embodiments in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art. Further, different illustrative embodiments may provide different features as compared to other illustrative
10 embodiments. 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
15 the particular use contemplated.

CLAIMS:

What is claimed is:

- 5 1. An apparatus comprising:
an outer sleeve having a first channel with an inner wall
with a first number of substantially planar surfaces; and
an inner sleeve having a second channel and an outer wall
with a second number of substantially planar surfaces, wherein
10 the outer wall is configured to be received within the first
channel, and at least one of the second number of substantially
planar surfaces on the outer wall of the inner sleeve is
configured to slide against at least one of the first number of
substantially planar surfaces.
- 15 2. The apparatus of claim 1, wherein the second channel is
configured to receive an elongate structure.
3. The apparatus of any previous claim, wherein the second
20 channel is configured to be a transition fit with the elongate
structure.
4. The apparatus of any previous claim, wherein the inner
sleeve is configured to transmit shear forces from the elongate
25 structure through the at least one of the second number of
substantially planar surfaces.
5. The apparatus of any previous claim, wherein the inner
sleeve is configured to slideably move within the first channel
30 along a first axis.
6. The apparatus of any previous claim, wherein the outer
sleeve further comprises an orientation feature configured to
orient the outer sleeve in relation to a structure.

7. The apparatus of any previous claim, wherein the outer sleeve further comprises a securing feature configured to secure the outer sleeve to a structure.

5

8. The apparatus of any previous claim, wherein at least one of the inner sleeve and the outer sleeve comprises a keeper feature configured to prevent removal of the inner sleeve from the outer sleeve in one direction.

10

9. The apparatus of claim 8, wherein the keeper feature is a lip located on a first side of the inner sleeve.

10. The apparatus of any previous claim, wherein the outer sleeve has an outer diameter configured to be a transition fit with a hole in a structure.

11. The apparatus of any previous claim, wherein the outer sleeve has an outer diameter configured to be a transition fit with a hole in a structure, and further wherein the inner sleeve comprises a keeper feature located on a first side of the inner sleeve, the keeper feature configured to prevent removal of the inner sleeve from the outer sleeve in a first direction, wherein the structure prevents removal of the inner sleeve from the outer sleeve in a second direction opposite of the first direction.

12. The apparatus of any previous claim, wherein at least one of the inner sleeve and the outer sleeve comprises hardened steel.

13. The apparatus of any previous claim, wherein the inner sleeve and the outer sleeve comprise at least one of a plastic, a metal, a ceramic, and a composite.

14. The apparatus of any previous claim, wherein the inner sleeve and the outer sleeve are made from different materials.

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15. A method comprising:

operating an aircraft; and

transferring a stress from an elongate structure to a first part during operation of the aircraft with an apparatus

10 comprising an outer sleeve having a first channel with an inner wall with a first number of substantially planar surfaces, and an inner sleeve having a second channel and an outer wall with a second number of substantially planar surfaces, wherein the outer wall is configured to be received within the first
15 channel, and at least one of the second number of substantially planar surfaces on the outer wall of the inner sleeve is configured to slide against at least one of the first number of substantially planar surfaces.

