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(54) **INTEGRATED DUAL FUEL DELIVERY SYSTEM**

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F23R 3/28 (2006.01)

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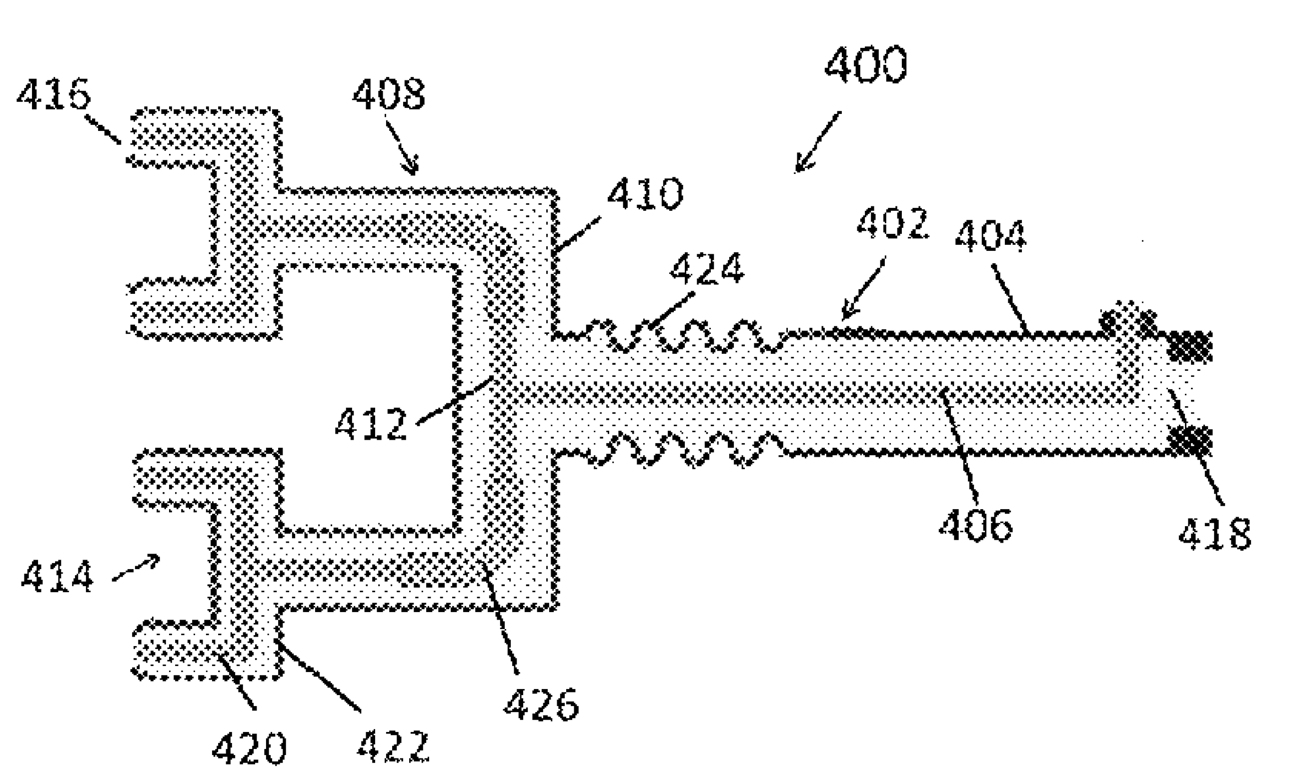
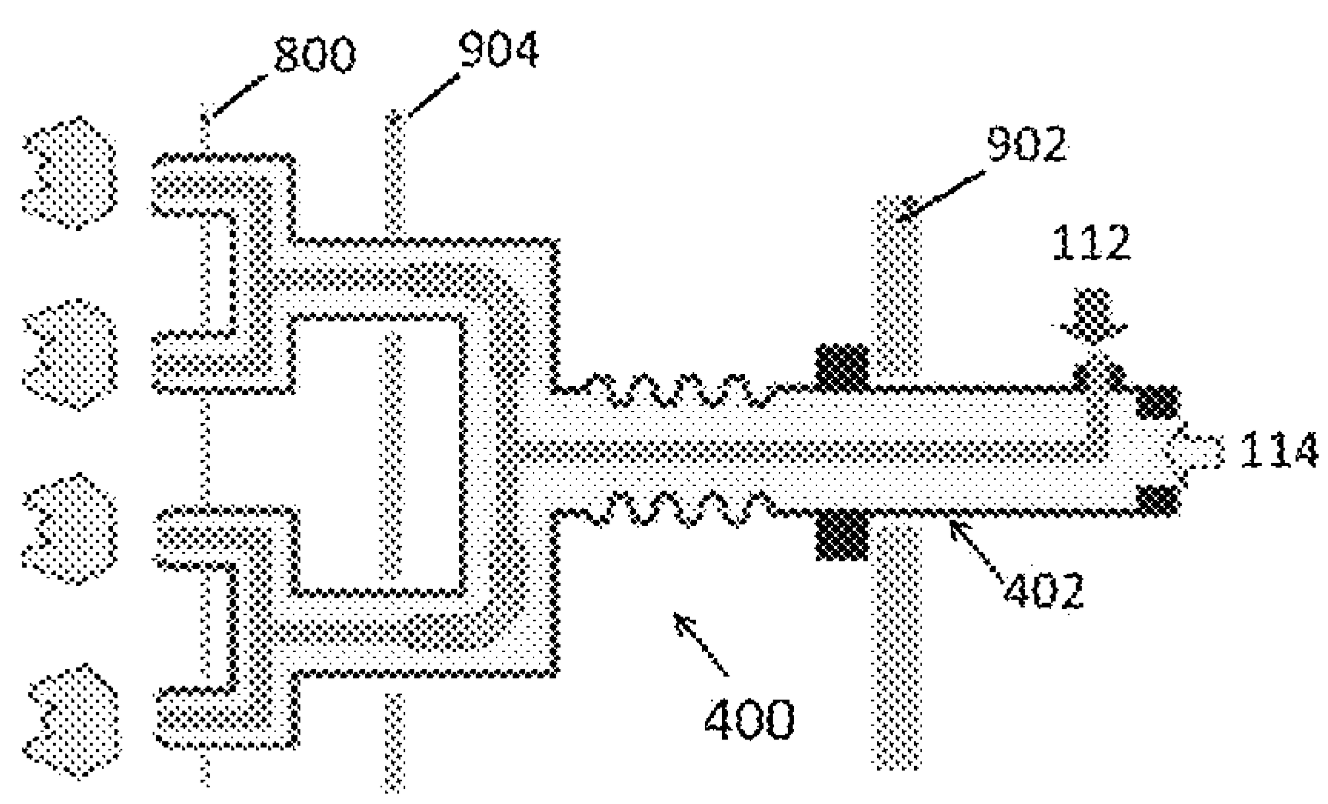
(57) **ABSTRACT**

The present invention relates to dual fuel delivery system for a gas turbine. A dual fuel delivery system for a gas turbine includes a main fuel line having a main fuel oil conduit and a main fuel gas conduit, wherein the main fuel gas conduit encloses, at least partially, the main fuel oil conduit; and a first fuel divider having a first fuel oil divider connected to the main fuel oil conduit and a first fuel gas divider connected to the main fuel gas conduit, wherein the first fuel gas divider encloses, at least partially, the first fuel oil divider.

16 Claims, 7 Drawing Sheets





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F02C 9/40 (2006.01)

(52) **U.S. Cl.**
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USPC 60/739, 742
See application file for complete search history.

