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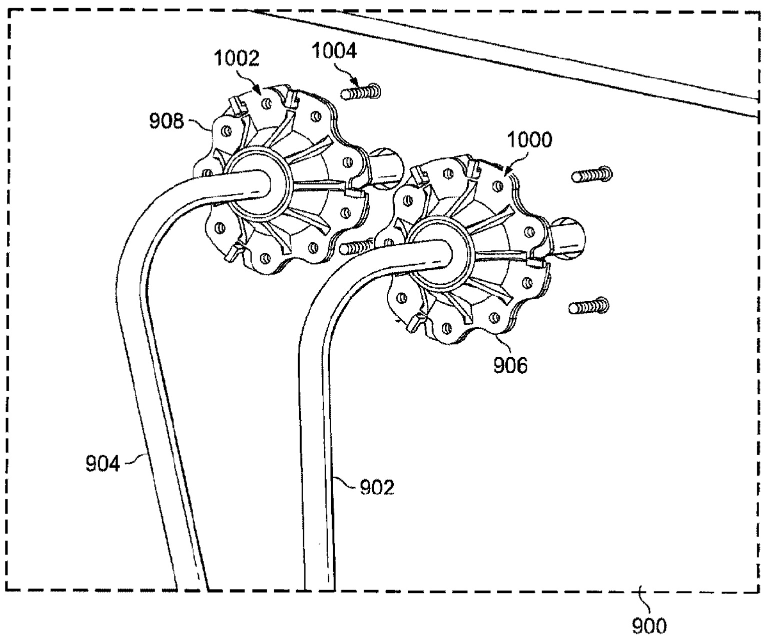
(54) **Titre : ASSEMBLAGE DE SUPPORT D'ELEMENT DE TRANSPORT**
(54) **Title: TRANSPORT ELEMENT SUPPORT ASSEMBLY**



(57) **Abrégé/Abstract:**
A transport element support assembly comprises a front plate, a back plate, and a grommet. The front plate has a first opening and a first set of holes. The back plate has a second opening and a second set of holes. A chamber is formed by the first opening and the second opening and is configured to hold a transport element. The grommet is positioned within the chamber. The transport element support assembly formed by the front plate, the back plate, and the grommet is configured to provide electrical isolation between the transport element and an aircraft structure.

ABSTRACT

A transport element support assembly comprises a front plate, a back plate, and a grommet. The front plate has a first opening and a first set of holes. The back plate has a second opening and a second set of holes. A chamber is formed by the first opening and the second opening and is configured to hold a transport element. The grommet is positioned within the chamber. The transport element support assembly formed by the front plate, the back plate, and the grommet is configured to provide electrical isolation between the transport element and an aircraft structure.

TRANSPORT ELEMENT SUPPORT ASSEMBLY

BACKGROUND INFORMATION

1. Field:

The present disclosure relates generally to transport elements for aircraft applications. More specifically, the present disclosure relates to a transport element support assembly that maintains electrical isolation between a transport element and a supporting structure and secures the transport element to the supporting structure.

2. Background:

Various transport systems are used during operation of an aircraft to move fluid or electricity from one place to another. When these transport systems contain fluid, that fluid may be fuel, hydraulic fluid, or gas. The fluid is often stored in tanks and moves through transport elements running about the aircraft. The transport elements pass through openings in support structures in their path.

During operation, the aircraft may be exposed to electromagnetic events. To protect systems from decompensation, combustion, and damage, Federal Aviation Administration regulations require aircraft manufacturers to ensure that no sparking occurs in flammable zones of the aircraft. To comply with these regulations, aircraft manufacturers must ground or isolate metal objects in the flammable zones. In many cases, assemblies having electrically isolating material are installed around transport elements to prevent sparking.

Transport systems also have separate fittings used to support and restrain the transport element as it flexes under the conditions of aircraft operation. Hundreds of these fittings are installed in an aircraft. A fitting may contain multiple parts that must be aligned and connected separately before system installation can begin. Each of these parts must adhere to predetermined electromagnetic effect requirements. Positioning and alignment of each assembly takes innumerable hours of manpower. Further, the number of parts involved may limit the structural support capability of the fitting. Manufacturing defects in the tube, the fitting, or the electrically isolating assembly may cause misalignment, resulting in more rework than desired.

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

SUMMARY

An illustrative embodiment of the present disclosure provides a transport element support assembly comprising a front plate, a back plate, and a grommet. The front plate has a first opening and a first set of holes. The back plate has a second opening and a second set of holes. A chamber is formed by the front plate and the back plate and is configured to hold a transport element. The grommet is positioned within the chamber. The tube support assembly formed by the front plate, the back plate, and the grommet is configured to provide electrical isolation between the transport element and an aircraft structure.

Another illustrative embodiment of the present disclosure provides a method for stabilizing a transport element in an aircraft structure. A transport element support assembly is positioned around the transport element. The transport element support assembly comprises a front plate, a back plate, and a grommet. The front plate has a first opening and a first set of holes. The back plate has a second opening and a second set of holes. A chamber is formed by the front plate and the back plate and configured to hold the transport element. The grommet is positioned within the chamber. The transport element support assembly is configured to provide electrical isolation between the transport element and the aircraft structure. The transport element is positioned in a hole in the aircraft structure.

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A further illustrative embodiment of the present disclosure provides a fluid system for an aircraft comprising a tube and a tube support assembly. Fluid flows through the tube. The tube support assembly comprises a front plate, a back plate, and a grommet. The front plate has a first opening and a first set of holes. The back plate has a second opening and a second set of holes. A chamber is formed by the front plate and the back plate and configured to hold the tube. The grommet is positioned within the chamber. The tube support assembly formed by the front plate, the back plate, and the grommet is configured to provide electrical isolation between the tube and an aircraft structure.

In one embodiment, there is provided a support assembly for a transport element. The support assembly comprises a front plate having a first opening and a first set of holes and a back plate having a second opening and a second set of holes. Alignment of the first set of holes and the second set of holes forms a support assembly hole pattern split into at least three hole pattern sets. Each of the at least three hole pattern sets is configured to match an aircraft hole pattern in an aircraft structure and each of the at least three hole pattern sets is configured to provide a different centerline of the transport element. The support assembly further comprises a chamber formed by the front plate and the back plate and configured to hold the transport element and a grommet positioned within the chamber.

In another embodiment, there is provided a method for stabilizing a transport element in an aircraft structure. The method comprises positioning a support assembly around the transport element. The support assembly comprises a front plate having a first opening and a first set of holes and a back plate having a second opening and a second set of holes. Alignment of the first set of holes and the second set of holes forms a support assembly hole pattern split into at least three hole pattern sets. Each of the at least three hole pattern sets is configured to match an aircraft hole pattern in an aircraft structure and each of the at least three hole pattern sets is configured to provide a different centerline of the transport element. The support assembly further comprises a chamber formed by the front plate and the back plate and configured to hold the

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transport element and a grommet positioned within the chamber. The method further comprises positioning the transport element in a hole in the aircraft structure.

In another embodiment, there is provided a fluid system for an aircraft comprising a tube and a support assembly comprising a front plate having a first opening and a first set of holes and a back plate having a second opening and a second set of holes. Alignment of the first set of holes and the second set of holes forms a support assembly hole pattern split into at least three hole pattern sets. Each of the at least three hole pattern sets is configured to match an aircraft hole pattern in an aircraft structure and each of the at least three hole pattern sets is configured to provide a different centerline of the tube. The support assembly further comprises a chamber formed by the front plate and the back plate and configured to hold the tube and a grommet positioned within the chamber.

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.

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BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the illustrative embodiments are set forth in the appended claims. The illustrative embodiments, and further 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 a perspective view of a wing of an aircraft in accordance with an illustrative embodiment;

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

Figure 3 is an illustration of an exploded view of pieces of a tube support assembly in accordance with an illustrative embodiment;

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Figure 4 is an illustration of a perspective view of a tube support assembly in accordance with an illustrative embodiment;

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

Figure 6 is an illustration of a back perspective view of a tube support assembly in accordance with an illustrative embodiment;

Figure 7 is an illustration of a front view of a tube support assembly in accordance with an illustrative embodiment;

Figure 8 is an illustration of a graph of tube centerline shift in accordance with an illustrative embodiment;

Figure 9 is an illustration of a section of a fluid system installed in a wing of an aircraft in accordance with an illustrative embodiment;

Figure 10 is an illustration of a more-detailed view of a fluid system positioned in a rib in accordance with an illustrative embodiment;

Figure 11 is an illustration of a back view of tube support assemblies installed in a rib in accordance with an illustrative embodiment;

Figure 12 is an illustration of an alternate implementation for a tube support assembly in accordance with an illustrative embodiment;

Figure 13 is an illustration of a tube support assembly installed in a rib in accordance with an illustrative embodiment;

Figure 14 is an illustration of a flowchart of a process for aligning and stabilizing a tube in an aircraft structure in accordance with an illustrative embodiment;

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Figure 15 is an illustration of a flowchart of a process for positioning a transport element support assembly in accordance with an illustrative embodiment;

Figure 16 is an illustration of a block diagram of an aircraft manufacturing and service method in accordance with an illustrative embodiment; and

Figure 17 is an illustration of an aircraft in which an illustrative embodiment may be implemented.

DETAILED DESCRIPTION

The illustrative embodiments recognize and take into account one or more different considerations. For example, the illustrative embodiments recognize and take into account that the manufacturing process for electrically isolating and supporting transport elements in aircraft is often more expensive and time consuming than desired. Current solutions employ one assembly that provides electrical isolation for the transport element and another fitting with multiple parts that supports and restrains the transport element within its surrounding structure.

Manually aligning and connecting multi-piece, complicated fittings takes significant assembly time. Positioning of the fitting may be difficult when installed in an aircraft structure. Any one of these parts may be misaligned beyond selected tolerances, slowing down the aircraft manufacturing process.

Misalignment of tubing upstream in the installation process may result in problems when attempting to reach a desired fit for a transport element running through the support structure. For example, if holes in the supporting structure are not drilled correctly, installation of the assembly may shift the transport element such that the desired level of preload reduction cannot be achieved. As another example, upstream installation offsets may result in transport elements that are out of alignment, resulting in rework.

Moreover, each part of an assembly must adhere to specific electromagnetic effect requirements. As a result, it may take more time than desired to design, manufacture, and implement these parts.

The disclosed embodiments relate to a transport element support assembly that combines electromagnetic isolation and structural support. The embodiments can be used in a wide variety of aircraft applications for stabilizing and protecting transport systems from electromagnetic effects.

With reference now to the figures and, in particular, with reference to **Figure 1**, an illustration of a perspective view of a wing of an aircraft is depicted in accordance with an illustrative embodiment. Wing **100** in aircraft **101** has ribs **102** and spars **104**. Transport system **106** runs through wing **100**. Transport system **106** has transport elements **108**. Transport elements **108** carry fluid through wing **100** in this illustrative example. In other illustrative examples, transport elements **108** may carry electricity or some other medium.

Transport elements **108** pass through ribs **102** in this illustrative example. Transport elements **108** may be secured to ribs **102** using transport element support assemblies (not shown in this view). Each one of the transport element support assemblies provides electrical isolation between transport element **108** and ribs **102**. The assemblies also provide structural support to hold transport element **108** in place.

Section **110** of wing **100** shows a portion of transport system **106**. Components in section **110** are shown in greater detail in **Figure 9**.

Turning now to **Figure 2**, an illustration of a block diagram of a manufacturing environment is depicted in accordance with an illustrative embodiment. Manufacturing environment **200** is an environment where transport element support assembly **202** may be manufactured for use in aircraft **204**. Transport element support assembly **202** may then be installed in aircraft **204**. Specifically, transport element support assembly **202** may be positioned around transport element **206** in transport system **208** and secured to aircraft structure **210** to provide electrical isolation **212** between transport element **206** and aircraft structure **210**.

As depicted, transport system **208** comprises a series of transport elements **206** configured to move a medium from one place in the aircraft to another. That medium may take the form of, for example, without limitation, fluid, electricity, or some other medium. When fluid flows through transport system **208**, transport element **206** takes the form of tube **207** and transport element support assembly **202** takes the form of tube support assembly **211**.