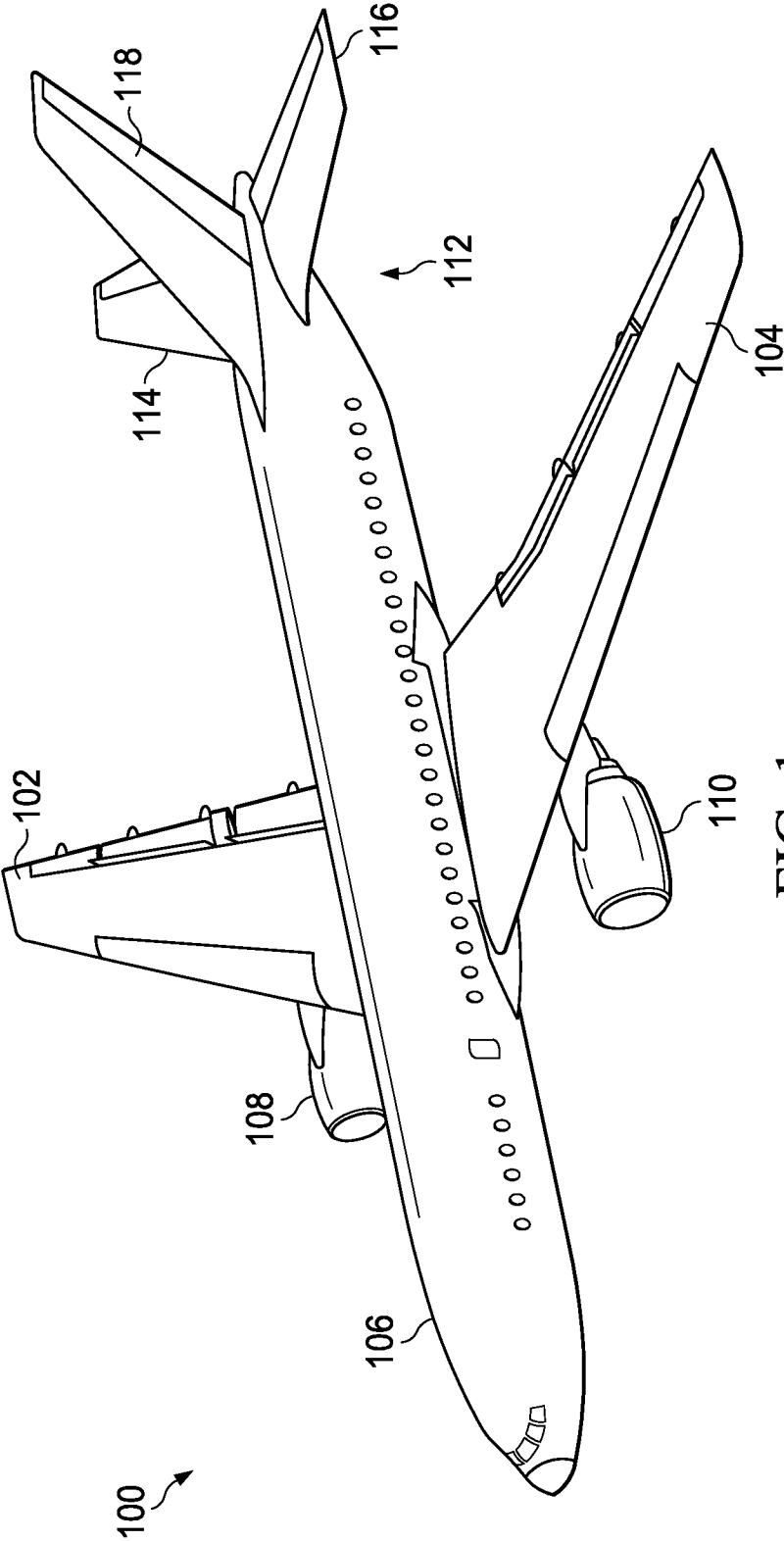
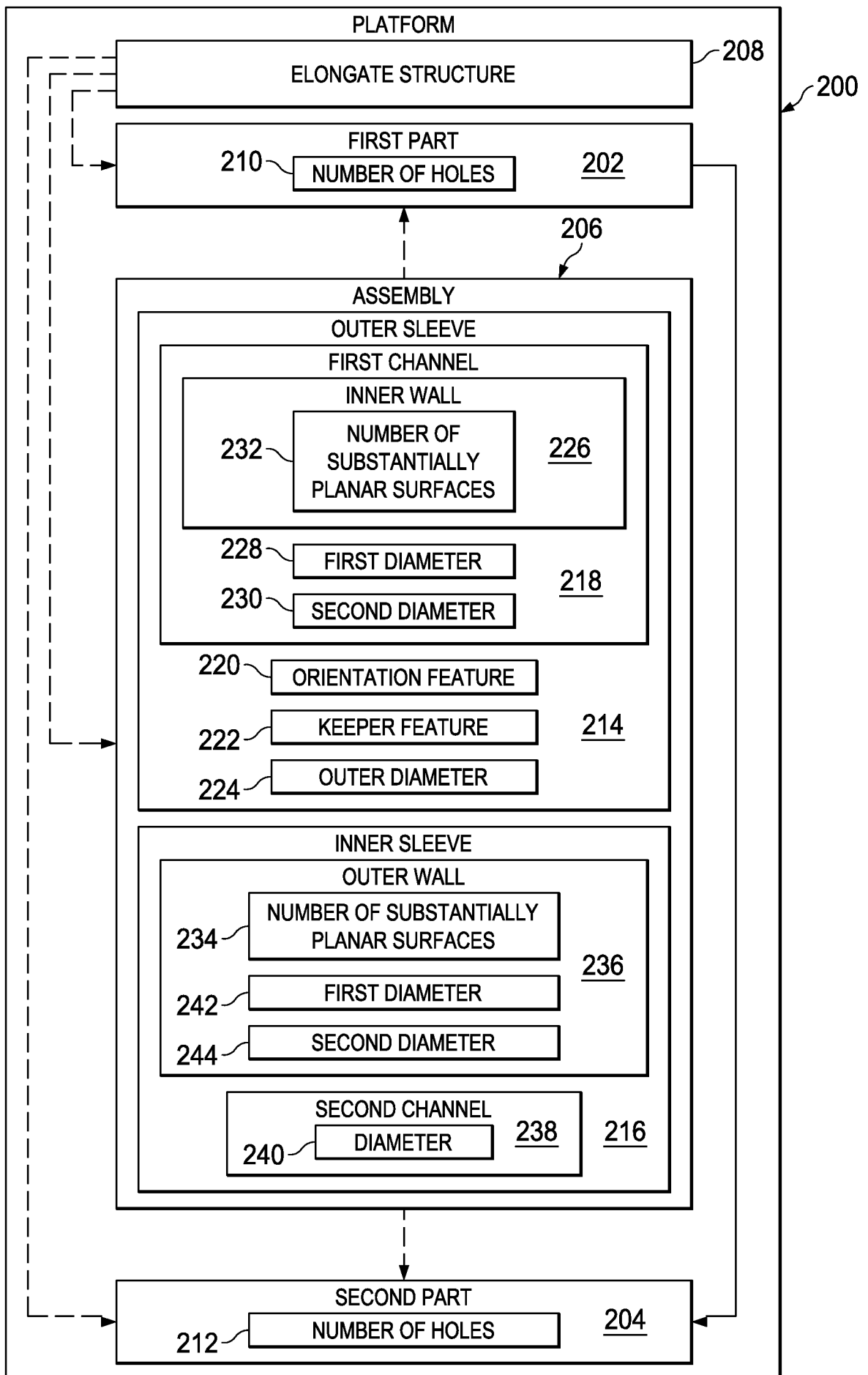
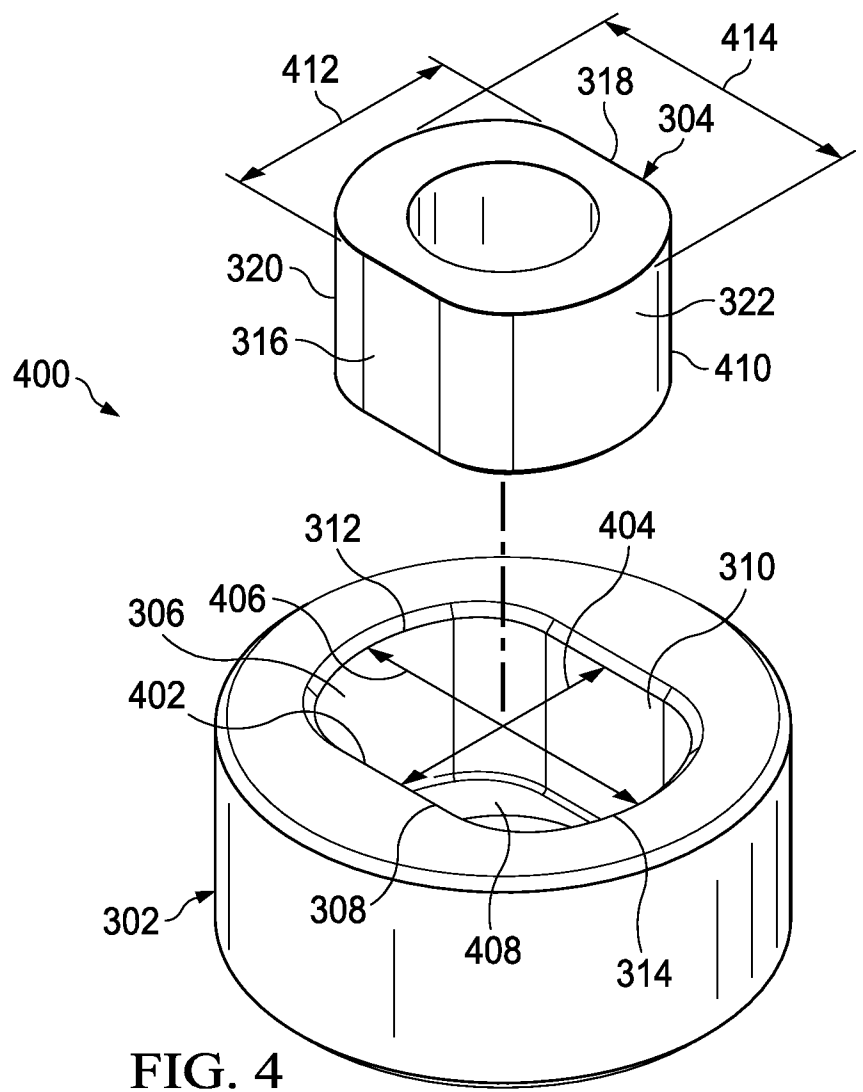
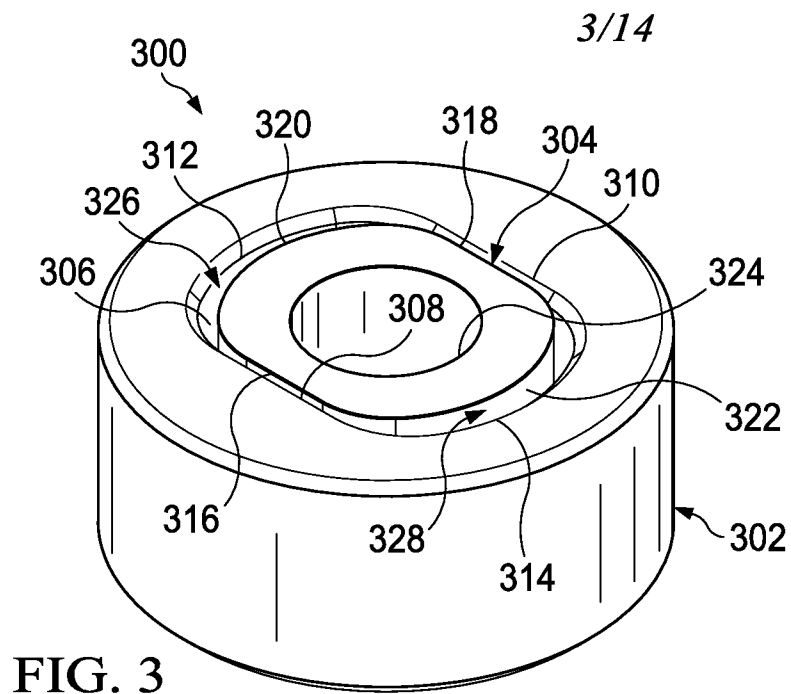