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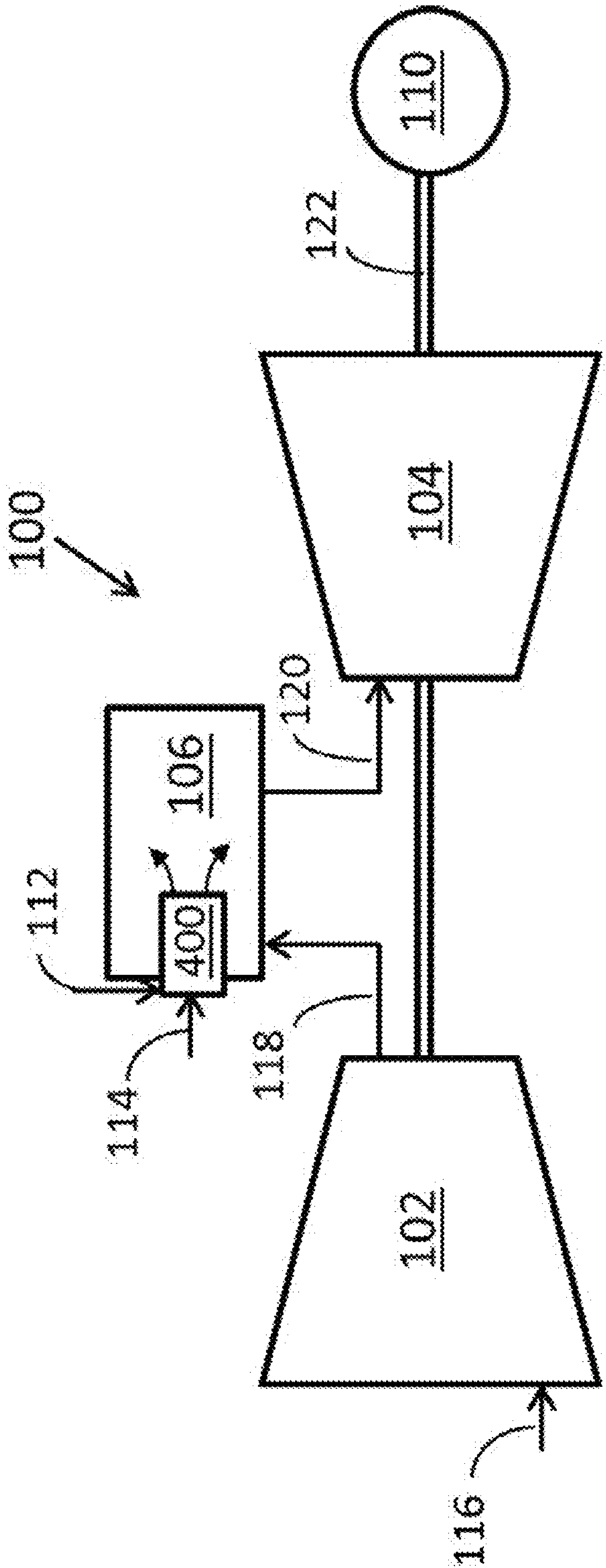