In an illustrative example, aircraft structure **210** may be any type of aerospace structure through which transport elements in transport system **208** pass. Aircraft structure **210** is located in wing **214** in this illustrative example. In other examples, aircraft structure **210** may be located in an engine, a compartment, a housing, a tank, a cabin, a waste system, or other portions of aircraft **204**.

Aircraft structure **210** may be a rib, a spar, an engine nacelle, a muffler, a panel, a portion of the fuselage, or any other type of aerospace structure where tube support assembly **202** may be used. In this illustrative example, aircraft structure **210** takes the form of rib **216**.

Aircraft structure **210** has hole pattern **218** and opening **220**. Opening **220** is configured for transport element **206** to pass through. Hole pattern **218** is formed from a number of holes surrounding opening **220**. As used herein, "a number of" when used with reference to items means one or more items. Thus, a number of holes include one or more holes. Hole pattern **218** in aircraft structure **210** has three holes in this illustrative example.

At least one of fluid **222** or electricity **223** flows through transport element **206**. Fluid **222** may be selected from at least one of a fuel, a gas, a hydraulic fluid, or some other type of fluid. The shape, size, diameter, wall thickness, and material for transport element **206** may be selected to comply with aircraft regulations or manufacturing specifications, depending on the type of fluid **222** flowing through transport element **206**.

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. In other words, "at least one of" means any combination of items and number of items may be used from the list, but not all of the items in the list are required. The item may be a particular object, a thing, or a category.

For example, "at least one of item A, item B, or item C" may include, without limitation, item A, item A and item B, or item B. This example also may include item A, item B, and item C, or item B and item C. Of course, any combination of these items may be present. In other examples, "at least one of" may be, for example, without limitation, two of item A, one of item B, and ten of item C; four of item B and seven of item C; or other suitable combinations.

In this illustrative example, transport element **206** has centerline **224**. Centerline **224** is the axis that runs longitudinally along transport element **206** through the midpoint of its diameter. Centerline **224** may have nominal position **225**. Nominal position **225** is a desired position for transport element **206** within opening **220** in aircraft structure **210**. Nominal position **225** represents a position where there is no shift in centerline **224**.

During installation of transport element **206** in aircraft structure **210**, centerline **224** may be adjusted in one or more direction. For example, to ensure transport element **206** is installed in aircraft structure **210** to have desired tolerances **226**, centerline **224** of transport element **206** may be moved in at least one of lateral direction **228** or vertical direction **230**. Desired tolerances **226** represent tolerances for centerline **224** of transport element **206** that maintain a desired location for transport element **206** within aircraft structure **210**.

Electrical isolation **212** is desirable to prevent sparking from electromagnetic effects **232**. Electromagnetic effects **232** may result from an electromagnetic event such as a lightning strike during operation of aircraft **204**. Electromagnetic effects **232** may result from other events as well.

In this illustrative example, transport element support assembly **202** comprises front plate **234**, back plate **236**, and grommet **240**. Chamber **238** is formed by the shape of front plate **234** and back plate **236** when put together.

Front plate **234** and back plate **236** may comprise dielectric material **241**. Dielectric material **241** may be selected from at least one of a polyether ether ketone, a ceramic, or other suitable materials.

As depicted, transport element support assembly **202** formed by front plate **234**, back plate **236**, and grommet **240** is configured to provide electrical isolation **212** between transport element **206** and aircraft structure **210**. Transport element support assembly **202** is also configured to secure transport element **206** within aircraft structure **210**.

Front plate **234** has first opening **242** and first set of holes **244**. Back plate **236** has second opening **246** and second set of holes **248**. Back plate **236** is configured to be positioned against surface **235** of aircraft structure **210** when installed.

Hole pattern **243** is formed by alignment **245** of first set of holes **244** and second set of holes **248**. Hole pattern **243** is configured to match hole pattern **218** in aircraft structure **210**.

Chamber **238** is formed when front plate **234** and back plate **236** interface with one another. Chamber **238** is configured to hold grommet **240**. In other words, transport element **206** passes through grommet **240**. Grommet **240** may be comprised of a material selected from at least one of a metal, a rubber, polytetrafluoroethylene, or some other suitable material.

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Transport element support assembly **202** also may include alignment features **250** and key **252**. Alignment features **250** are configured to align front plate **234** to back plate **236** such that first set of holes **244** remains aligned to second set of holes **248**. Alignment features **250** may include pins, tabs, clips, flanges, interference fit structures, bolts, collars, or other types of alignment features.

Alignment features **250** ensure that rotation **253** of tube support assembly **202** rotates front plate **234**, back plate **236**, and grommet **240** simultaneously. For example, during installation, grommet **240** may be placed in chamber **238** when front plate **234** and back plate **236** are put together. Twisting of front plate **234** and back plate **236** may result in locking the two pieces together such that tube support assembly **202** may be rotated as one part.

Key **252** represents a configuration of transport element support assembly **202** where centerline **224** of tube **206** is in nominal position **225**. In this illustrative example, key **252** is an indicator of positioning with reference to centerline **224**. Key **252** may be a number, a slit, a letter, a symbol, or some other suitable type of indicator.

In this illustrative example, back plate **236** may have flange **254** with circular shape **256** and angle **258** configured to hold grommet **240** in place. Front plate **234** may have recess **260** having angle **262** configured to hold grommet **240** in place. For example, circular shape **256** and angle **258** of flange **254** coupled with recess **260** and angle **262** in front plate **234** may form a shape for chamber **238** such that grommet **240** fits securely within chamber **238**.

Rotation **253** of transport element support assembly **202** as a whole adjusts centerline **224** of transport element **206** in at least one of lateral direction **228** or vertical direction **230** in this illustrative example. In particular, rotation **253** of transport element support assembly **202** adjusts centerline **224** of transport element **206** in at least one of lateral direction **228** or vertical direction **230** within selected tolerances **226**. Rotation **253** creates desired fit **264** between transport element support assembly **202** and aircraft structure **210**.

In an illustrative example, rotation **253** may be needed to create desired fit **264** on fasteners (e.g., studs) placed in the holes in aircraft structure **210**. For instance, if upstream manufacturing defects or misalignment creates problems with fitting, transport element support assembly **202** may simply be rotated to attain desired fit **264**, without additional rework.

In some examples, transport element support assembly **202** may include fastener system **266**. Fastener system **266** may be configured to secure transport element support assembly **202** to aircraft structure **210** after rotation **253** is completed. In an illustrative example, fastener system does not touch transport element **206**. As a result, the components in fastener system **266** do not need electromagnetic effect protection.

Fastener system **266** may include one or more fasteners, collars, and other suitable components. For example, fastener system **266** may include the studs placed through holes forming hole pattern **218** in aircraft structure **210**. During installation, transport element support assembly **202** may be placed on the studs in a desired manner. Once placed on the studs, transport element support assembly **202** may be further secured to aircraft structure **210** using collars in fastener system **266**.

With an illustrative embodiment, manufacturing and installation of transport system **208** may take less time than with currently used systems. Transport element support assembly **202** is both a clamp and a bracket that provides electromagnetic isolation and support for transport element **206** in one mechanism. Additionally, transport element support assembly **202** is designed such that it may be rotated to create a desired fit within selected tolerances for centerline **224** of transport element **206**, taking into account possible manufacturing and installation defects.

An illustrative embodiment eliminates the need for various parts to have separate electromagnetic effect protection. Electromagnetic isolation is achieved

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from transport element support assembly **202** alone. Hole pattern **243** in transport element support assembly **202** may be designed and adjusted to provide a desired location for the transport element. The distance between holes and the number of holes in hole pattern **243** may be changed to provide a desired level of performance, centerline shift, and ease of install, depending on the particular implementation.

With reference next to **Figure 3**, an illustration of an exploded view of pieces of a tube support assembly is depicted in accordance with an illustrative embodiment. **Figure 3** depicts an example of one implementation for transport element support assembly **202** shown in block form in **Figure 2**.

As depicted, tube support assembly **300** has front plate **302**, back plate **304**, and grommet **306**. Front plate **302**, back plate **304**, and grommet **306** are illustrative examples of implementations for front plate **234**, back plate **236**, and grommet **240** in **Figure 2**, respectively.

Front plate **302** has flange **308**, opening **310**, slits **312**, and holes **313**. In this illustrative example, flange **308** protrudes from the surface of front plate **302**. Flange **308** protrudes at angle **314**. Angle **314** has a shape that corresponds to the shape of portion **316** of grommet **306** such that grommet **306** interfaces securely with front plate **302**.

In this illustrative example, back plate **304** has flange **318**, opening **320**, alignment features **322**, and holes **323**. Flange **318** protrudes from the surface of back plate **304**. Flange **318** protrudes at angle **324**. Angle **324** has a shape that corresponds to the shape of portion **326** of grommet **306** such that grommet **306** interfaces securely with back plate **304**. Both front plate **302** and back plate **304** each have nine holes in this illustrative example, but other numbers are possible.

Alignment features **322** include tab **328**, tab **329**, tab **330**, and tab **331**. Tab **328**, tab **329**, tab **330**, and tab **331** in back plate **304** correspond to slit **332**, slit **334**, slit **336**, and slit **338**, respectively, in front plate **302**. During installation, grommet **306** is positioned in the chamber formed by front plate **302** and back plate **304**. Each tab in back plate **304** is placed within its corresponding slit in front plate **302**. Front plate **302** is then rotated counterclockwise to align holes **313** with holes **323**.

Figures 4-6 show different views of tube support assembly **300** once it has been aligned. In some cases, front plate **302** and back plate **304** may be locked together allowing all pieces to be rotated as one during installation around a tube passing through an aircraft structure.

Figure 4 shows a front perspective view of tube support assembly **300** from **Figure 3**. Chamber **400** and key **402** are shown in this illustrative example. Chamber **400** is formed by front plate **302** and back plate **304**. A tube (not shown) will pass through grommet **306** when installed in an aircraft structure.

As depicted, key **402** has three indicators. Indicator **404** represents the nominal position. If indicator **404** is at the top most position during installation, the centerline of the tube will be in the nominal position.

Indicator **406** represents the positive position while indicator **408** represents the negative position.

Figure 5 depicts a side view of tube support assembly **300** in the direction of view lines **5-5** in **Figure 4**. **Figure 6** depicts a back view of tube support assembly **300** in the direction of view lines **6-6** in **Figure 4**.

With reference next to **Figure 7**, a front view of tube support assembly **300** is shown in the direction of view lines **7-7** in **Figure 3**. As shown in this view, holes **313** and holes **323** have been aligned to form hole pattern **700**.

During installation, tube support assembly **300** may be rotated in the direction of arrow **701** to attain a desired fit on the aircraft structure. **Figure 8** shows a graph of the movement of the centerline of the tube corresponding with each rotation. Graph **800** in **Figure 8** shows centerline movement in both the lateral direction and the vertical direction to achieve transport element location, manufacturing specifications, and support. Graph **800** shows axis **801**, axis **802**, and axis **803**. Axis

801 represents the z-axis, axis **802** represents the x-axis and axis **803** represents the y-axis.

In this illustrative example, tube support assembly **300** is designed such that centerline movement in the lateral direction is limited to +/- **.0693** inches. Movement in the vertical direction is limited to +/- **.08** inches. In other illustrative examples, centerline movement in either direction may be limited to more or less, depending on the particular implementation.

In this illustrative example, hole pattern **700** includes hole **702**, hole **704**, hole **706**, hole **708**, hole **710**, hole **712**, hole **714**, hole **716**, and hole **718**. Hole pattern **700** is split into three sets in this illustrative example. Each set has three holes that correspond to a hole pattern in an aircraft structure. In particular, a set of holes will fit on studs installed in an aircraft structure. Only three studs are used during installation in this illustrative example. Accordingly, only three holes are used. The other holes remain empty in this particular example.

As depicted, hole **702**, hole **708**, and hole **714** form a first set of holes. If any of these holes are aligned at the top most position of tube support assembly **300** during installation, the centerline of the tube will be in nominal position **804**.