FIG. 1

FIG. 2

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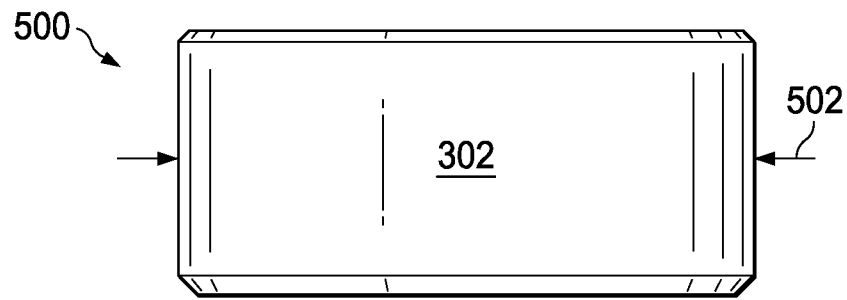


FIG. 5

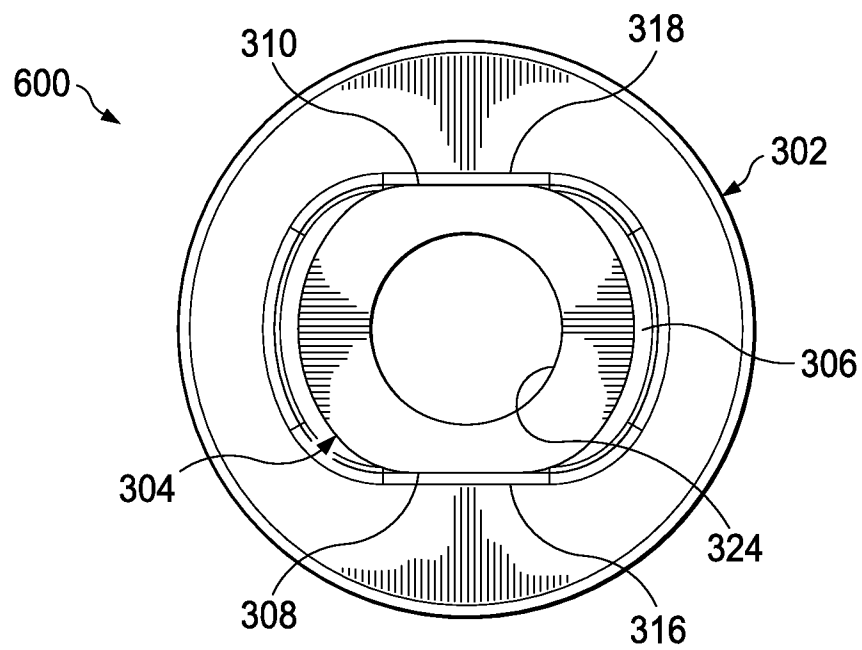


FIG. 6

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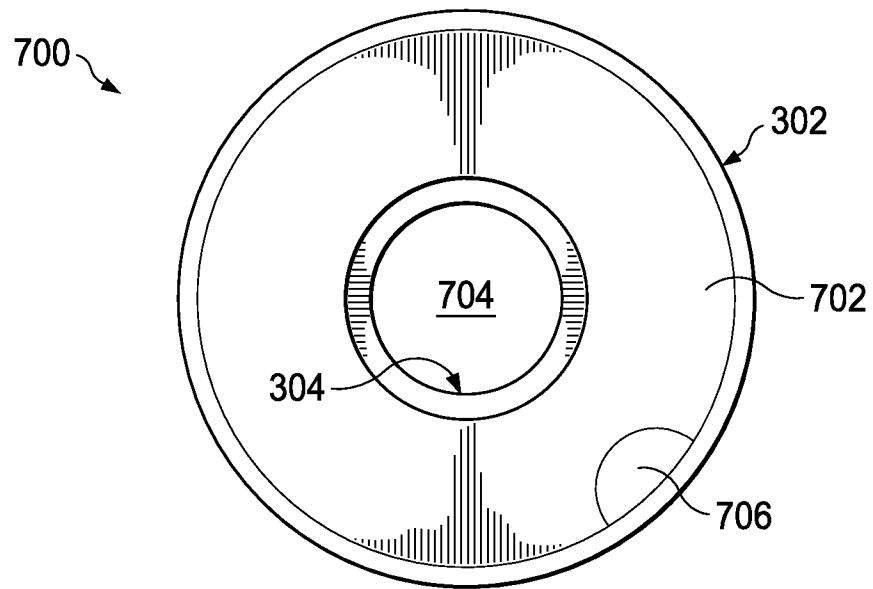