Fig. 1

PRIOR ART

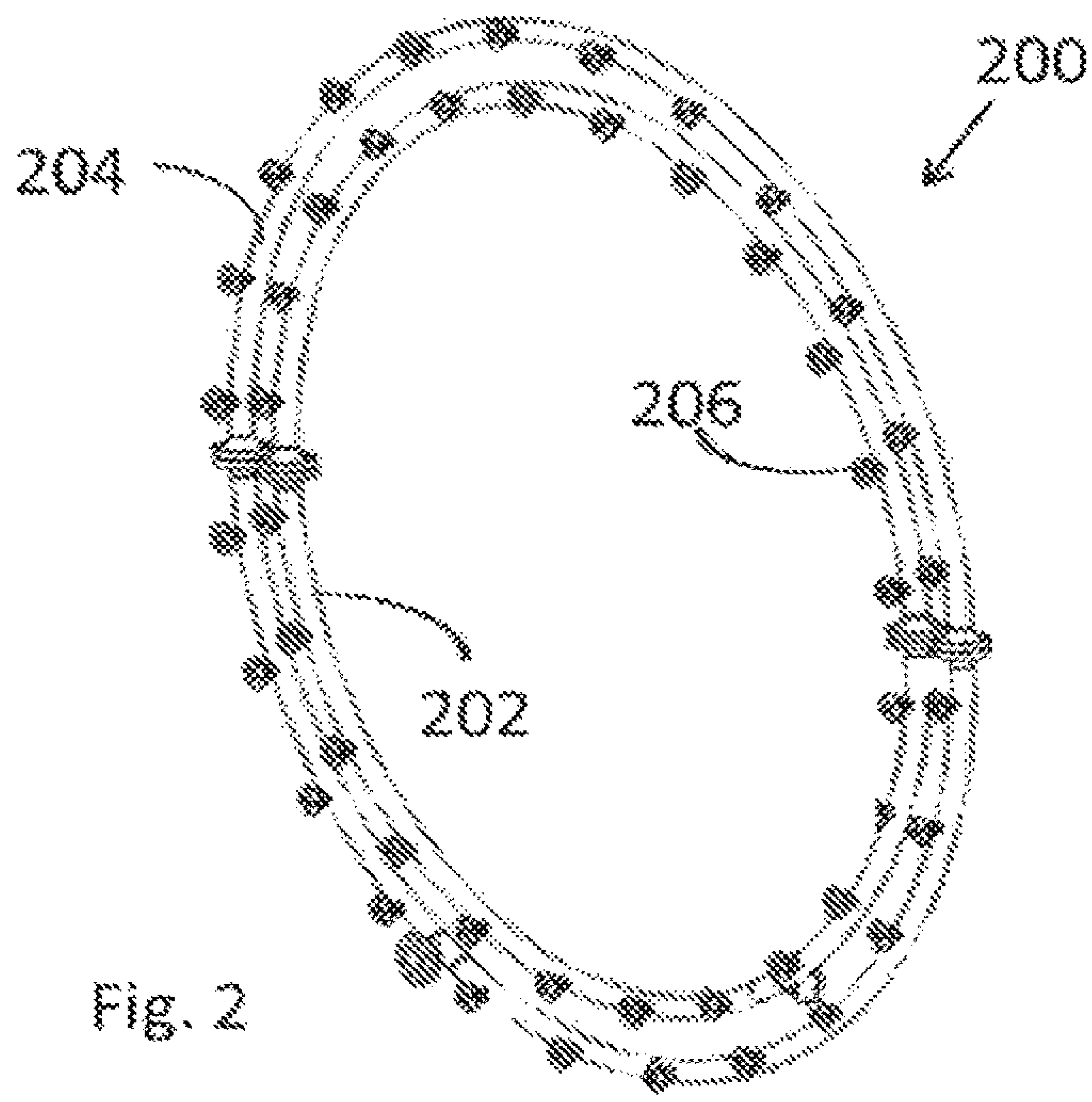


Fig. 2

PRIOR ART

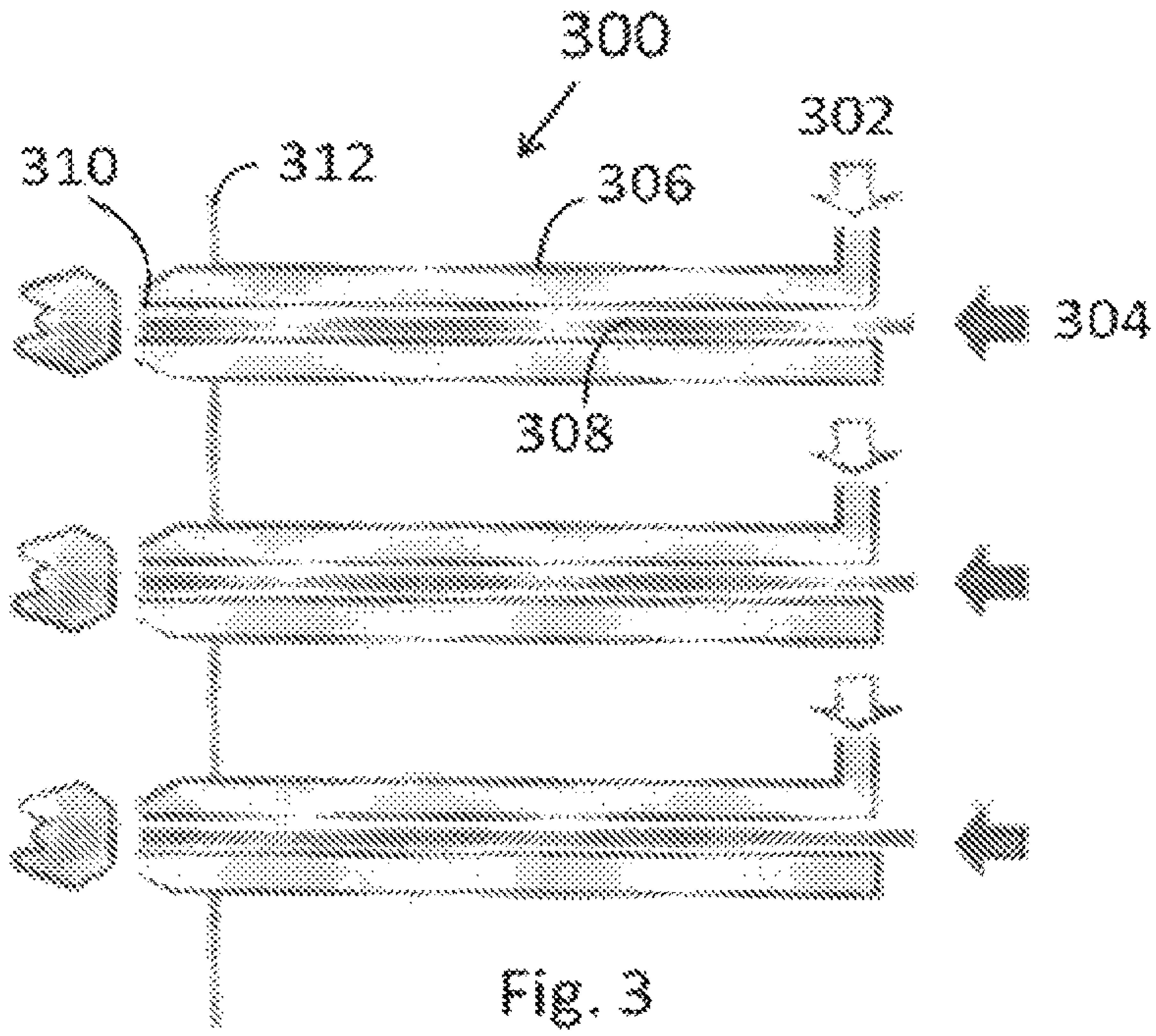


Fig. 3