Hole **704**, hole **710**, and hole **716** form a second set of holes. When hole **704** is in the uppermost position, the centerline of the tube is in position **806**. When hole **710** is in the uppermost position, the centerline of the tube is in position **808**. When hole **716** is in the uppermost position, the centerline of the tube will be in position **810**.

Hole **706**, hole **712**, and hole **718** form a third set of holes. When hole **706** is in the uppermost position, the centerline of the tube is in position **812**. When hole **712** is in the uppermost position, the centerline of the tube is in position **814**. When hole **718** is in the uppermost position, the centerline of the tube is in position **816**.

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Tube support assembly **300** as depicted in **Figures 3-7** may be configured for use with tubes carrying hydraulic fluid. The design of each tube support assembly may be modified depending on the type of fluid in each tube.

Turning now to **Figure 9**, an illustration of a section of a fluid system installed in a wing of aircraft is depicted in accordance with an illustrative embodiment. **Figure 9** depicts a more-detailed view of section **110** of transport system **106** shown in **Figure 1**.

In this illustrative example, transport elements **108** pass through rib **900** in wing **100**. Transport elements **108** include tube **902** and tube **904**. Tube support assembly **906** has been positioned around tube **902**. Tube support assembly **908** has been positioned around tube **904**. Tube support assembly **906** and **908** are examples of implementations for transport element support assembly **202** shown in block form in **Figure 2**. Both tube support assembly **906** and tube support assembly **908** contain the features and functions depicted with reference to tube support assembly **300** shown in **Figures 3-7**.

In **Figure 10**, a more detailed view of a transport system positioned in a rib is depicted in accordance with an illustrative embodiment. Transport system **106** is shown in the direction of view lines **10-10** in **Figure 9**. Transport system **106** is a fluid system having tubing in this illustrative example.

As depicted, rib **900** has hole pattern **1000** and hole pattern **1002**. Tube support assembly **906** may be rotated to create a desired fit for hole pattern **1000**, shifting the centerline of tube **902** as necessary and within desired tolerances. Tube support assembly **908** may be rotated to create a desired fit for hole pattern **1002**, shifting the centerline of tube **904** as necessary and within desired tolerances.

In this illustrative example, fastener system **1004** is shown installed in rib **900**. Fastener system **1004** includes studs placed in hole pattern **1002** of rib **900**. Tube support assembly **908** will be aligned with the studs, fit flush against rib **900**, and secured with collars in later manufacturing steps.

Figure 11 depicts a back view of tube support assembly **906** and tube support assembly **908** installed in rib **900**. Fluid system **106** is shown in the direction of view lines **11-11** in **Figure 9**.

Turning next to **Figure 12**, an illustration of an alternate implementation for a tube support assembly is depicted in accordance with an illustrative embodiment. Tube support assembly **1200** is another example of an implementation for tube support assembly **202** shown in block form in **Figure 2**.

Tube support assembly **1200** includes front plate **1202**, back plate **1204**, and grommet **1206**. Front plate **1202** has holes **1208** and back plate **1204** has holes **1210**. The pieces of tube support assembly **1200** are put together such that holes **1208** and holes **1210** create a hole pattern that corresponds to a hole pattern in a rib. Back plate **1204** sits flush on the surface of rib **1300** shown in **Figure 13**.

Figure 13 depicts a tube support assembly installed in a rib in accordance with an illustrative embodiment. Tube **1302** is positioned within chamber **1212** formed by front plate **1202**, back plate **1204**, and grommet **1206**. Tube **1302** may carry fuel in this illustrative example. Accordingly, tube support assembly **1200** may be configured for use with tubes that carry fuel. Tube support assembly **1200** is secured to rib **1300** using fastener system **1304**.

Wing **100** in **Figure 1** is only one physical implementation of a platform incorporating transport element support assembly **202** in **Figure 2**. Although the examples for an illustrative embodiment are described with respect to an aircraft, an illustrative embodiment may be applied to other types of platforms. Transport element support assembly **202** may be used in any platform where tubing is present. The platform may be, for example, a mobile platform, a stationary platform, a land-based structure, an aquatic-based structure, or a space-based structure. More specifically, the platform, may be 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

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bridge, a dam, a house, a manufacturing facility, a building, and other suitable platforms.

The different components shown in **Figure 1** and **Figures 3-13** 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 3-6** may be illustrative examples of how components shown in block form in **Figure 2** may be implemented as physical structures.

With reference next to **Figure 14**, an illustration of a flowchart of a process for aligning and stabilizing a tube in an aircraft structure is depicted in accordance with an illustrative embodiment. The method depicted in **Figure 14** may be used to install transport element support assembly **202** shown in **Figure 2**.

The process begins by positioning a transport element support assembly around a transport element (operation **1400**). The transport element support assembly comprises the components described with reference to **Figure 2**.

Next, the transport element is positioned in a hole in an aircraft structure (operation **1402**). A hole pattern in the transport element support assembly is aligned with a hole pattern in the aircraft structure (operation **1404**). Operation **1404** includes rotating the transport element support assembly to find a desired fit. Rotating the transport element support assembly adjusts a centerline of the transport element in at least one of the lateral direction or the vertical direction.

A back plate of the transport element support assembly is positioned against a surface of the aircraft structure (operation **1406**). Studs positioned within the holes in the rib pass through holes in the transport element support assembly to hold it in the desired position.

The transport element support assembly is fastened to the aircraft structure (operation **1408**), with the process terminating thereafter. Fastening of the transport element support assembly to the aircraft structure occurs after rotation is completed.

Turning to **Figure 15**, an illustration of a flowchart of a process for positioning a transport element support assembly is depicted in accordance with an illustrative embodiment. The method depicted in **Figure 15** may be used during operation **1404** shown in **Figure 14** to connect components in a transport element support assembly together.

The process begins by positioning a grommet within a chamber formed when a front plate and a back plate are placed together (operation **1500**). Next, a first set of holes in the front plate is aligned with a second set of holes in the back plate to create a hole pattern in the transport element support assembly (operation **1502**). The front plate and the back plate are then locked into place using locking mechanisms such that the hole pattern remains aligned during installation of the transport element support assembly in the aircraft structure (operation **1504**) with the process terminating thereafter.

The flowcharts and block diagrams in the different depicted illustrative embodiments illustrate the architecture, functionality, and operation of some possible implementations of apparatuses 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.

Illustrative embodiments of the disclosure may be described in the context of aircraft manufacturing and service method **1600** as shown in **Figure 16** and aircraft **1700** as shown in **Figure 17**. Turning first to **Figure 16**, 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 **1600** may include specification and design **1602** of aircraft **1700** in **Figure 17** and material procurement **1604**.

During production, component and subassembly manufacturing **1606** and system integration **1608** of aircraft **1700** in **Figure 17** takes place. Thereafter, aircraft **1700** in **Figure 17** may go through certification and delivery **1610** in order to be

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placed in service **1612**. While in service **1612** by a customer, aircraft **1700** in **Figure 17** is scheduled for routine maintenance and service **1614**, which may include modification, reconfiguration, refurbishment, and other maintenance or service.

Transport system **208** from **Figure 2** and the components within transport system **208** may be made during component and subassembly manufacturing **1606**. In addition, transport element support assembly **202** may be used in parts made for routine maintenance and service **1614** as part of a modification, reconfiguration, or refurbishment of aircraft **1700**.

Each of the processes of aircraft manufacturing and service method **1600** may be performed or carried out by a system integrator, a third party, an operator, or some combination thereof. 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 17**, an illustration of an aircraft is depicted in which an illustrative embodiment may be implemented. In this example, aircraft **1700** is produced by aircraft manufacturing and service method **1600** in **Figure 16** and may include airframe **1702** with plurality of systems **1704** and interior **1706**. Examples of systems **1704** include one or more of propulsion system **1708**, electrical system **1710**, hydraulic system **1712**, and environmental system **1714**. 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 **1600** in **Figure 16**.

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In one illustrative example, components or subassemblies produced in component and subassembly manufacturing **1606** in **Figure 16** may be fabricated or manufactured in a manner similar to components or subassemblies produced while aircraft **1700** is in service **1612** in **Figure 16**. As yet another example, one or more apparatus embodiments, method embodiments, or a combination thereof may be utilized during production stages, such as component and subassembly manufacturing **1606** and system integration **1608** in **Figure 16**. One or more apparatus embodiments, method embodiments, or a combination thereof may be utilized while aircraft **1700** is in service **1612,** during maintenance and service **1614** in **Figure 16**, or both. The use of a number of the different illustrative embodiments may substantially expedite the assembly of aircraft **1700,** reduce the cost of aircraft **1700**, or both expedite the assembly of aircraft **1700** and reduce the cost of aircraft **1700**.

The illustrative embodiments decrease transport system manufacturing and installation time. The transport element support assembly is a single structure that provides electromagnetic isolation, location adjustment, and support for a transport element. With components in the transport element support assembly secured, a mechanic can rotate the entire mechanism in order to achieve the desired alignment with respect to pre-drilled holes in the rib. As the assembly is rotated, the centerline of the transport element is moved. The design of the assembly makes sure that the transport element centerline only moves within a desired distance range. Since hundreds of these structures are installed in an aircraft, significant time savings will be realized.

Illustrative embodiments eliminate many of the components previously used to isolate and secure tubing. Further, the illustrative embodiments eliminate the need for each of the components to have separate electromagnetic effect protection. Electromagnetic isolation is achieved from transport element support assembly **202** alone.

Because rotation of the assembly offsets manufacturing defects and upstream alignment problems, less rework will be necessary during installation. Decreasing rework saves time, saves manpower, and drives down cost.

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.

The description of the different illustrative embodiments has been presented for purposes of illustration and description, 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 desirable 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 the particular use contemplated.

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EMBODIMENTS IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A support assembly for a transport element, the support assembly comprising:

a front plate having a first opening and a first set of holes;

a back plate having a second opening and a second set of holes, wherein:

alignment of the first set of holes and the second set of holes forms a support assembly hole pattern split into at least three hole pattern sets, and

each of the at least three hole pattern sets is configured to match an aircraft hole pattern in an aircraft structure and each of the at least three hole pattern sets is configured to provide a different centerline of the transport element;

a chamber formed by the front plate and the back plate and configured to hold the transport element; and

a grommet positioned within the chamber.

2. The support assembly of claim **1** further comprising:

alignment features configured to align the front plate to the back plate such that the first set of holes remains aligned to the second set of holes.

3. The support assembly of claim **2**, wherein the alignment features comprise at least one of pins, tabs, clips, flanges, interference fit structures, bolts, and collars.

4. The support assembly of any one of claims **1**-**3**, wherein the back plate has a flange with a circular shape and an angle configured to hold the grommet in place.

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5. The support assembly of any one of claims **1**-**4**, wherein the front plate has a recess with an angle configured to hold the grommet in place.

6. The support assembly of any one of claims **1**-**5** further comprising:

a key representing a configuration of the support assembly when the centerline of the transport element is in a nominal position.

7. The support assembly of any one of claims **1**-**6**, wherein the at least three hole pattern sets comprises three hole pattern sets.

8. The support assembly of any one of claims **1**-**7**, wherein a rotation of the support assembly such that one of the at least three hole pattern sets matches the aircraft hole pattern adjusts the centerline of the transport element in at least one of a lateral direction and a vertical direction.

9. The support assembly of claim **8**, wherein the rotation of the support assembly adjusts the centerline of the transport element in at least one of the lateral direction and the vertical direction within selected tolerances.

10. The support assembly claim **8** or **9**, wherein the rotation of the support assembly creates a desired fit between the support assembly and the aircraft structure.

11. The support assembly of any one of claims **1**-**10** further comprising:

a fastener system configured to secure the support assembly to the aircraft structure.

12. The support assembly of any one of claims **1**-**11**, wherein the front plate and the back plate abut each other.

13. The support assembly of any one of claims **1**-**12**, wherein the support assembly couples the transport element to the aircraft structure and a distance away from the aircraft structure to provide electrical isolation between the transport element and the aircraft structure.