FIG. 7

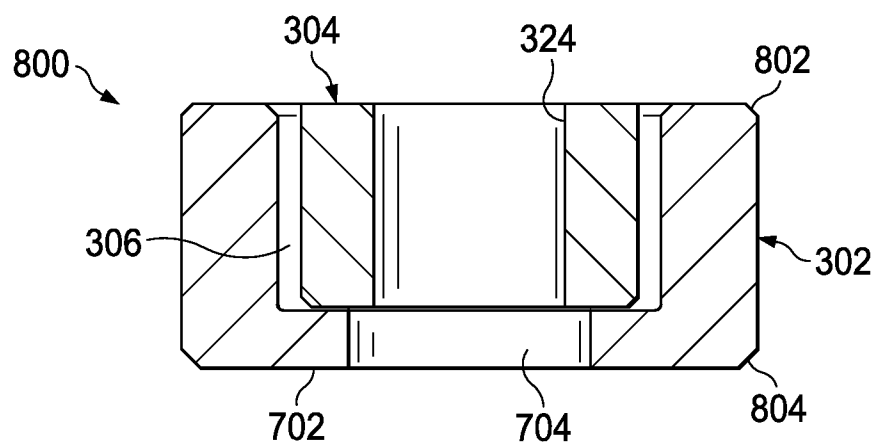


FIG. 8

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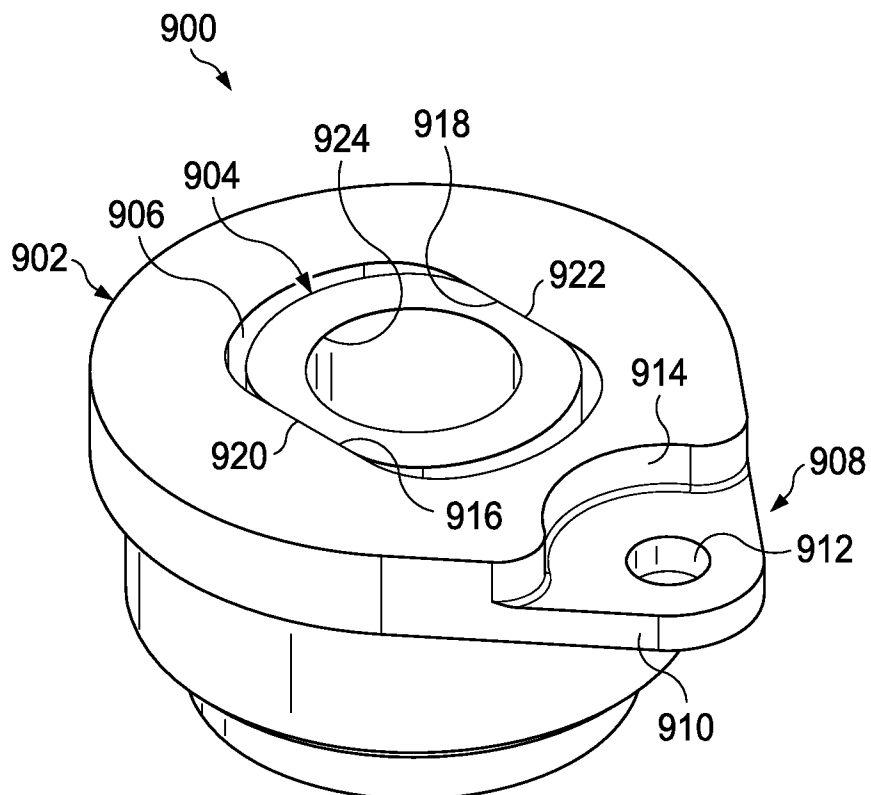


FIG. 9

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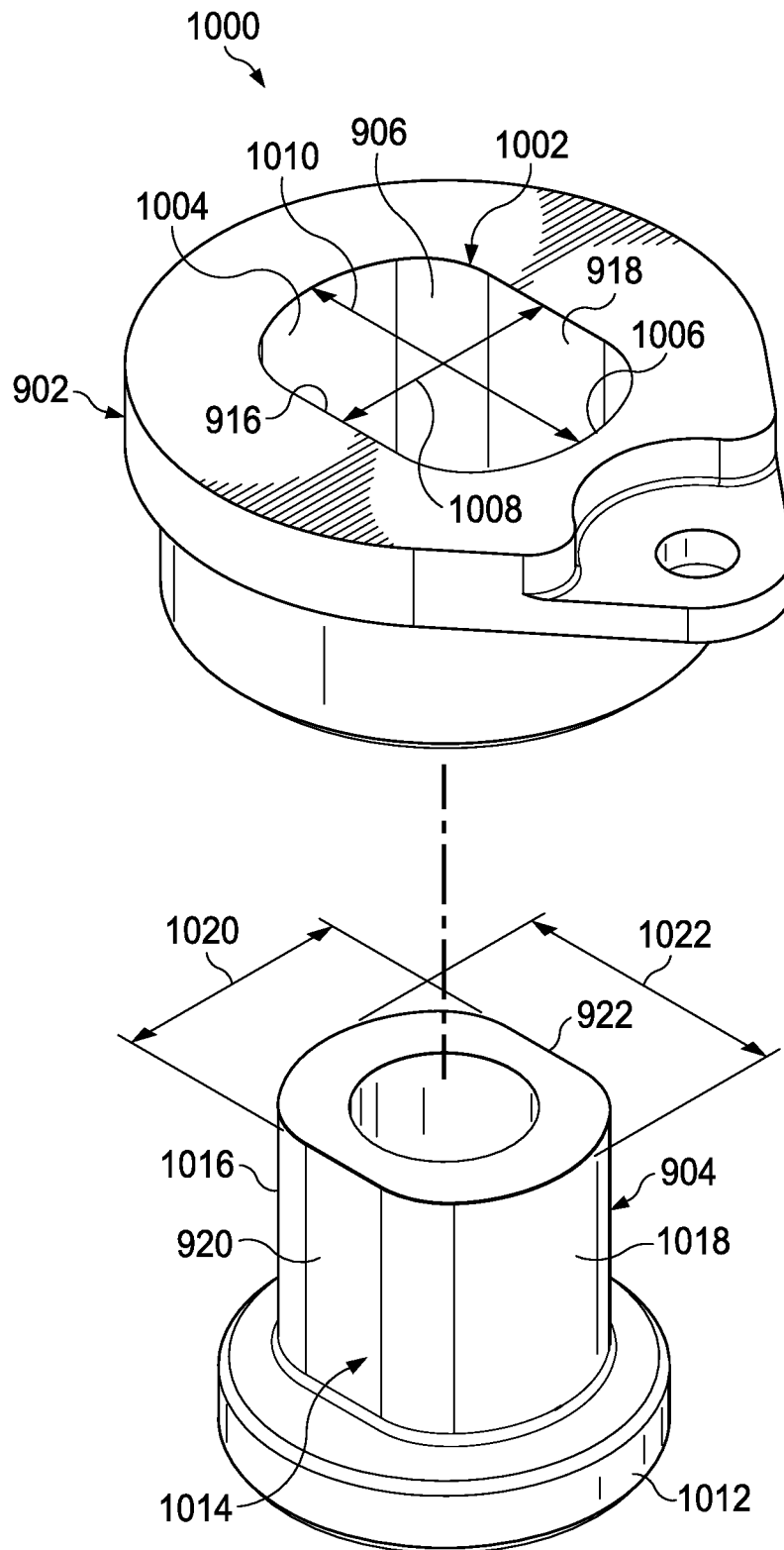