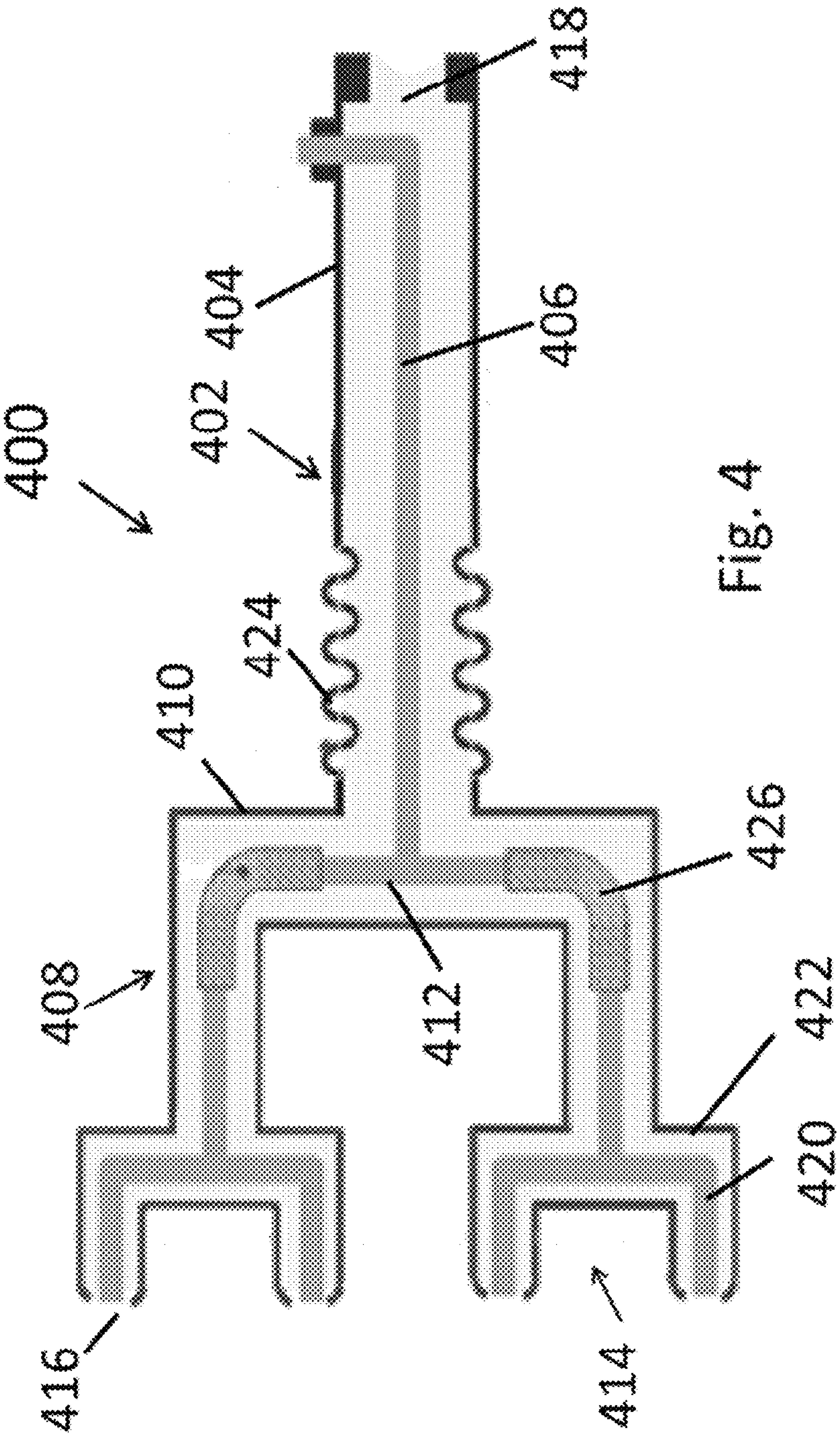


Fig. 4

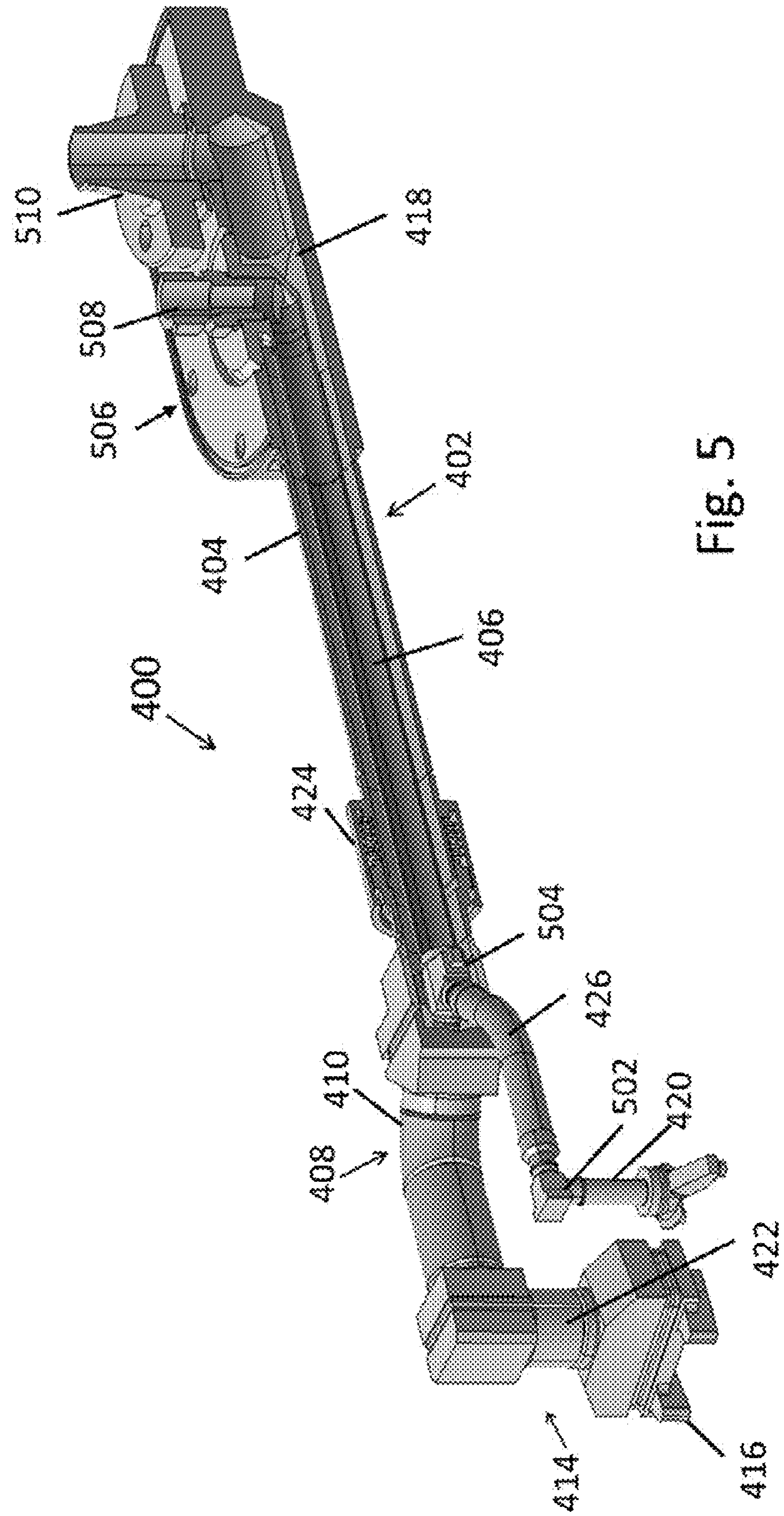

510
418
508
506
402
404
406
400
424
504
426
410
502
420
408
422
414
416