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14. A method for stabilizing a transport element in an aircraft structure, the method comprising:

positioning a support assembly around the transport element, wherein the support assembly comprises:

a front plate having a first opening and a first set of holes;

a back plate having a second opening and a second set of holes, wherein:

alignment of the first set of holes and the second set of holes forms a support assembly hole pattern split into at least three hole pattern sets, and

each of the at least three hole pattern sets is configured to match an aircraft hole pattern in an aircraft structure and each of the at least three hole pattern sets is configured to provide a different centerline of the transport element;

a chamber formed by the front plate and the back plate and configured to hold the transport element; and

a grommet positioned within the chamber; and

positioning the transport element in a hole in the aircraft structure.

15. The method of claim **14**, wherein positioning the support assembly comprises:

aligning the first set of holes with the second set of holes to form the support assembly hole pattern.

16. The method of claim **15**, wherein positioning the support assembly comprises:

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fixing the aligned first set of holes and the second set of holes with at least one alignment feature such that the first set of holes remains aligned to the second set of holes during installation of the support assembly in the aircraft structure.

17. The method of claim **16**, wherein the at least one alignment feature comprises at least one of pins, tabs, clips, flanges, interference fit structures, bolts, and collars.

18. The method of any one of claims **14**-**17** further comprising:

positioning the back plate against a surface of the aircraft structure prior to aligning one of the at least three hole pattern sets with the aircraft hole pattern.

19. The method of claim **18**, wherein aligning the one of the at least three hole pattern sets comprises:

rotating the support assembly to find a desired fit, wherein rotating the support assembly adjusts the centerline of the transport element in at least one of a lateral direction and a vertical direction.

20. The method of claim **19**, wherein rotating the support assembly adjusts the centerline of the transport element in at least one of the lateral direction and the vertical direction within selected tolerances.

21. The method of claim **19** or **20** further comprising:

fastening the support assembly to the aircraft structure after rotating the support assembly.

22. The method of any one of claims **14**-**21**, wherein positioning the transport element in the hole comprises positioning the transport element in the hole a distance away from the aircraft structure using the support assembly to provide electrical isolation between the transport element and the aircraft structure.

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23. A fluid system for an aircraft comprising:

a tube; and

a support assembly comprising:

a front plate having a first opening and a first set of holes;

a back plate having a second opening and a second set of holes, wherein:

alignment of the first set of holes and the second set of holes forms a support assembly hole pattern split into at least three hole pattern sets, and

each of the at least three hole pattern sets is configured to match an aircraft hole pattern in an aircraft structure and each of the at least three hole pattern sets is configured to provide a different centerline of the tube;

a chamber formed by the front plate and the back plate and configured to hold the tube; and

a grommet positioned within the chamber.

24. The fluid system of claim **23**, wherein the support assembly further comprises:

alignment features configured to align the front plate to the back plate such that the first set of holes remains aligned to the second set of holes.

25. The fluid system of claim **24**, wherein the alignment features comprise pins, tabs, clips, flanges, interference fit structures, bolts, or collars.

26. The fluid system of any one of claims **23**-**25**, wherein the support assembly further comprises:

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a key representing a configuration of the support assembly when the centerline of the tube is in a nominal position.

27. The fluid system of any one of claims **23**-**26**, wherein the front plate and the back plate are positioned on a same side of the aircraft structure.

28. The fluid system of any one of claims **23**-**27**, wherein the back plate has a flange with a circular shape and an angle configured to hold the grommet in place.

29. The fluid system of any one of claims **23**-**28**, wherein the front plate has a recess with an angle configured to hold the grommet in place.

30. The fluid system of any one of claims **23**-**29**, wherein the front plate and the back plate abut each other.

31. The fluid system of any one of claims **23**-**30** further comprising:

a fastener system configured to secure the support assembly to the aircraft structure.

32. The fluid system of any one of claims **23**-**31**, wherein the support assembly couples the tube to the aircraft structure and a distance away from the aircraft structure to provide electrical isolation between the tube and the aircraft structure.

33. The fluid system of any one of claims **23**-**31**, wherein the aircraft structure is a rib and the support assembly couples the tube to the rib and a distance away from the rib to provide electrical isolation between the tube and the rib during an electromagnetic event.

34. The fluid system of any one of claims **23**-**33**, wherein a rotation of the support assembly such that one of the at least three hole pattern sets matches the aircraft hole pattern adjusts the centerline of the tube in at least one of a lateral direction and a vertical direction.

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35. The fluid system of claim **34**, wherein the rotation of the support assembly adjusts the centerline of the tube in at least one of the lateral direction and the vertical direction within selected tolerances.

36. The fluid system of claim **34** or **35**, wherein the rotation of the support assembly adjusts the centreline of the tube in at least one of the lateral direction and the vertical direction to create a desired fit between the support assembly and the aircraft structure.

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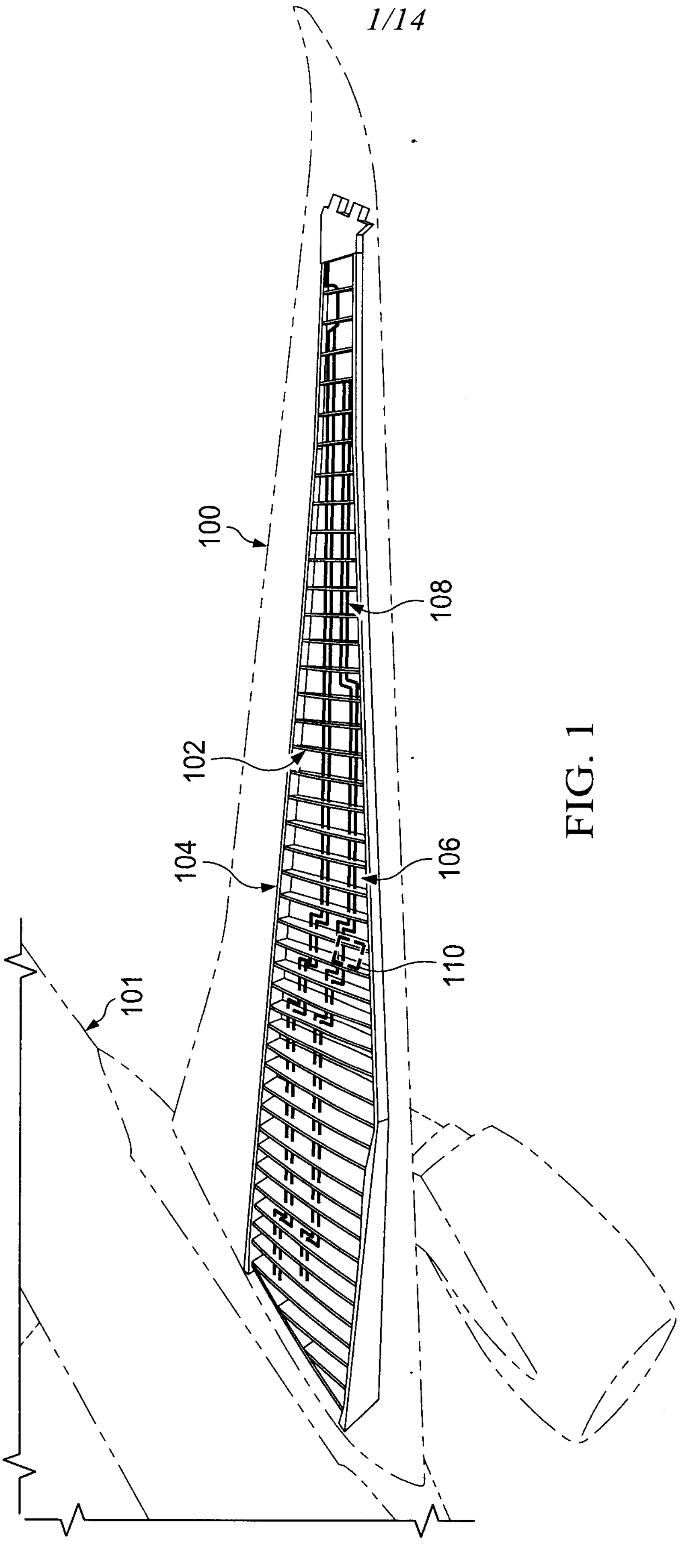
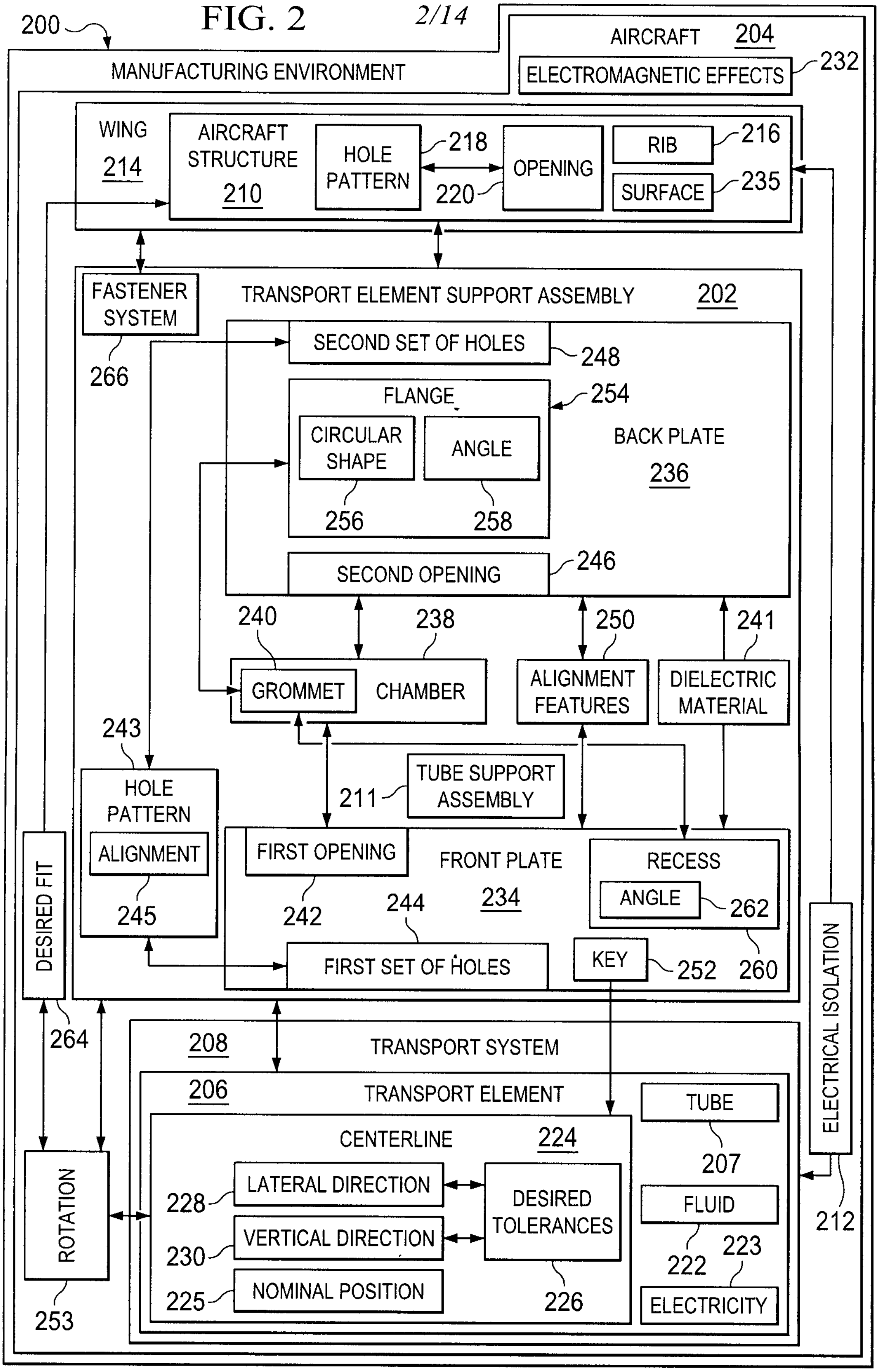


