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(54) METHOD AND APPARATUS FOR MODIFYING AN OEM FUEL SYSTEM FOR BI-FUEL USE

(71) Applicant: **Optimus Technologies, Inc.**, Pittsburgh, PA (US)

(72) Inventors: **Colin N. Huwyler**, Pittsburgh, PA (US); **Jonathan Ewing**, Pittsburgh, PA (US); **Aaron R. Sieczkarek**, Orchard Park, NY (US)

(73) Assignee: **Optimus Technologies, Inc.**, Pittsburgh, PA (US)

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(60) Provisional application No. 61/973,890, filed on Apr. 2, 2014.

(51) **Int. Cl.**

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F02M 37/00	(2006.01)
F02M 43/02	(2006.01)
F02M 37/22	(2019.01)
F02D 19/00	(2006.01)
F02D 19/06	(2006.01)

(52) **U.S. Cl.**

CPC ***F02M 37/0064*** (2013.01); ***F02D 19/00*** (2013.01); ***F02D 19/066*** (2013.01); ***F02M 37/22*** (2013.01); ***F02M 43/00*** (2013.01); *F02M 43/02* (2013.01); *F02D 19/0673* (2013.01); *F02D 19/0697* (2013.01); *Y02T 10/36* (2013.01)

(58) **Field of Classification Search**

CPC F02M 37/0064; F02M 37/22; F02M 43/02; F02D 19/00; F02D 19/02; F02D 19/023; F02D 19/066

See application file for complete search history.

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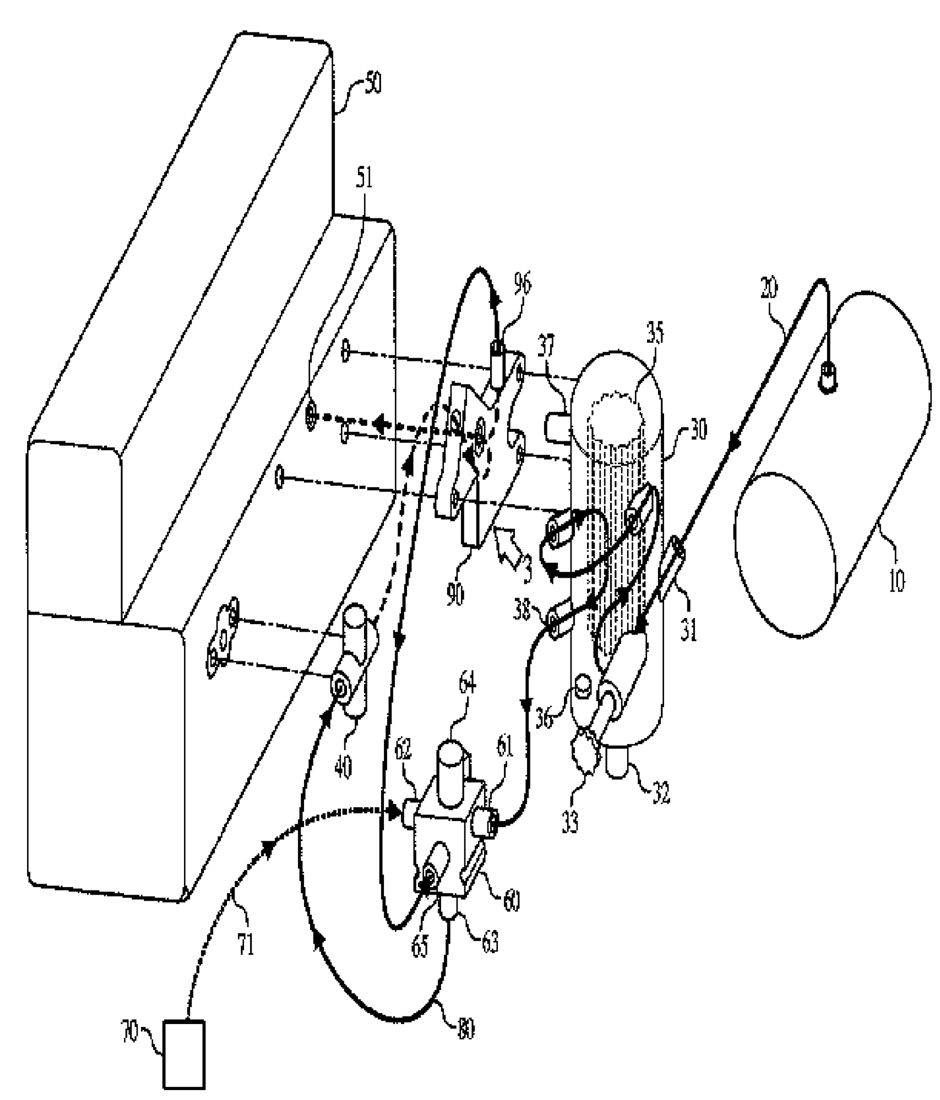
Primary Examiner — Jacob M Amick

(74) *Attorney, Agent, or Firm* — Babst Calland Clements & Zomnir, PC; Carl A. Ronald, Esq.