Fig. 5

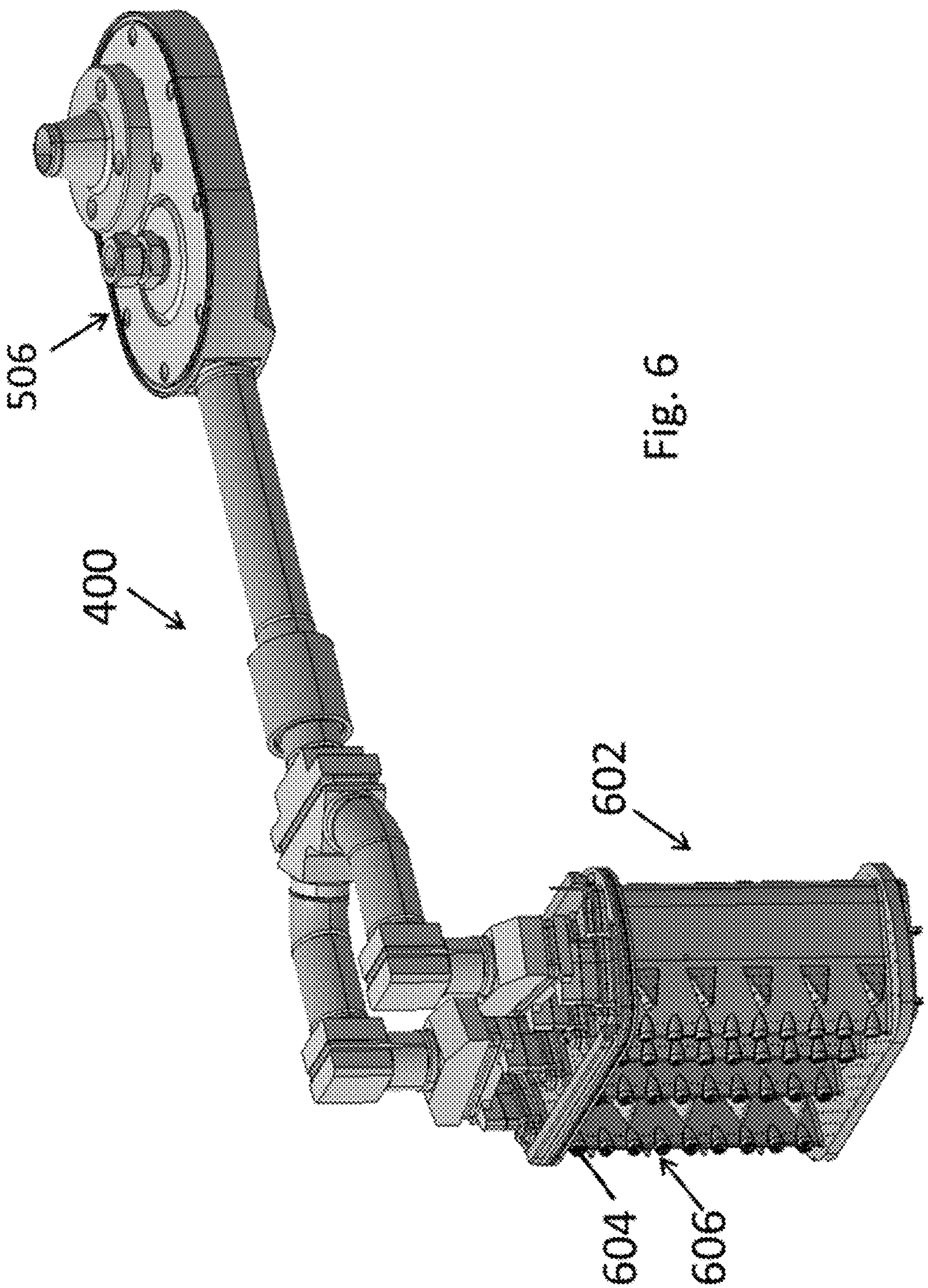


Fig. 6

Fig. 7

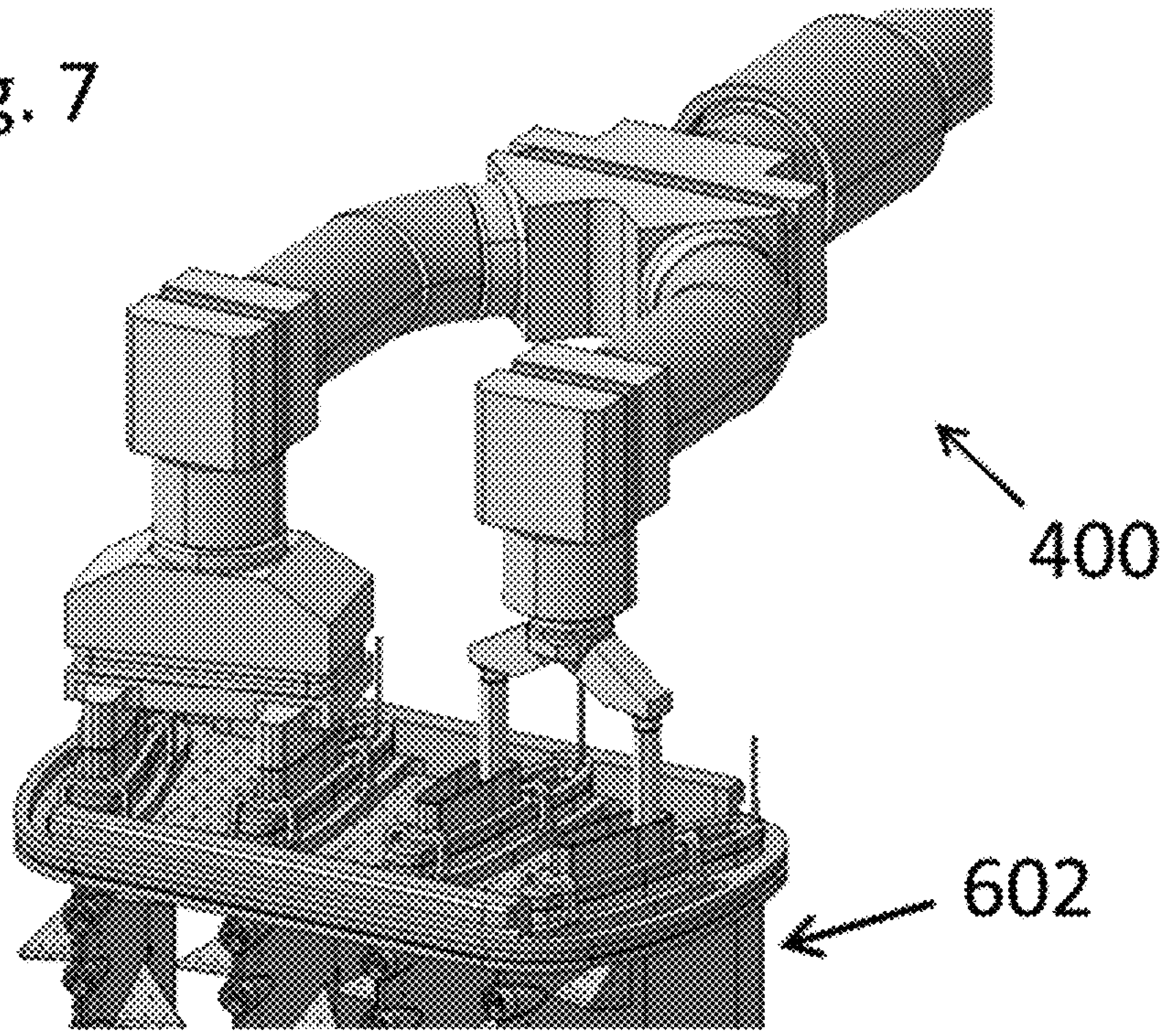
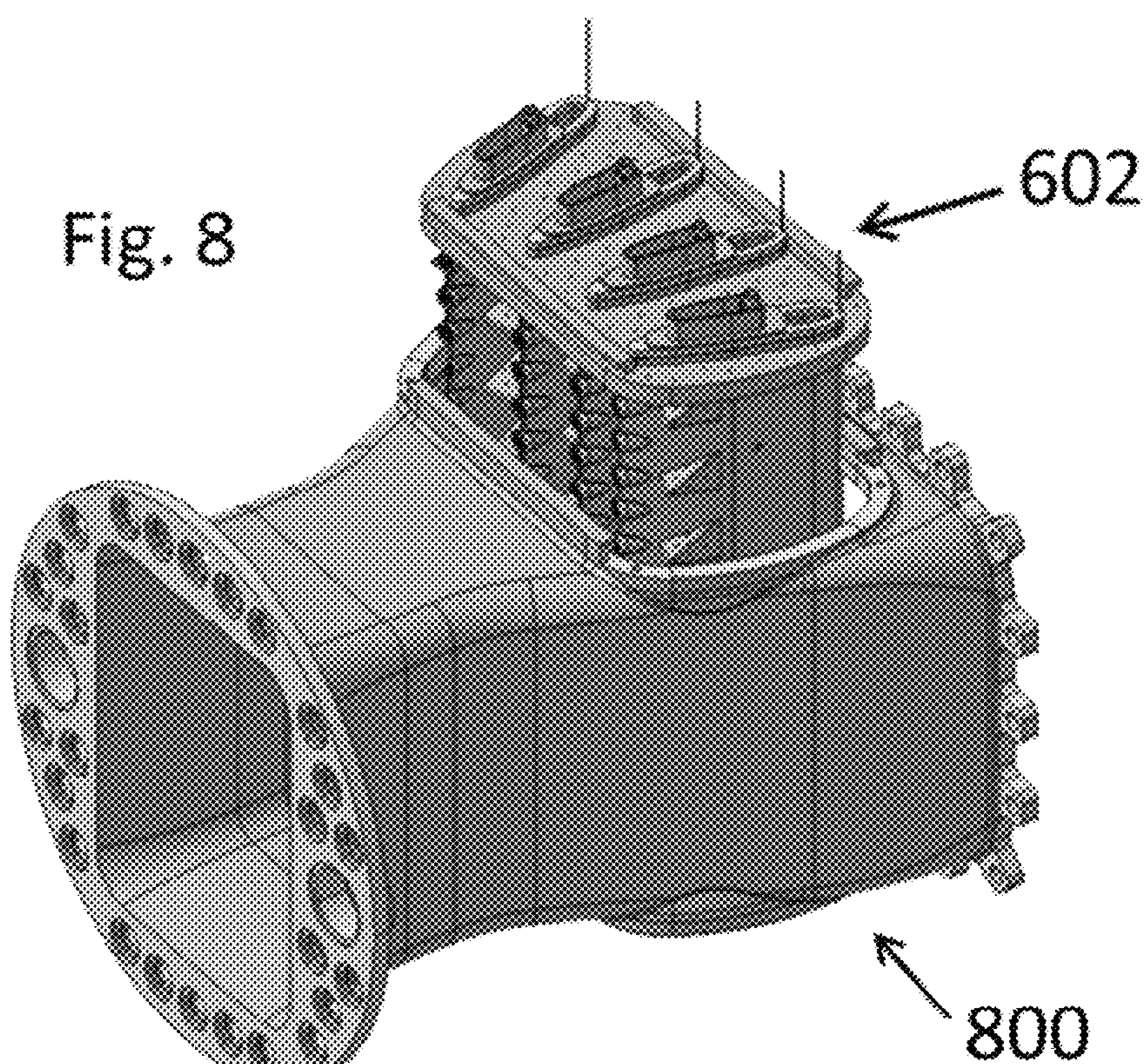