FIG. 1

FIG. 2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OPENING 220
RIB 216
SURFACE 235
FASTENER SYSTEM 266
TRANSPORT ELEMENT SUPPORT ASSEMBLY 202
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CIRCULAR SHAPE 256
ANGLE 258
BACK PLATE 236
SECOND OPENING 246
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CHAMBER
ALIGNMENT FEATURES
DIELECTRIC MATERIAL
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HOLE PATTERN
ALIGNMENT 245
211 TUBE SUPPORT ASSEMBLY
FIRST OPENING 242
244
FRONT PLATE 234
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ANGLE 262
FIRST SET OF HOLES
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DESIRED FIT 264
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208 TRANSPORT SYSTEM
206 TRANSPORT ELEMENT
CENTERLINE 224
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ROTATION 253

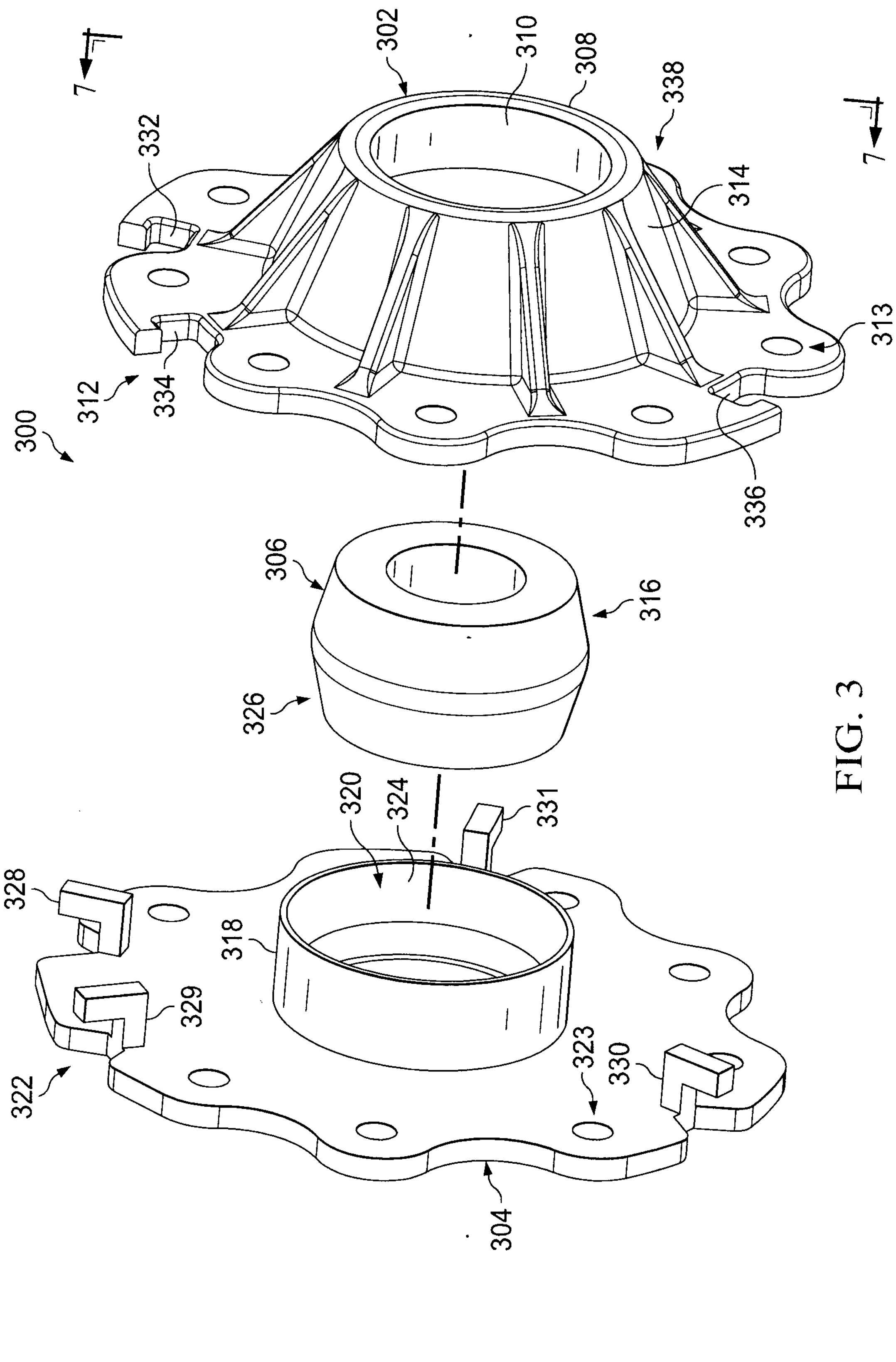
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FIG. 3

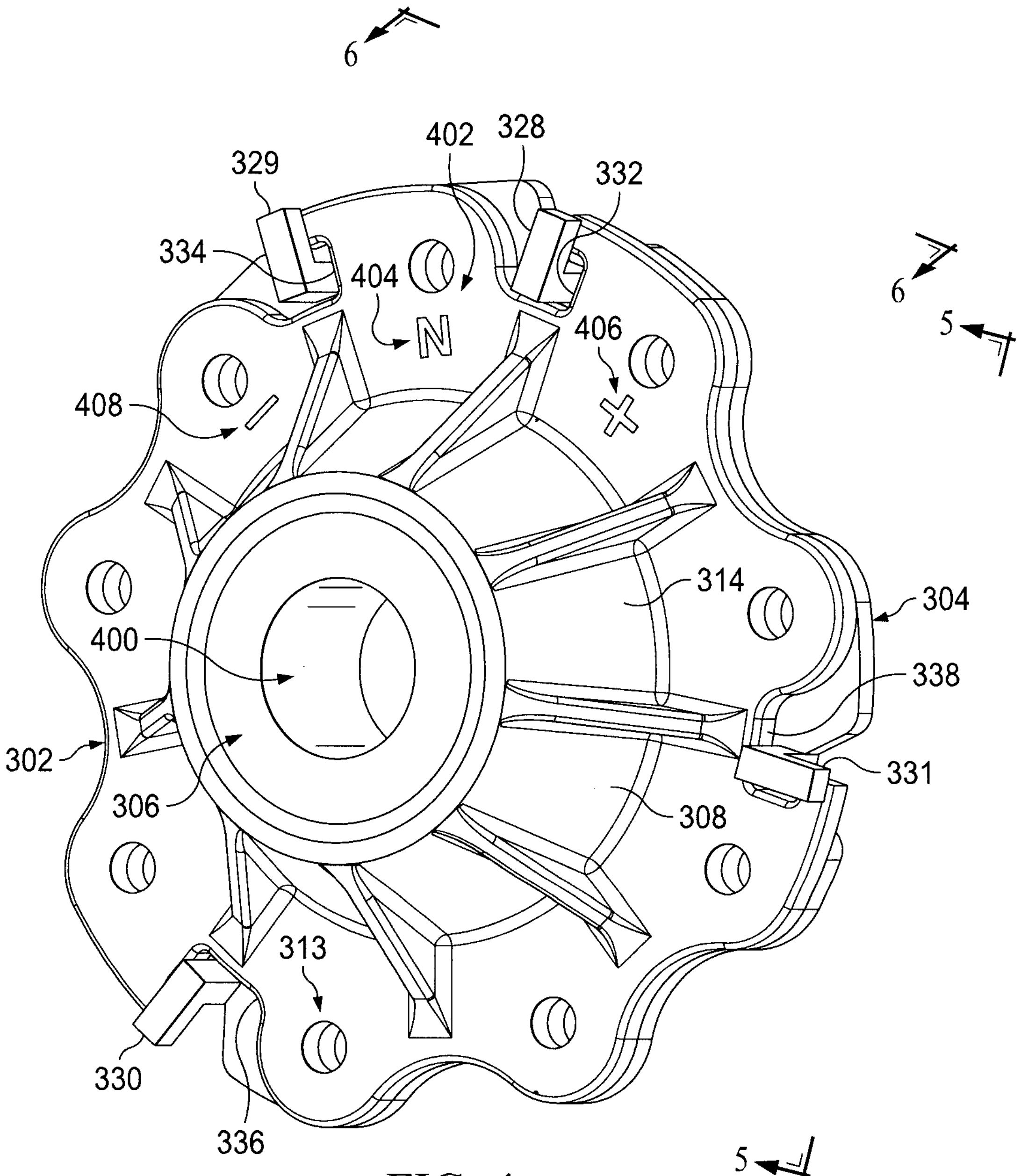
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FIG. 4