FIG. 10

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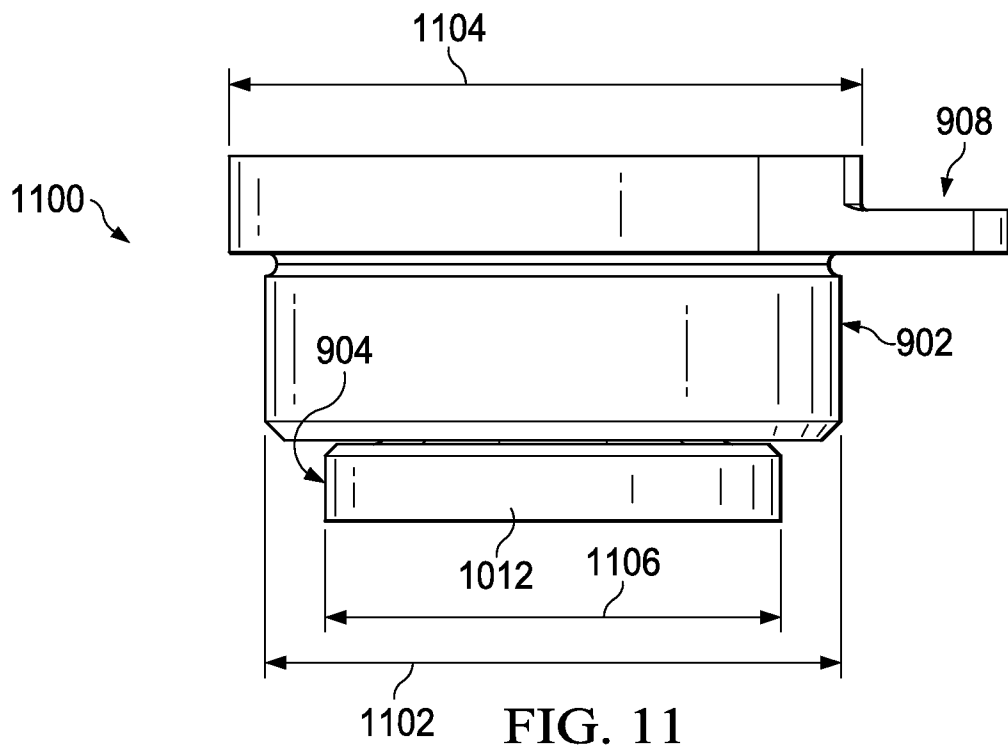