Fig. 8



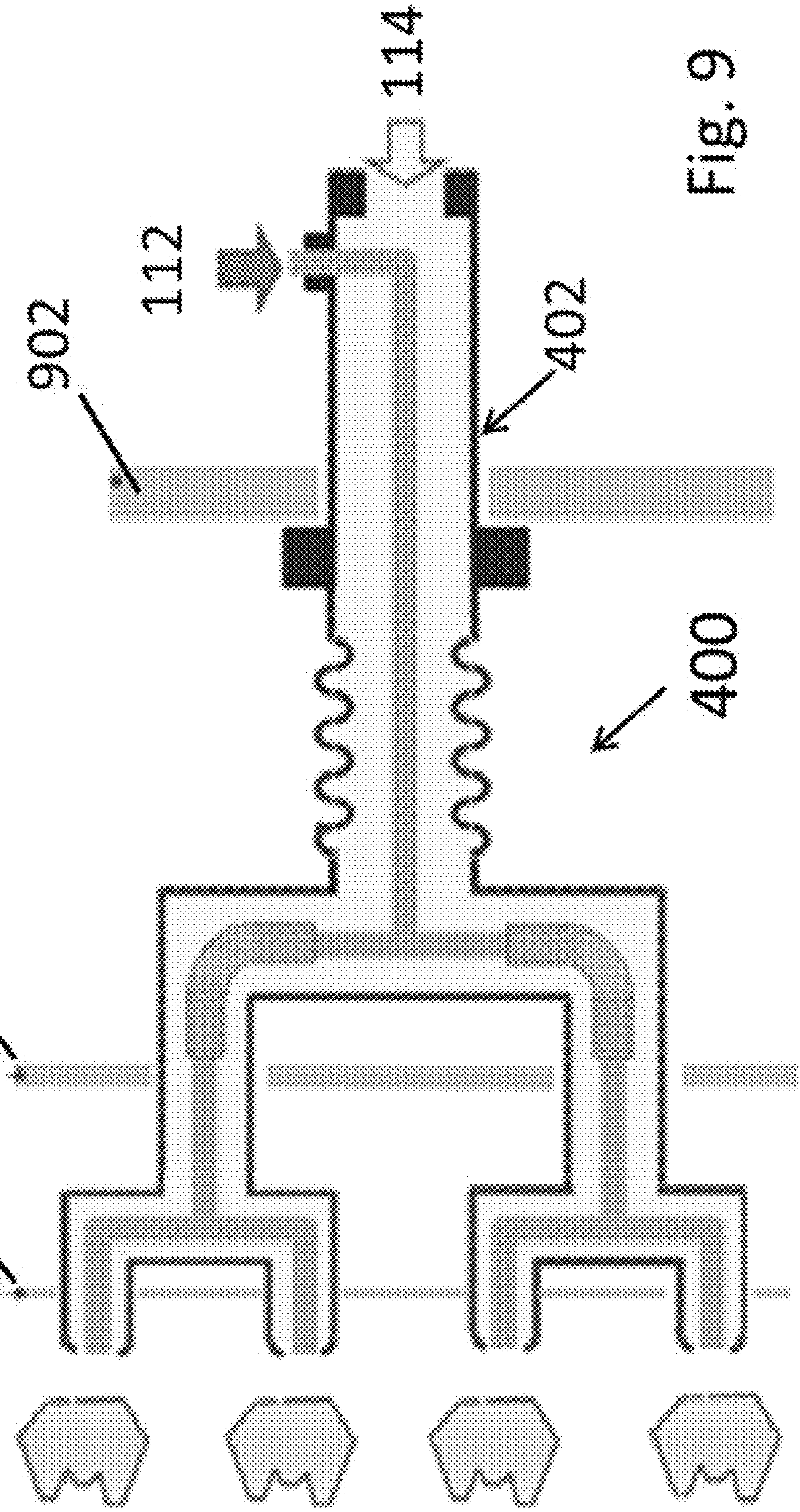


Fig. 9

INTEGRATED DUAL FUEL DELIVERY SYSTEM

TECHNICAL FIELD

The present invention relates to a fuel delivery system, and more particularly the invention relates to dual fuel delivery system for a gas turbine engine.

BACKGROUND

Modern gas turbines may operate on a number of different fuels, such as various kinds of liquid and gaseous fuels. For this reason, power plants may have gas turbine engines that can operate with dual fuel capability, for example, natural gas and diesel fuel. In general, the choice of the operational fuel depends on the price, availability and operational parameters.

Gas turbines comprise various types of combustors configured to produce a hot gas by burning a fuel in a compressed air. The fuel is introduced in the combustor using one or more fuel nozzles. To provide an operational flexibility, the nozzles usually have capabilities to inject a dual fuel.

Dual fuel has to be delivered to the fuel nozzles from the fuel source. Design of such dual fuel delivery systems has various challenges such as: space constrains, vibrational instabilities and thermal expansions.

FIG. **2** shows a fuel delivery system **200** comprising two fuel ring pipes, **202** and **204**. Each of the ring pipes, **202** and **204**, supplies one type of the fuel, and each pipe has plurality of fuel feeds **206** which are connected to combustor burners (not shown) of a gas turbine. In the configuration where every burner has one lance, one fuel line from each of the ring pipes **202** and **204** supplies two types of the fuel to the single burner. This design results in the high level of complexity and high number of supply lines and connections. FIG. **3** shows dual fuel supply system **300** for a burner **312** having several (in this example three) injection nozzles **310**. Two types of fuel, **302** and **304**, are supplied to every nozzle **310**. Fuel **302** is supplied via a first fuel line **306**, while second fuel **304** is supplied via a second fuel line **308**. Similarly to the design from FIG. **2**, this fuel delivery system is not compact and it could suffer from thermal and vibrational instabilities.

What is desired, therefore, is dual fuel delivery system that is simpler and more efficient than the systems from the prior art.

SUMMARY OF THE INVENTION

In view of the above mentioned problems, it is primary object of the present invention to provide an improved dual fuel delivery system for a gas turbine engine.

One object of the present invention is to provide improved dual fuel delivery system in terms of the complexity and space saving.

Another object of the present invention is to provide improved dual fuel delivery system in terms of thermal and vibrational stability.

Yet another object of the present invention is to provide improved dual fuel system particularly adapted to substantially rectangular shaped burners.

The above and other objects of the invention are achieved by a dual fuel delivery system for a gas turbine, comprising: a main fuel line having a main fuel oil conduit and a main fuel gas conduit, wherein the main fuel gas conduit encloses, at least partially, the main fuel oil conduit, and a first fuel divider having a first fuel oil divider connected to the main fuel oil conduit and a first fuel gas divider connected to the main fuel gas conduit, wherein the first fuel gas divider encloses, at least partially, the first fuel oil divider.

According to one embodiment, the dual fuel delivery system further comprises at least one second fuel divider having a second fuel oil divider and a second fuel gas divider, wherein one outlet of the first fuel divider is connected to an inlet of the second fuel divider. In one preferred embodiment, the dual fuel delivery system comprises two second fuel dividers.

According to yet another embodiment, the first fuel divider is positioned in a first plane and the second fuel divider is positioned in a second plane, and the first plane is different from the second plane . . . . In one preferred embodiment these two planes are substantially at degrees angle. This configuration is particularly advantageous regarding space saving inside a gas turbine.

According to another embodiment, both the first fuel oil divider and the first fuel gas divider, have one inlet and two outlets.

According to yet another embodiment, the main fuel gas conduit comprises an extension means, preferably metallic bellows. This configuration is particularly advantageous regarding problem of thermal expansions.

According to another embodiment, the first fuel oil divider comprises at least one extension means, such as a metallic hose or an extension joint.

According to yet another embodiment, a connection between the main fuel oil conduit and the first fuel oil divider comprises a horizontal sliding guide, and/or a connection between the first fuel oil divider and the second fuel oil divider comprises a vertical sliding guide.