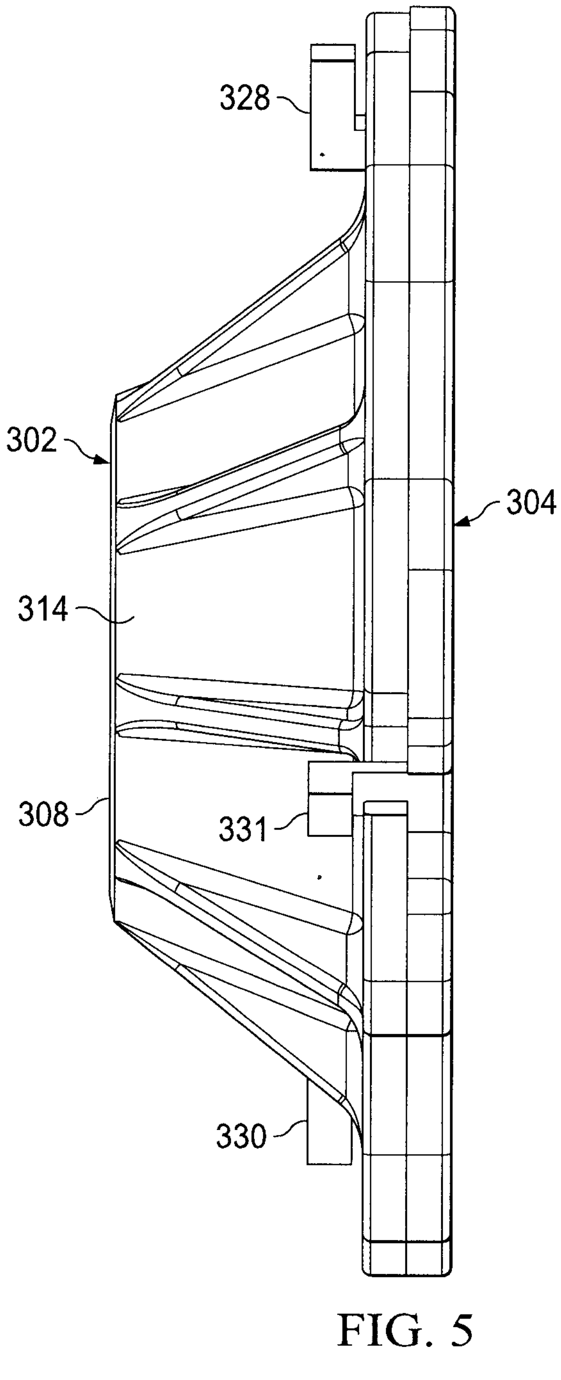


FIG. 5

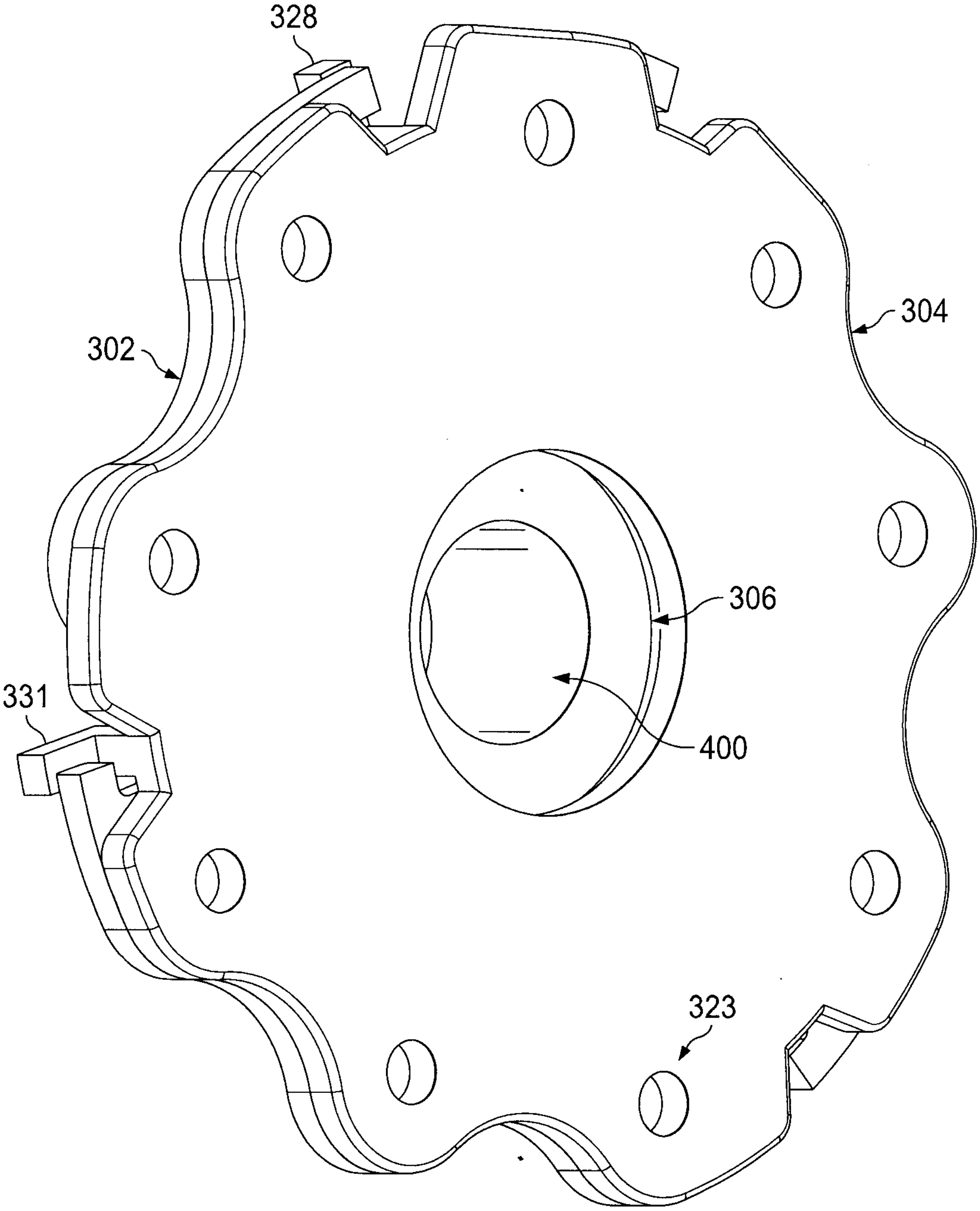


FIG. 6

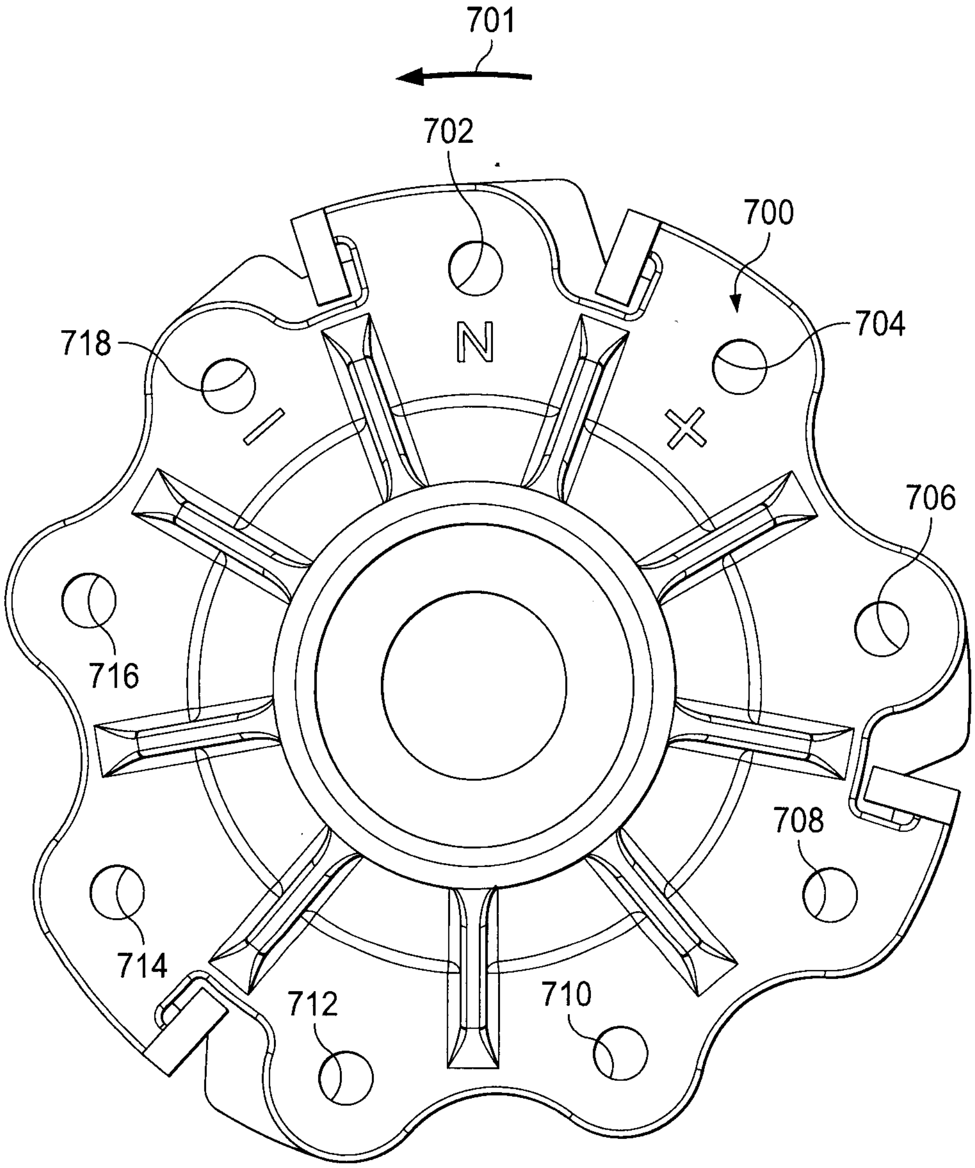
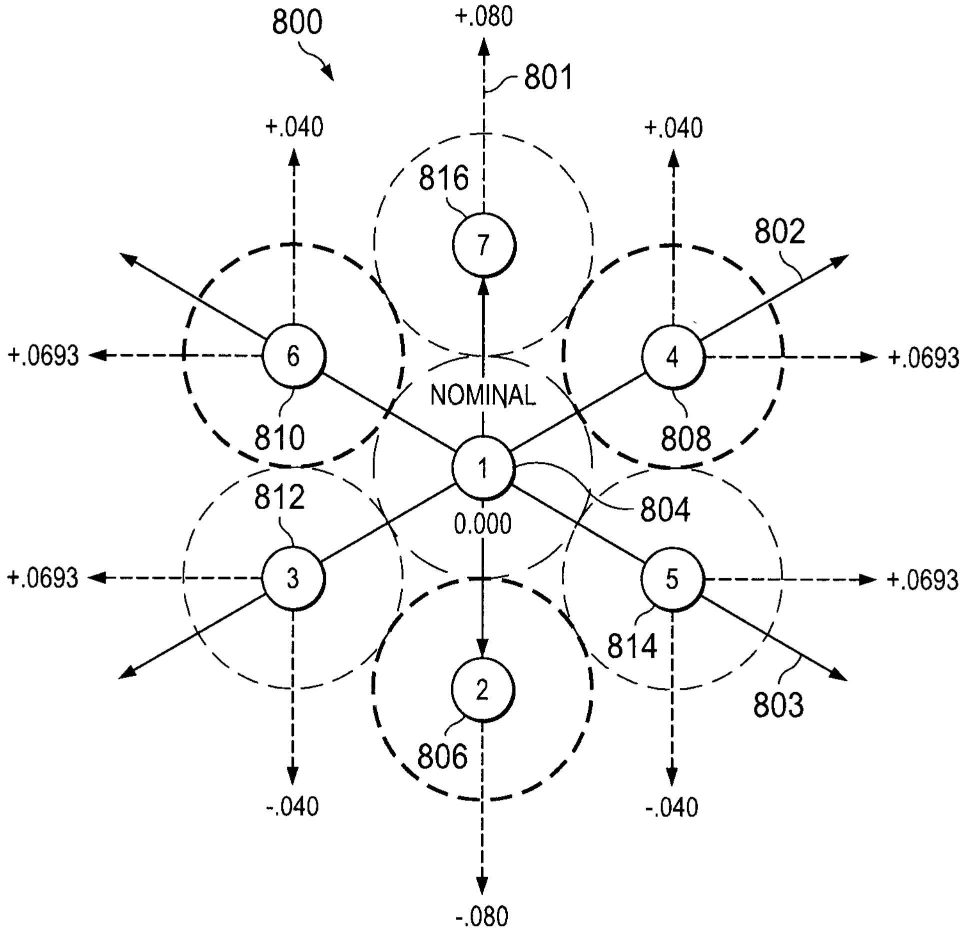


FIG. 7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3
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2
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-.040
-.080