FIG. 11

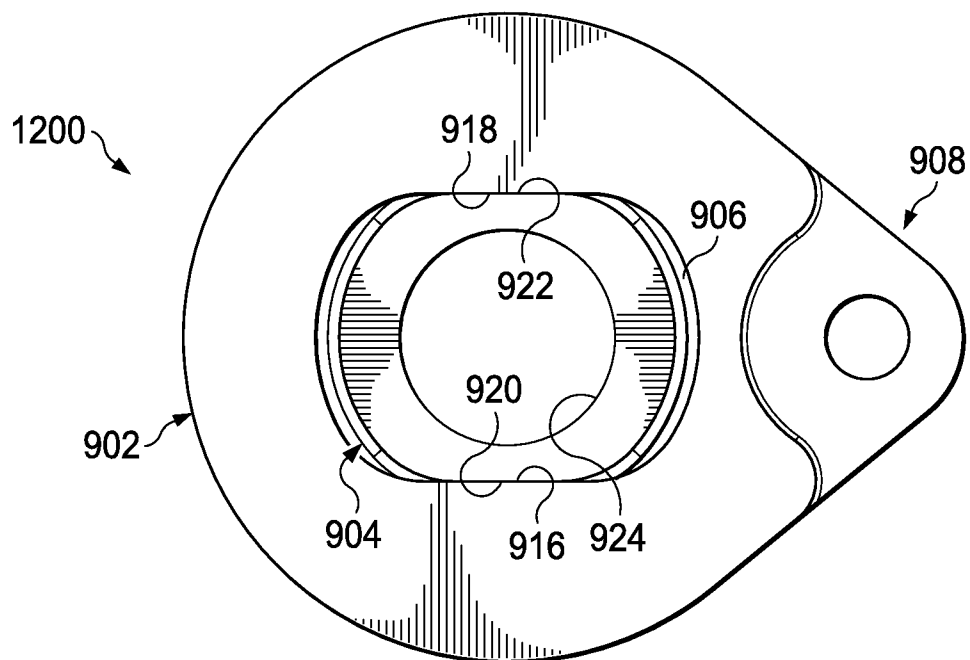


FIG. 12

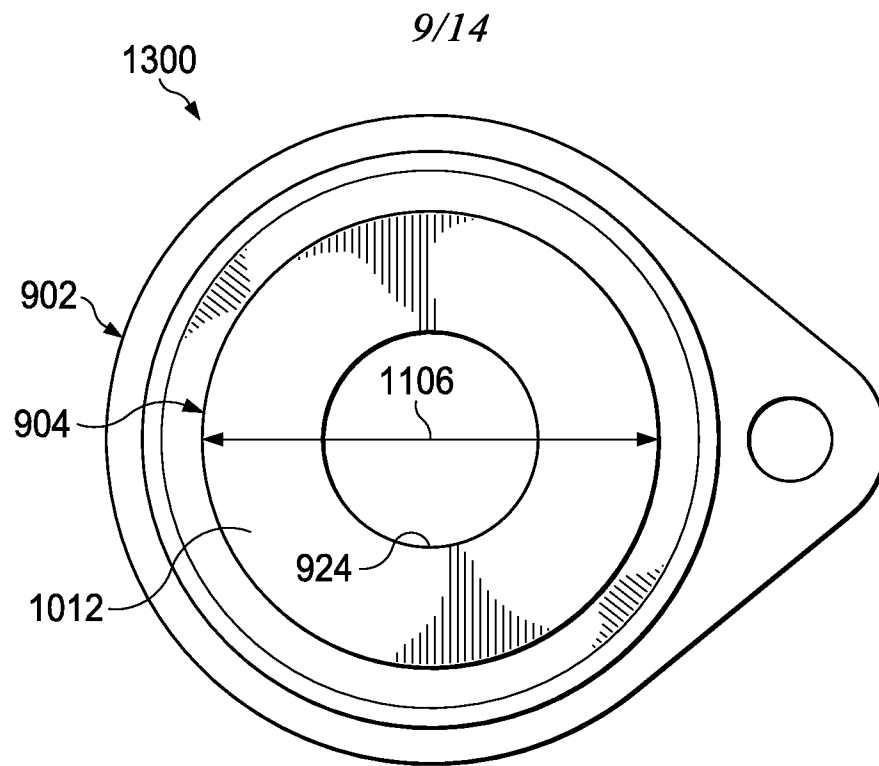


FIG. 13

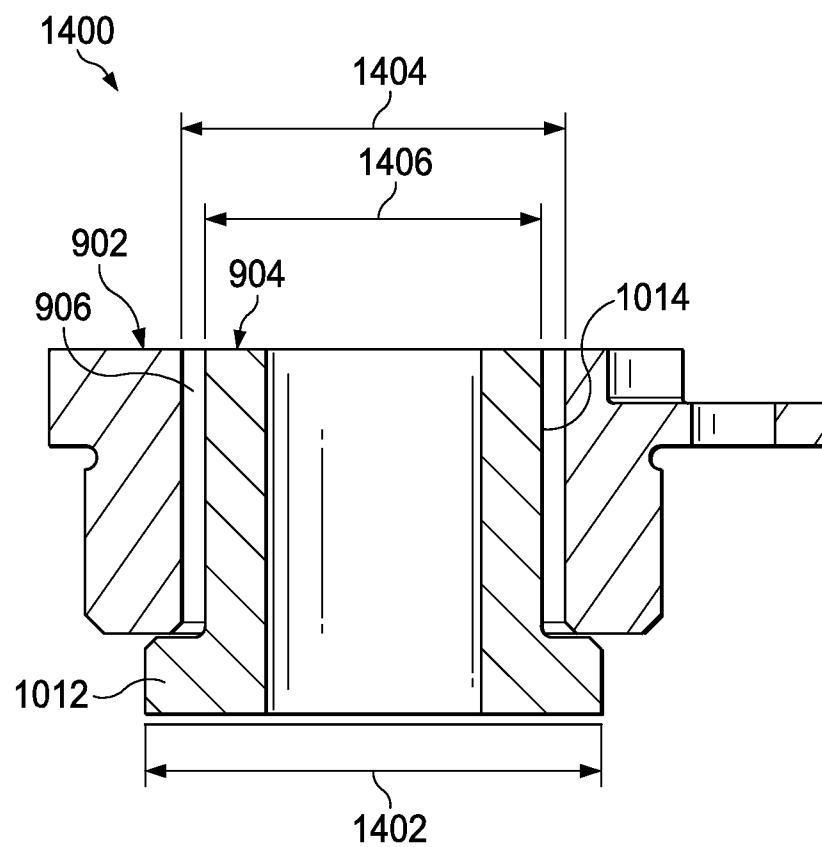


FIG. 14

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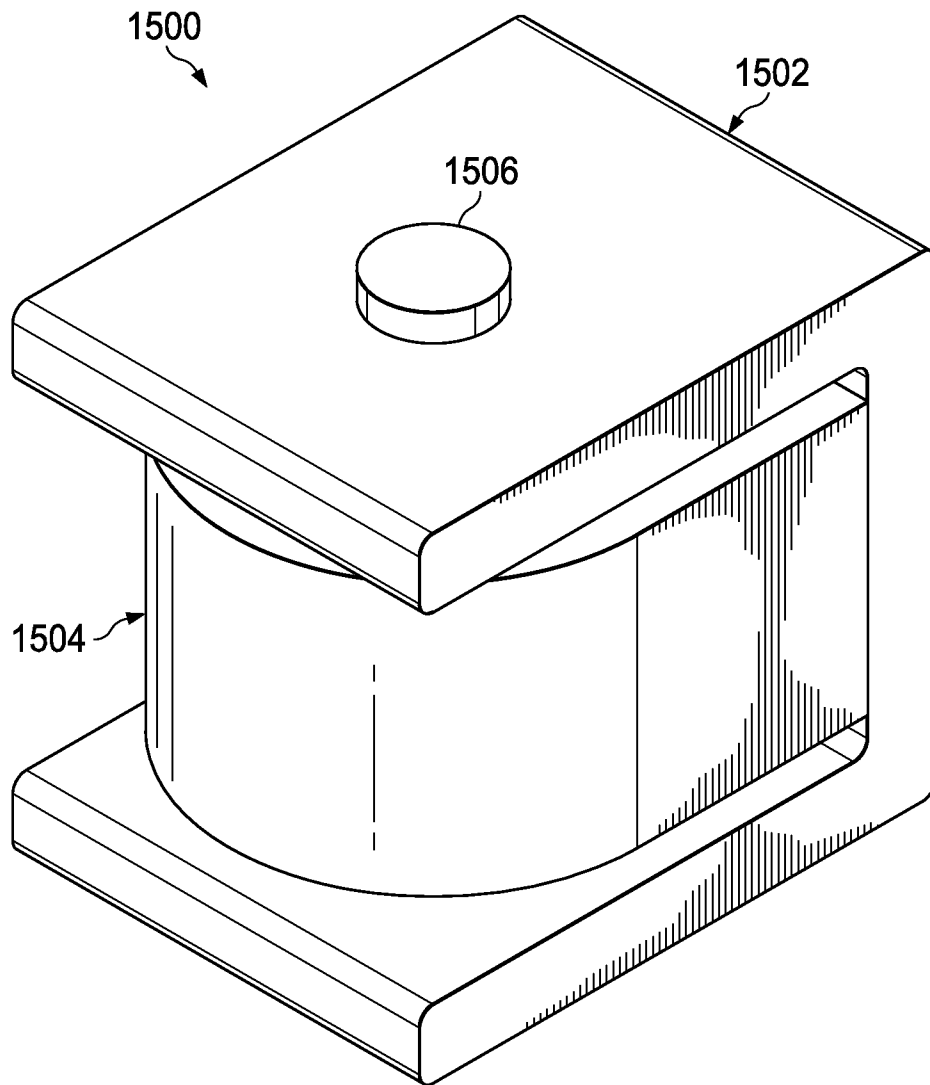