According to another embodiment, the dual fuel delivery system further comprises an injection head, which comprises at least one injection nozzle adapted to inject fuel oil and/or fuel gas, wherein the injection head is connected to the first fuel divider or the second fuel divider. In one preferred embodiment, the injection head comprises plurality of injection sections, wherein every injection section is connected to one outlet of the first fuel divider or the second fuel divider.

According to yet another embodiment, the dual fuel delivery system comprises fuel manifold connected to the inlet of the main fuel line, and adapted to supply fuel gas and fuel oil to the main fuel line.

The present application also relates to a gas turbine comprising dual fuel delivery system. In one preferred embodiment, a gas turbine comprises a can combustor, a cooling air housing, and a burner adapted to receive the injection head, wherein the inlet of the main fuel line is positioned outside the can housing, the outlet of the main fuel line and the inlet to the first fuel divider are positioned between the can housing and the cooling air housing.

In addition, the present application also provides for a method for delivering dual fuel to the injection head inside the burner of the gas turbine comprising the dual fuel delivery system. The method comprises following steps: supplying fuel oil and/or fuel gas to the main fuel line, dividing the fuel oil and/or the fuel gas in the first fuel divider, and guiding fuel oil and/or fuel gas to the injection head.

Additional advantages and features of the present invention will be set forth in part in a description which follows, and in part will become apparent to those skilled in the art upon examination of the following, or may be learned from practice of the invention. The instant invention will now be described with particular reference to the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

Preferred embodiments of the invention are described in the following with reference to the drawings, which are for the purpose of illustrating the present preferred embodiments of the invention and not for the purpose of limiting the same. In the drawings,

FIG. **1** is a schematic diagram of a gas turbine according to the invention.

FIG. **2** is a perspective view of dual ring fuel delivery system from prior art.

FIG. **3** is a schematic diagram of a fuel delivery system from prior art.

FIG. **4** is a schematic representation of a dual fuel delivery system according to one embodiment of the present invention.

FIG. **5** is a perspective view of a part of a dual fuel delivery system according to one embodiment of the present invention.

FIG. **6** is a perspective view of a dual fuel delivery system according to one embodiment of the present invention.

FIG. **7** is a perspective view of a part of a dual fuel delivery system according to one embodiment of the present invention.

FIG. **8** is a perspective view of a rectangular burner adapted to receive injection nozzle head.

FIG. **9** is a schematic representation of a dual fuel delivery system inside a gas turbine according to one embodiment the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings, in which like numerals refer to like elements throughout the several views, figure shows a schematic view of gas turbine engine **100** according to one embodiment of the invention. The gas turbine **100** is comprised of a compressor **102**, which compresses a flow of air **116**. The compressed air **118** is directed to a combustor **106** which may comprise several combustor cans and burners. In the combustor **106**, the compressed air **118** is mixed with fuel oil **112** or fuel gas **114**, and the mixture of air and fuel is ignited to create a flow of hot combustion gases **120**, which are directed to drive a turbine **104**. The mechanical work produced in the turbine **104** drives the compressor **102** and load **110** via a shaft **122**. Fuels **112** and **114** are delivered to the combustor **106** via a dual fuel delivery system **400** according to the invention.

FIG. **4** shows the dual fuel delivery system **400** according to the invention, which may be used with the gas turbine **100**. The dual fuel delivery system **400** comprises a main fuel line **402** having a main fuel oil conduit **406** and a main fuel gas conduit **404**. In the preferred embodiment shown in FIG. **4**, the conduits **404** and **406** are in the form of two concentric conduits, wherein the main fuel gas conduit **404** completely encloses the main fuel oil conduit **406**, except for the entry section of the conduit **406**. In general, the main fuel gas conduit **404** encloses at least partially the main fuel oil conduit **406**.

The dual fuel delivery system **400** comprises also a first fuel divider **408**, having a first fuel oil divider **412** connected to the main fuel oil conduit **406** and a first fuel gas divider **410** connected to the main fuel gas conduit **404**. In general, a fuel divider is a device for dividing a fuel flow, and it has one inlet and two or more outlets. The number of branches of the divider is equal to the number of the outlets. The fuel flow may be divided equally or non-equally among the branches. The first fuel gas divider **410** encloses, at least partially, the first fuel oil divider **412**. In the preferred embodiment, shown in FIG. **4**, the first fuel gas divider **410** encloses completely the first fuel oil divider **412**. Every branch of the fuel gas divider **410** is enclosing corresponding branch of the fuel oil divider **412**. The corresponding branches may be in the form of the concentric conduits. In the operation, the fuel oil supply channel (main fuel oil line and fuel oil divider) is advantageously protected by the fuel gas supply channel (main fuel gas line and fuel gas divider) against the hot air stream. In the preferred embodiment, the fuel divider **408** has one inlet and two outlets, but more outlets are also possible.

The dual fuel delivery system **400** may have a second fuel divider **414**. In one preferred embodiment shown in FIG. **4**, there are two second fuel dividers **414**. The purpose of these dividers is to further divide fuel flows coming from the main line **402**. In the preferred embodiment, the second dividers **414** may have one inlet and two outlets. The second fuel divider **414** has a second fuel oil divider **420** and a second gas fuel divider **422**. One outlet of the first fuel divider **408** is connected to an inlet of the second fuel divider **414**. In this configuration, system **400** has one inlet **418** (main fuel line inlet) and four outlets **416** i.e. both of the fuels, fuel gas and fuel oil, may be separated in four separated flows.

Additional advantageous features which contribute to avoid thermal expansions and negative vibrational effects are also show in FIG. **4**. Firstly, the main fuel gas conduit **404** may comprise an extension means, preferably a metallic bellow **424**. Secondly, the first fuel oil divider **412** may have an extension means, such as at least one metallic hose **426**, or an expansion joint. Preferably the divider **412** has two metallic hoses **426**, wherein one hose is comprised in every branch of the divider **412**. Other combinations of bellows and hoses in the main line **402** and/or in the different branches of any of the dividers are also possible.

FIG. **4** is a schematic, simplified and two-dimensional representation of the dual fuel delivery system **400**. The main fuel line **402** and fuel dividers **408** and **414** are not necessarily all positioned in one plane. In general, the fuel divider **408** is positioned in a first plane and the fuel divider **414** is positioned in a second plane.

FIG. **5** shows in more detail part of (and interior of) the dual fuel delivery system **400** according to one preferred embodiment of the present invention. Contrary to the example of FIG. **4** where the first fuel divider **408** and the second fuel divider **414** are positioned in one plane i.e., the first plane and the second plane are same planes, the second fuel divider **414** and the first fuel divider **408** of an embodiment in FIG. **5** are advantageously positioned in different planes i.e. the first plane is different from the second plane. In the preferred embodiment shown in FIG. **5**, inlet of the second fuel divider **414** and one outlet of the first fuel divider **408** are connected substantially at 90 degrees angle. In this way, dual fuel delivery system **400** has advantageously a more compact size, which reduces a need for a large space inside the gas turbine **100**. The two planes, the first plane and the second plane, may be inclined to each other at an angle >10 degrees, preferably greater of 50 degrees up to 90 degrees. Another advantage of having fuel dividers **408** and **414** in different planes instead in one plane is an additional degree of flexibility to compensate for thermal extension and/or vibrations in different directions.

Other designs, depending of the geometry of the gas turbine, are possible, without departing from the main concept of the invention.