FIG. 8

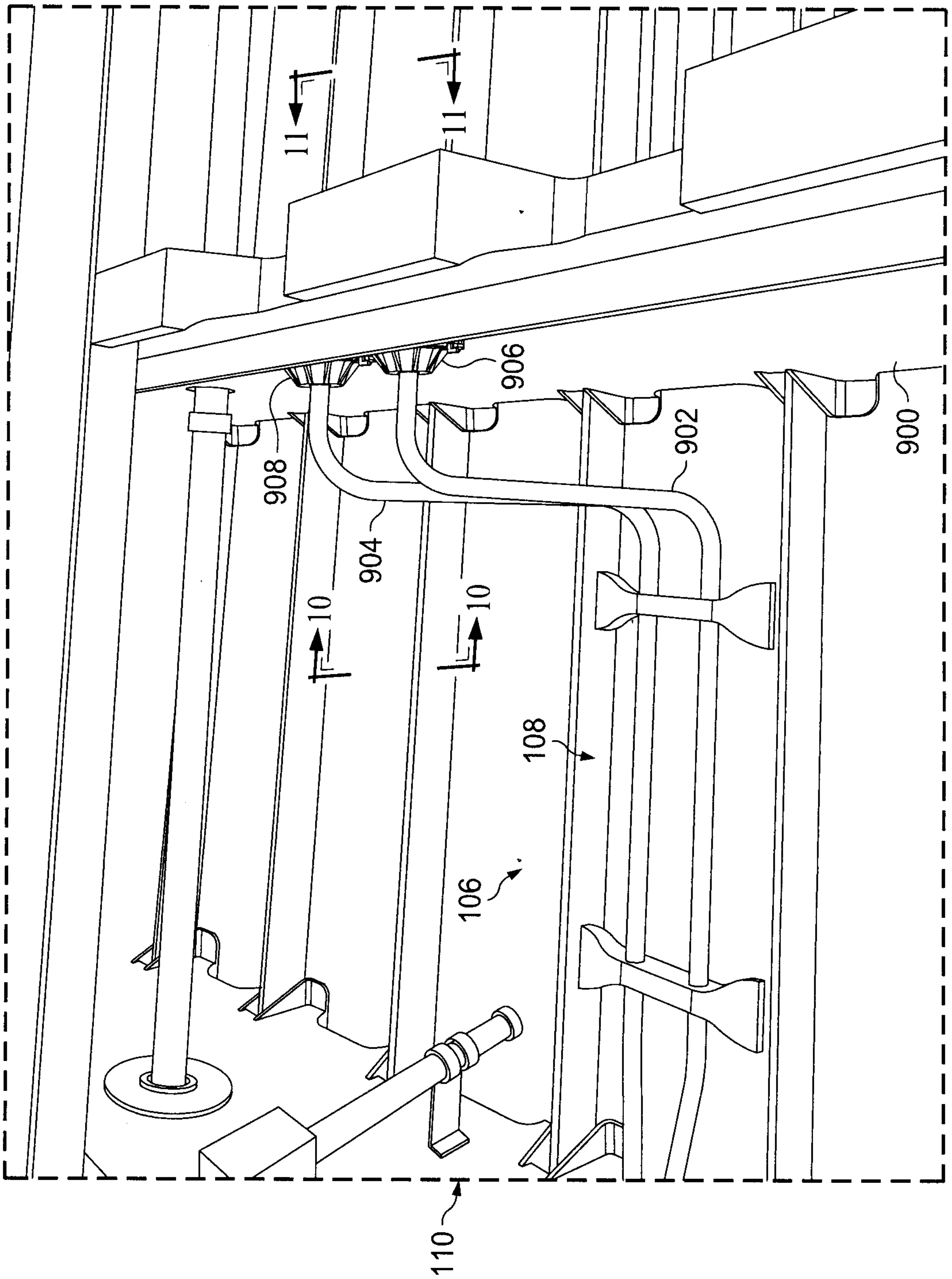


FIG. 9

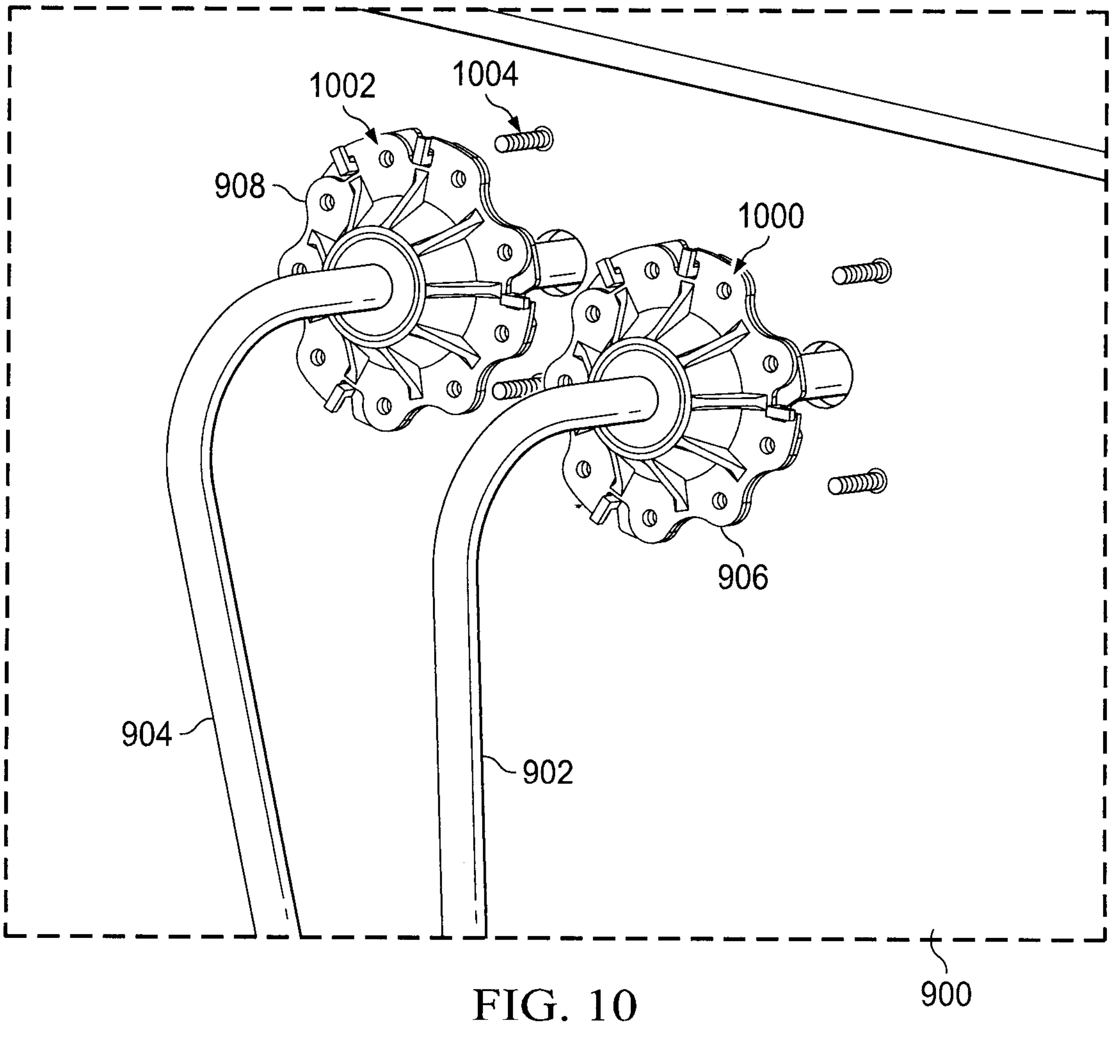


FIG. 10

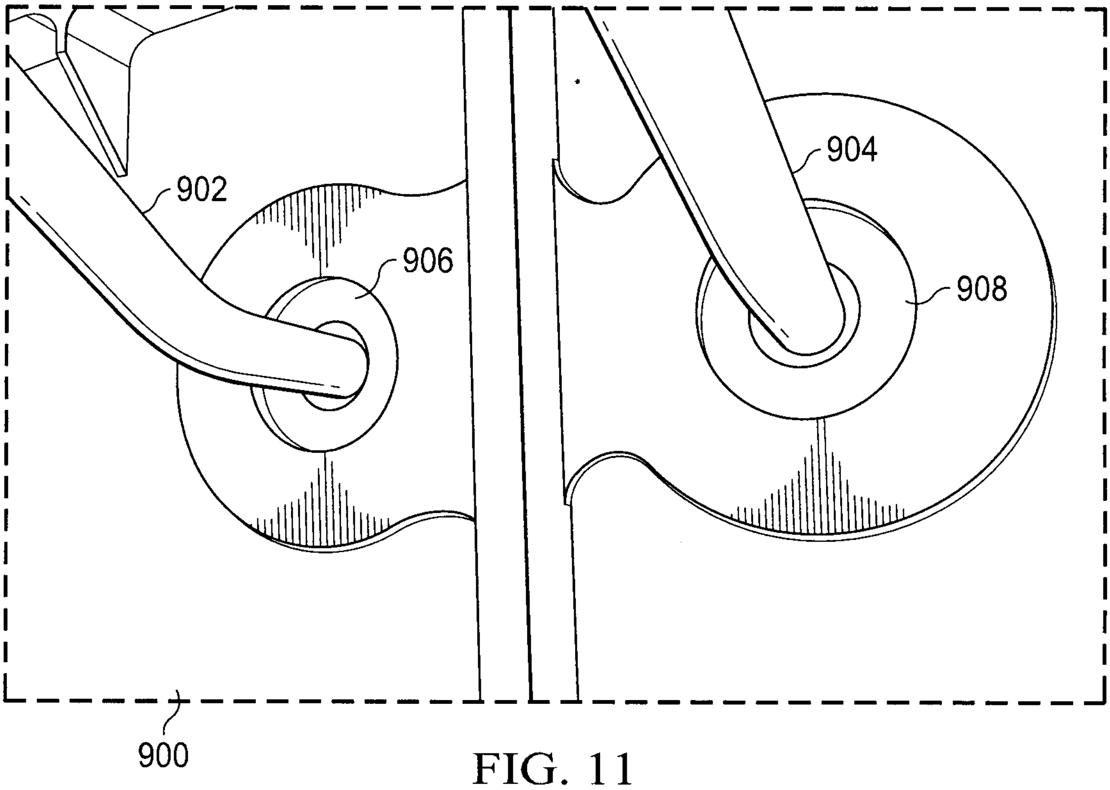


FIG. 11

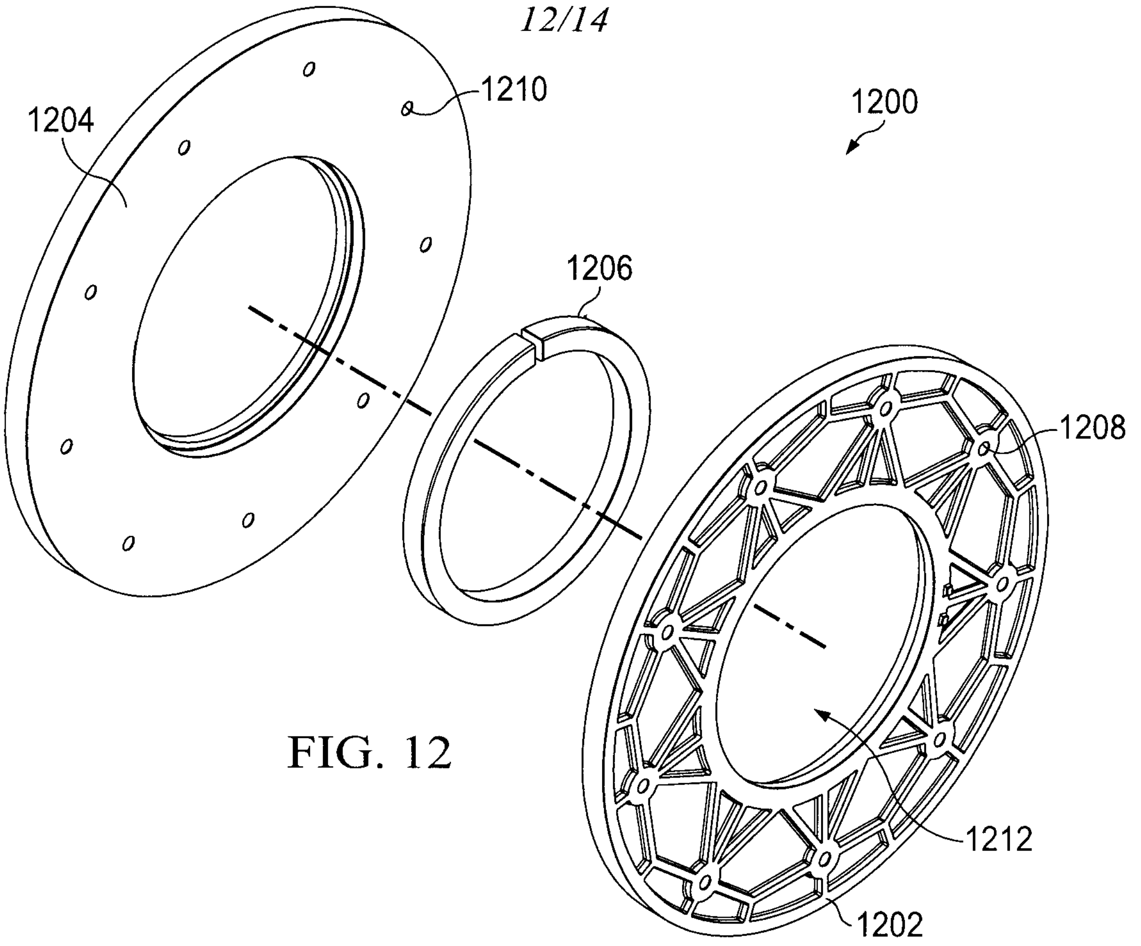


FIG. 12

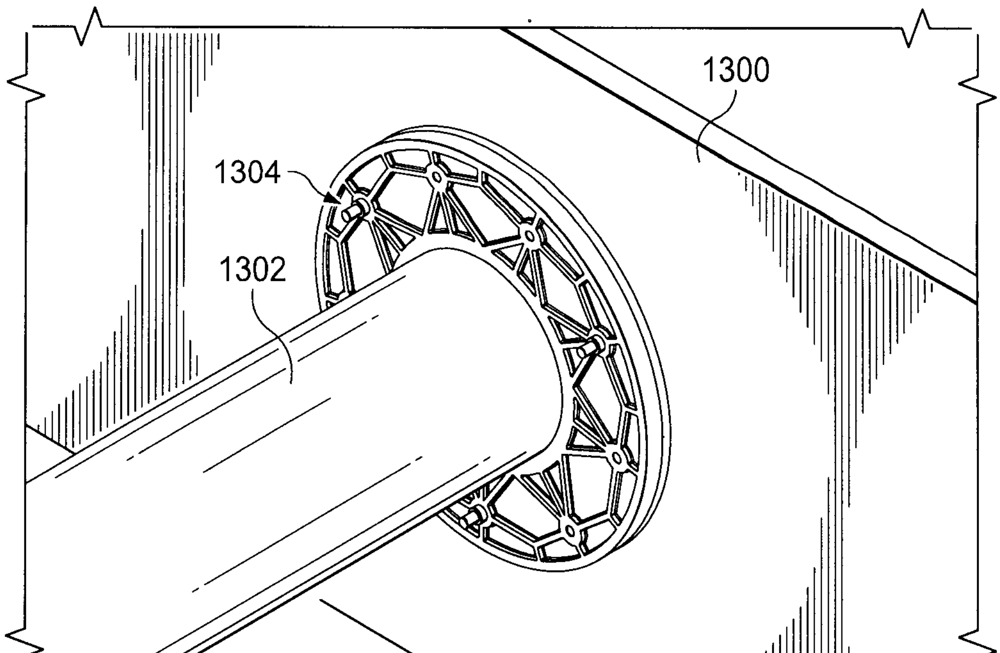


FIG. 13

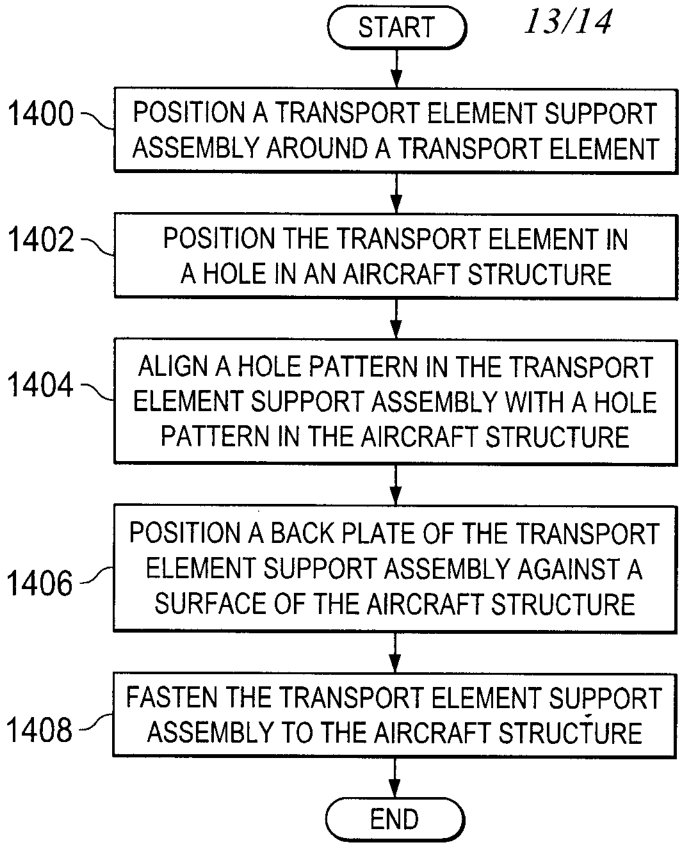

START
1400
POSITION A TRANSPORT ELEMENT SUPPORT ASSEMBLY AROUND A TRANSPORT ELEMENT
1402
POSITION THE TRANSPORT ELEMENT IN A HOLE IN AN AIRCRAFT STRUCTURE
1404
ALIGN A HOLE PATTERN IN THE TRANSPORT ELEMENT SUPPORT ASSEMBLY WITH A HOLE PATTERN IN THE AIRCRAFT STRUCTURE
1406
POSITION A BACK PLATE OF THE TRANSPORT ELEMENT SUPPORT ASSEMBLY AGAINST A SURFACE OF THE AIRCRAFT STRUCTURE
1408
FASTEN THE TRANSPORT ELEMENT SUPPORT ASSEMBLY TO THE AIRCRAFT STRUCTURE
END

FIG. 14

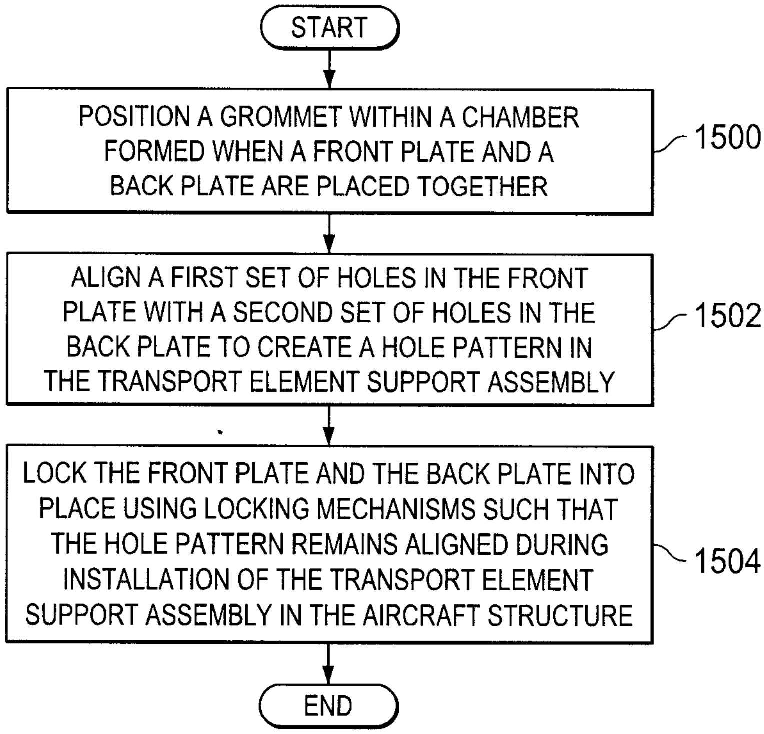
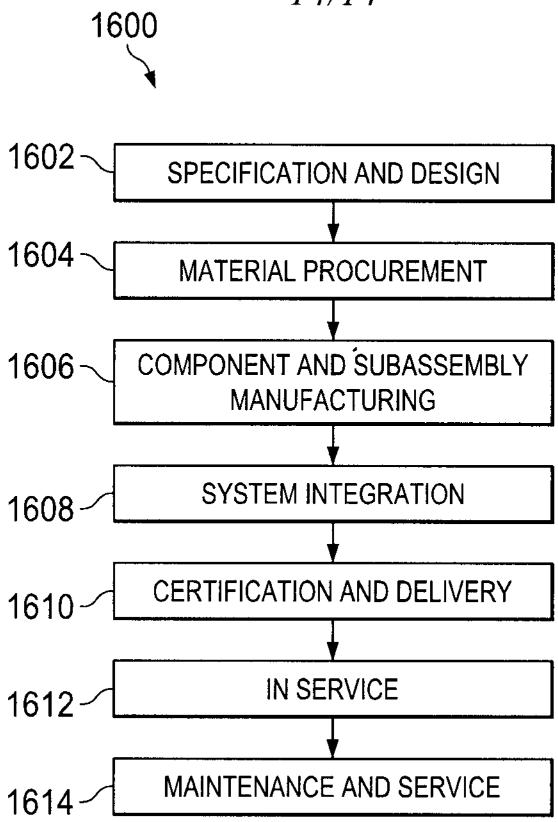

START
POSITION A GROMMET WITHIN A CHAMBER FORMED WHEN A FRONT PLATE AND A BACK PLATE ARE PLACED TOGETHER
1500