FIG. 15

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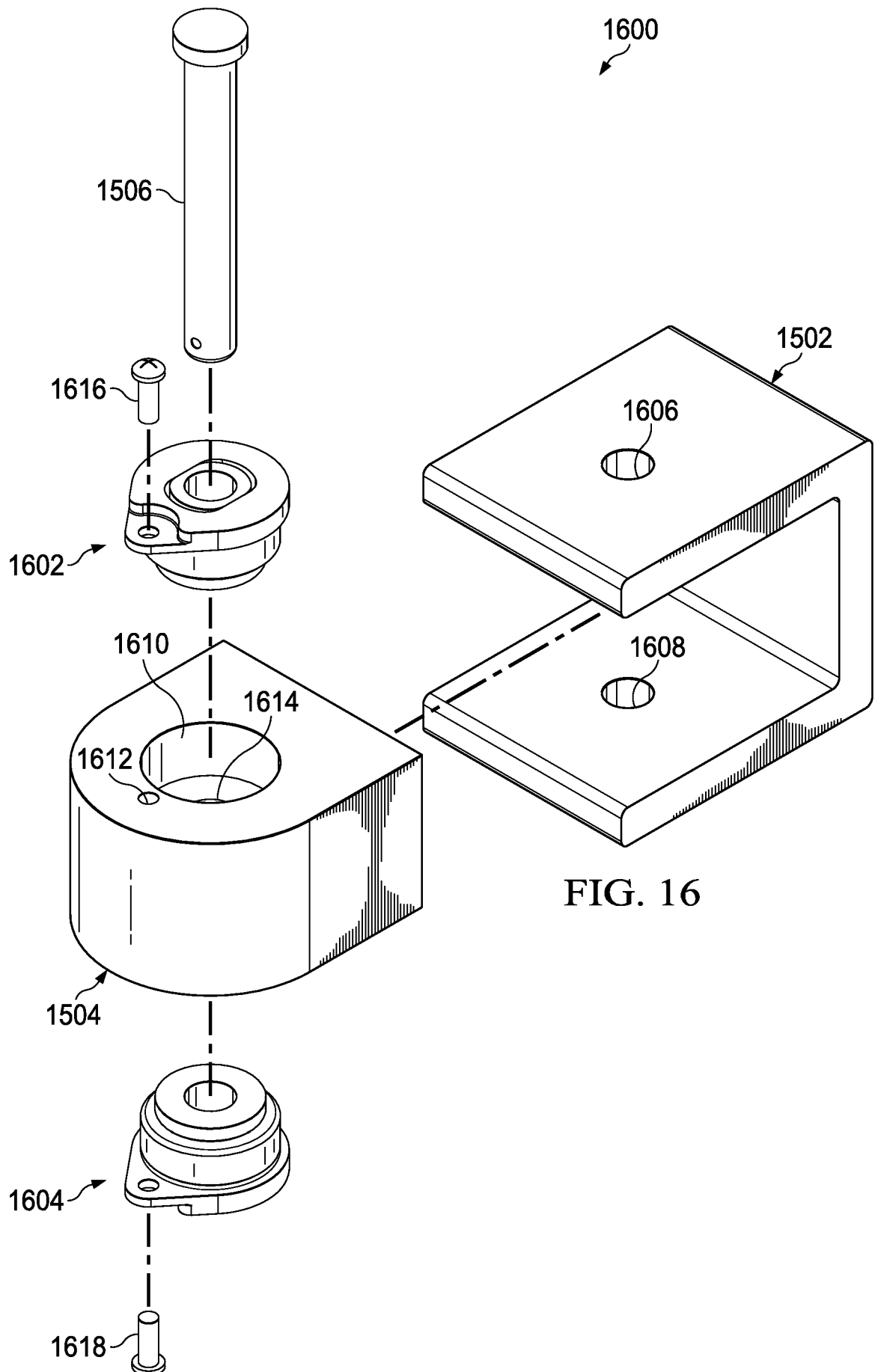


FIG. 16

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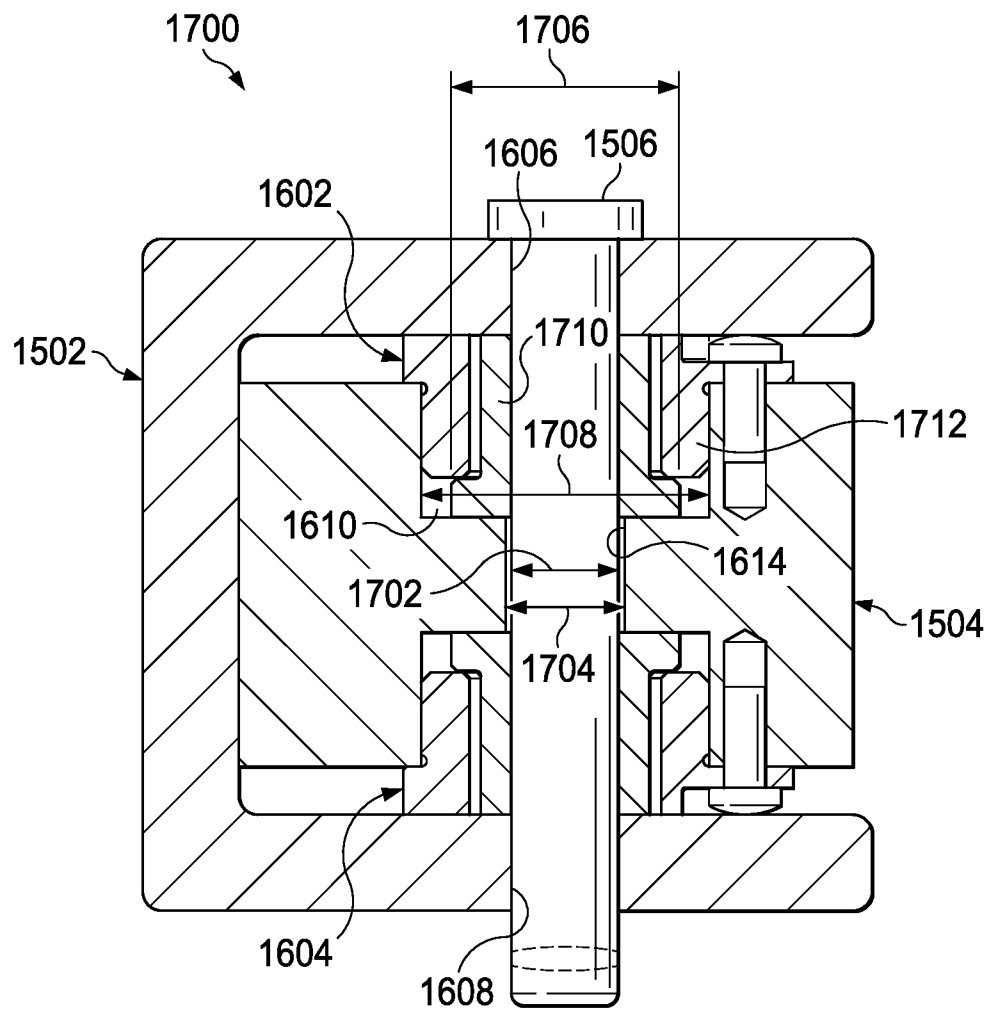