In addition, as shown in FIG. **5**, a connection between the main fuel oil conduit **406** and the first fuel oil divider **412** may have a horizontal sliding guide **504**. Advantageously, a connection between the first fuel oil divider **412** and the second fuel oil divider **414** may have a vertical sliding guide **502**. The use of the sliding guides **502** and **504** helps to guide the relative movements of the metal hoses **426** inside a gas turbine engine. FIG. **5** shows also a fuel manifold **506** connected to the inlet of the main fuel line **402**. The manifold **506** is used to supply the fuel gas and the oil gas to the main fuel line **402** via fuel oil inlet **508** and fuel gas inlet **510**. The inlets **508** and **510** are in general connected to the external fuel gas and fuel oil supply (not shown).

FIG. **6** shows perspective view of the dual fuel delivery system **400** according to another preferred embodiment of the present invention. FIG. **6** shows only external part of the system **400**, without showing internal gas oil conduits and dividers. In this embodiment according to the invention, the system **400** comprises also an injection head **602**. The role of the injection head **602** is to inject the fuel into a burner. The injection head **602** comprises one or more injection nozzles **604** adapted to inject the fuel oil and/or the fuel gas. The injection head **602** is connected to the second fuel dividers **414**. The dual fuel from the manifold **506** may be guided to the nozzles **604**. In the one preferred embodiment of the invention, the injection head **602** comprises plurality of fuel injection sections **606**. In the embodiment shown in FIG. **6**, there are 4 fuel injection sections **606**, each section having nine nozzles **604**. One example of the injection section **606** is described in patent application EP 2496883A2. In this example shown in FIG. **6**, the injection section **606** has streamlined body defined by two lateral surfaces joined in a smooth round transition at a leading edge and ending at a small radius/sharp angle at a trailing edge. Upstream of the trailing edge vortex generators may be located. The nozzles **604** are located on the trailing edge of the streamlined body of the injection sections **606**.

FIG. **7** shows in more detail a connection between the injection head **602** and the outlets of the dividers **414**, showing that every injection section **606** is connected to one outlet of the dividers **414**.

FIG. **8** shows a rectangular type burner **800** adapted to be used with the dual fuel delivery system **400** according to the invention. As shown, the burner **800** is adapted to receive the injection head **602**.

The present invention also discloses a gas turbine engine **100** adapted to be used with the dual fuel delivery system **400** according to the invention. FIG. **9** shows schematically representation of the part of the gas turbine **100**, wherein only parts of the walls of the main components are shown. As shown in FIG. **9**, gas turbine **100** according to the invention, preferably comprises a can combustor **902**, a cooling air housing **904**, and a burner **800** adapted to receive the injection head **602**. In one preferred embodiment, the inlet of the main fuel line **402** is positioned outside the can housing **902**; the outlet of the main fuel line **402** and the inlet to the first fuel divider **408** are positioned between the can housing **902** and the cooling air housing **904**. The outlets of the second fuel dividers are positioned inside the burner **800**.

FIG. **9** also illustrates the method for delivering dual fuel, the fuel oil **112** and the fuel gas **114**, to the injection head inside the burner **800** of the gas turbine **100** comprising the dual fuel delivery system **400**. The fuel oil **112** and/or the fuel gas **114** are supplied to the main fuel line **402**, and then they are divided in the fuel divider **408** and fuel dividers **414**, and guided to the burner **800** where the fuel is mixed with compressed air and burned.

It should be apparent that the foregoing relates only to the preferred embodiments of the present application and that numerous changes and modifications may be made herein by one of ordinary skill in the art without departing from the scope of the invention as defined by the following claims.

LIST OF DESIGNATIONS

100 Gas turbine engine
102 Compressor
104 Turbine
106 Combustor
110 Load
112 Fuel oil
114 Fuel gas
116 Inlet air
118 Compressed air
120 Combustion gas
122 Shaft
200 Fuel delivery system
202 Fuel ring pipe
204 Fuel ring pipe
206 Fuel feed
300 Dual fuel supply system
302 Fuel
304 Fuel
306 Fuel line
308 Fuel line
310 Nozzle
312 Burner
400 Dual fuel delivery system
402 Main fuel line
404 Main fuel gas conduit
406 Main fuel oil conduit
408 First fuel divider
410 First fuel gas divider
412 First fuel oil divider
414 Second fuel divider
416 Second divider outlet
418 Main fuel line inlet
420 Second fuel oil divider
422 Second fuel gas divider
424 Bellow
426 Metallic hose
506 Fuel manifold
508 Fuel oil inlet
510 Fuel gas inlet
602 Injection head
604 Injection nozzles
606 Fuel injection section
800 Burner
902 Can combustor
904 Cooling air housing

The invention claimed is:

1. A dual fuel delivery system for a gas turbine, comprising:

a main fuel line having a main fuel oil conduit and a main fuel gas conduit, wherein the main fuel gas conduit encloses, at least partially, the main fuel oil conduit; and

a first fuel divider having a first fuel oil divider connected to the main fuel oil conduit and a first fuel gas divider connected to the main fuel gas conduit, wherein the first fuel gas divider encloses, at least partially, the first fuel oil divider; and

at least one second fuel divider that includes at least one of a second fuel oil divider and a second fuel gas divider, wherein the second fuel gas divider encloses the second fuel oil divider.

2. The dual fuel delivery system of claim **1**, wherein one outlet of the first fuel divider is connected to an inlet of the second fuel divider.

3. The dual fuel delivery system of claim **2**, wherein the first fuel divider is positioned in a first plane and the second fuel divider is positioned in a second plane, and wherein the first plane is different from the second plane.

4. The dual fuel delivery system of claim **2**, comprising:

two second fuel dividers, wherein each of two second fuel dividers are connected to different outlets of the first fuel divider.

5. The dual fuel delivery system of claim **1**, wherein both the first fuel oil divider and the first fuel gas divider, have one inlet and two outlets.

6. The dual fuel delivery system of claim **1**, wherein the main fuel gas conduit comprises an extension means.

7. The dual fuel delivery system of claim **6**, wherein the extension means comprises a bellow.

8. The dual fuel delivery system of claim **1**, wherein the first fuel oil divider comprises at least one extension means.

9. The dual fuel delivery system of claim **1**, wherein a connection between the main fuel oil conduit and the first fuel oil divider comprises a horizontal sliding guide, and/or wherein a connection between the first fuel oil divider and the second fuel oil divider comprises a vertical sliding guide.

10. The dual fuel delivery system of claim **2**, comprising an injection head, the injection head comprises at least one injection nozzle adapted to inject a fuel oil and/or a fuel gas, wherein the injection head is connected to the second fuel divider.

11. The dual fuel delivery system of claim **10**, wherein the injection head comprises plurality of injection sections, and wherein every injection section is connected to one outlet of the second fuel divider.

12. The dual fuel delivery system of claim **1**, comprising fuel manifold connected to the inlet of the main fuel line, and adapted to supply the fuel gas and the fuel oil to the main fuel line.

13. A gas turbine comprising the dual fuel delivery system of claim **1**.

14. The gas turbine of claim **13** comprising a can combustor, a cooling air housing, and a burner, wherein the inlet of the main fuel line is positioned outside the can combustor, the outlet of the main fuel line and the inlet to the first fuel divider are positioned between the can combustor and the cooling air housing.

15. A Method for delivering dual fuel to the burner of the gas turbine of claim **14**, the method comprising:

supplying the fuel oil and/or the fuel gas to the main fuel line;

dividing the fuel oil and/or the fuel gas in the first fuel divider; and

guiding the fuel oil and/or the fuel gas to the burner.

16. The dual fuel delivery system of claim **1**, wherein the second fuel oil divider is connected to the first fuel oil divider and the second fuel gas divider is connected to the first fuel gas divider.

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