ALIGN A FIRST SET OF HOLES IN THE FRONT PLATE WITH A SECOND SET OF HOLES IN THE BACK PLATE TO CREATE A HOLE PATTERN IN THE TRANSPORT ELEMENT SUPPORT ASSEMBLY
1502
LOCK THE FRONT PLATE AND THE BACK PLATE INTO PLACE USING LOCKING MECHANISMS SUCH THAT THE HOLE PATTERN REMAINS ALIGNED DURING INSTALLATION OF THE TRANSPORT ELEMENT SUPPORT ASSEMBLY IN THE AIRCRAFT STRUCTURE
1504
END

FIG. 15


1600
1602
SPECIFICATION AND DESIGN
1604
MATERIAL PROCUREMENT
1606
COMPONENT AND SUBASSEMBLY MANUFACTURING
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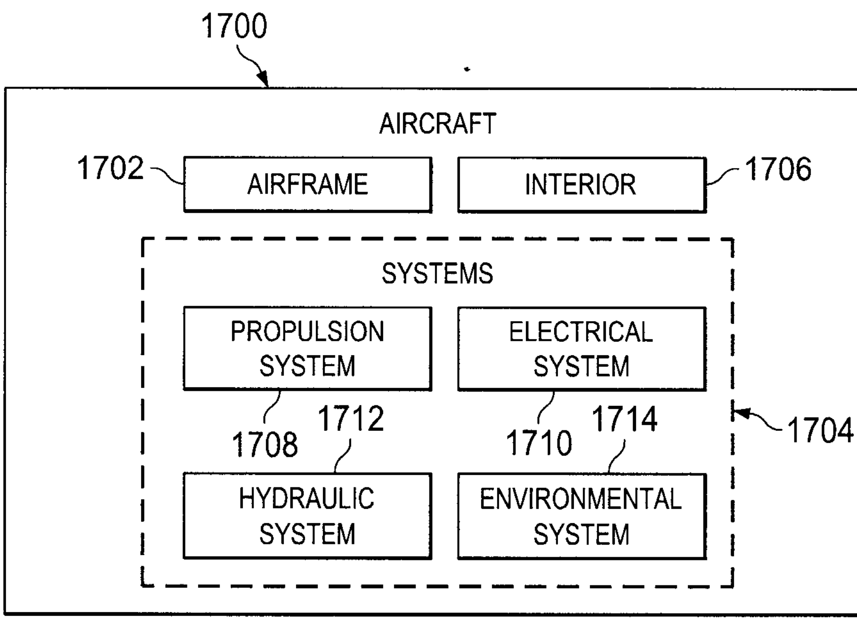
SYSTEM INTEGRATION
1610
CERTIFICATION AND DELIVERY
1612
IN SERVICE
1614
MAINTENANCE AND SERVICE

FIG. 16


1700
AIRCRAFT
1702
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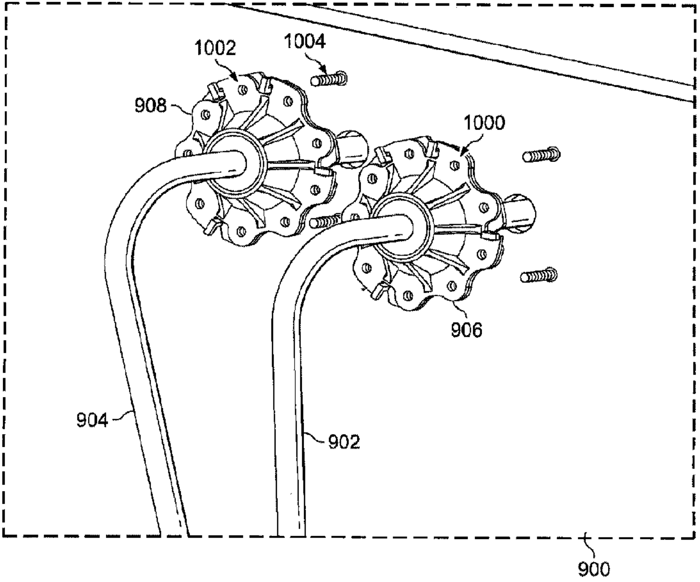
INTERIOR
1706
SYSTEMS
PROPULSION SYSTEM
ELECTRICAL SYSTEM
1708
1712
1710
1714
1704
HYDRAULIC SYSTEM
ENVIRONMENTAL SYSTEM

FIG. 17



1002
1004
908
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