FIG. 17

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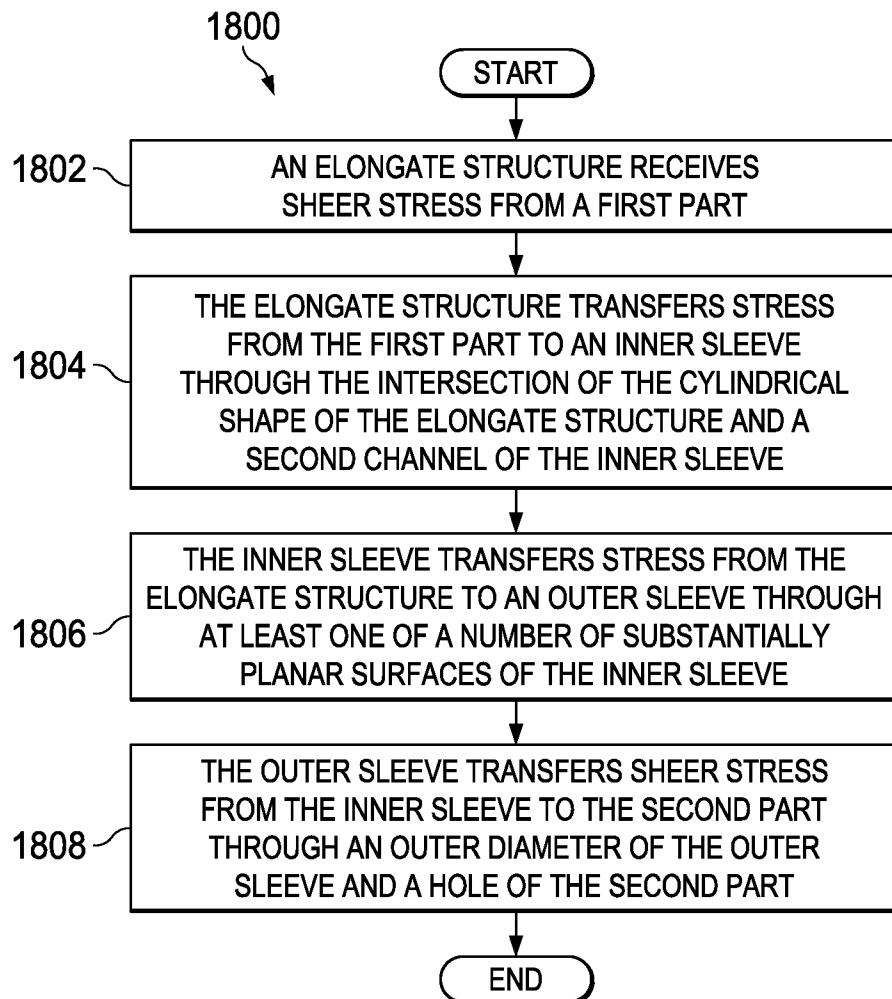


FIG. 18

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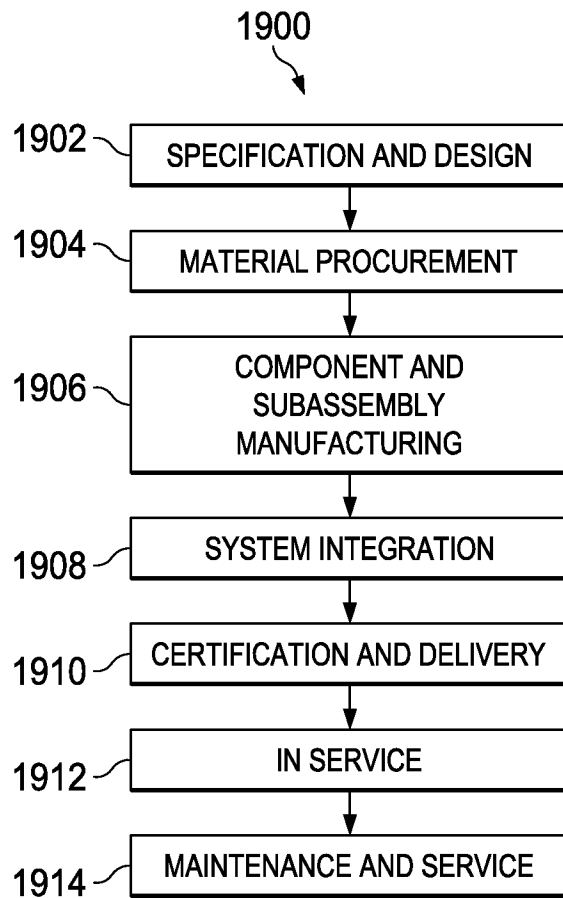


FIG. 19

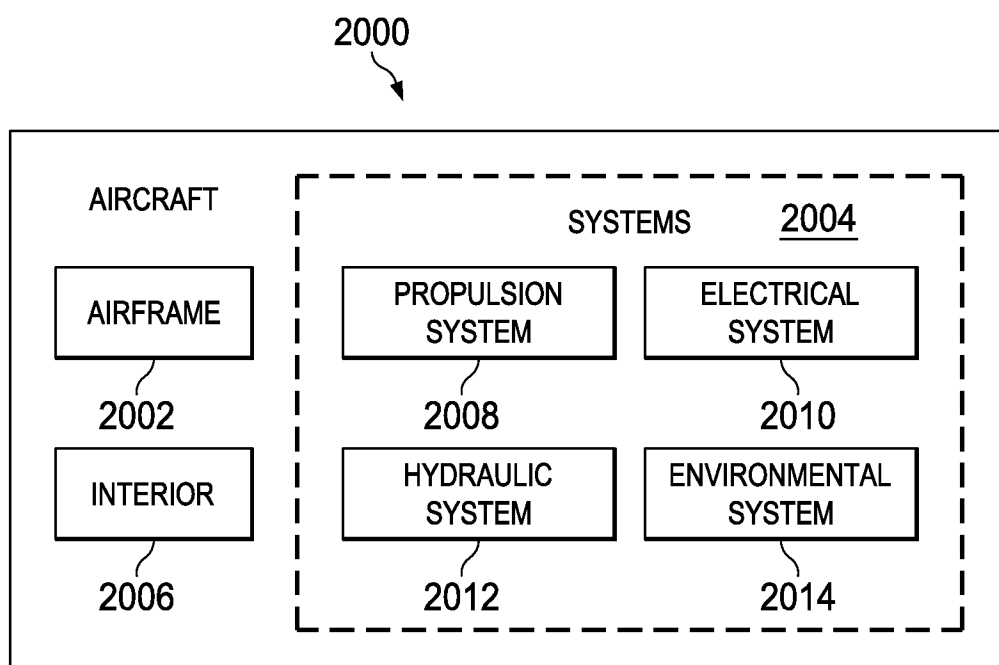


FIG. 20

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/075920

A. CLASSIFICATION OF SUBJECT MATTER
INV. F16B5/02
ADD.

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)

F16B F16C B64C B64F B60G

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 practicable, search terms used)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2010/033149 A2 (MCCLURE TRAVIS [US]) 25 March 2010 (2010-03-25)	1-11
Y	figures 1-3,4A,4B,4C page 10, line 26 - page 11, line 7 page 14, line 27 - page 15, line 30 -----	12-14
X	CN 201 613 517 U (CHENGDU AIRCRAFT INDUSTRIAL GROUP CO. LTD) 27 October 2010 (2010-10-27) figures 1,2 paragraphs [0002], [0004], [0005], [0009] abstract ----- -/--	1,2,4,5, 8,9,15

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

☒ See patent family annex.

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Date of the actual completion of the international search

2 April 2014

Date of mailing of the international search report

10/04/2014

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Authorized officer

Schandel, Yannick

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2013/075920

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	figures 1-4 page 3, lines 4-6,22-26 page 5, lines 1-5 page 7, lines 4-30 page 8, lines 9-11 -----	15
Y	AU 496 094 B2 (JOHN EDWORTH NILSSON) 9 December 1976 (1976-12-09) figure 1 page 6, lines 25-28 -----	12-14
Y	GB 478 369 A (OLIVER EDWIN SIMMONDS; SIMMONDS DEV CORP LTD) 18 January 1938 (1938-01-18) figures 1-3 page 1, lines 12-72, 83-86, 93-103 page 2, lines 37-45, 56-81, 93-94 page 3, lines 4-18, 51-73 -----	15

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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