(57) **ABSTRACT**

The present invention is a system and method for adapting and modifying an existing mono-fuel delivery system for an internal combustion engine to run as a bi-fuel system by reusing and repurposing OEM components of the mono-fuel system. The bi-fuel system makes use of an integration plate that may be mounted to the system fuel filter in substantially the same location as the fuel filter is mounted in the mono-fuel configuration. The integration plate also may deliver either fuel types into the existing engine fuel intake port thus the system does not require the creation of a secondary fuel intake port for the secondary fuel. The integration plate may also be situated such that it minimizes the space it must use within the engine compat anent and it may use the preexisting engine mounting points designed for the fuel filter in the mono-fuel system.

16 Claims, 6 Drawing Sheets



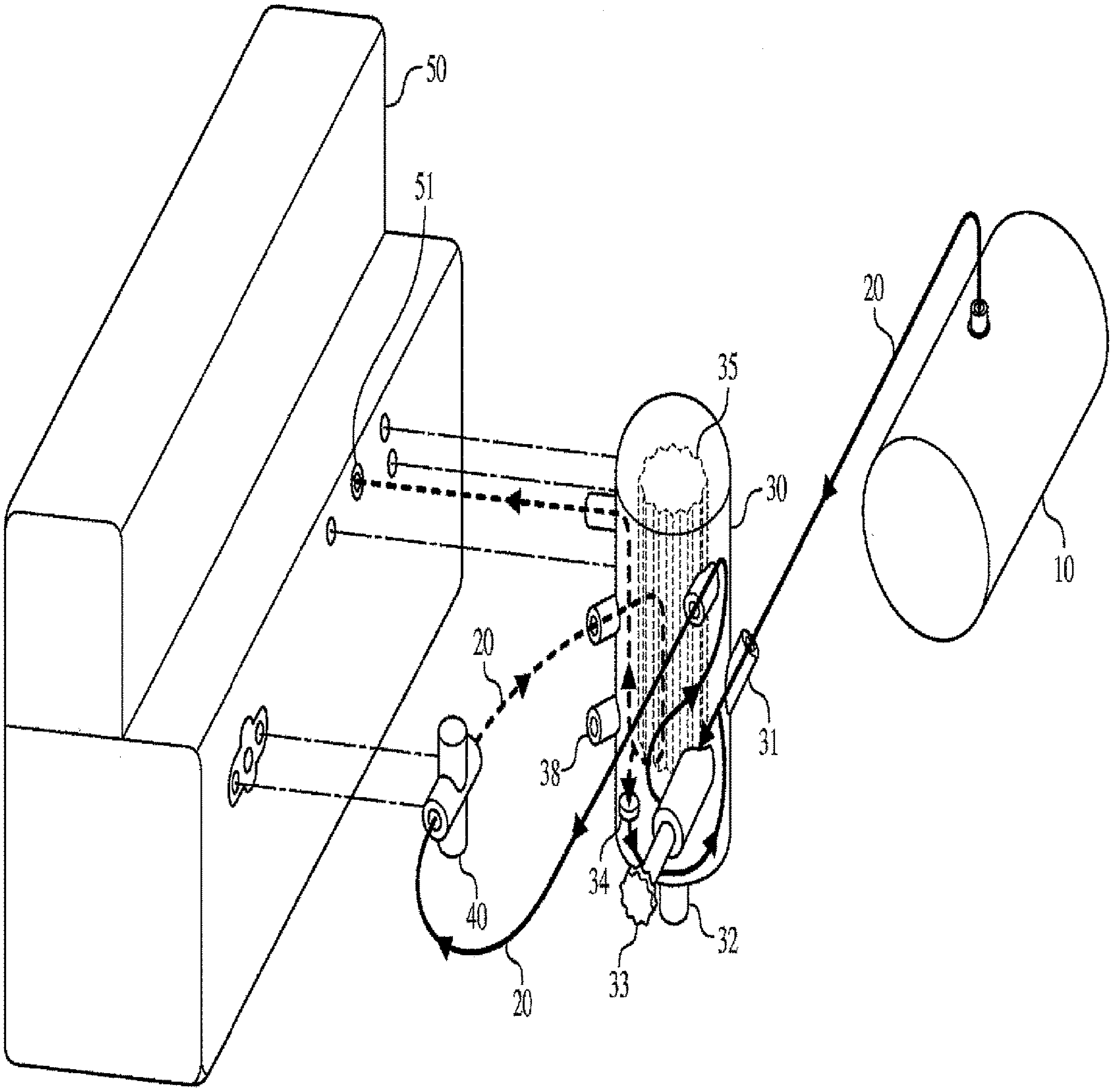


FIG. 1
(PRIOR ART)

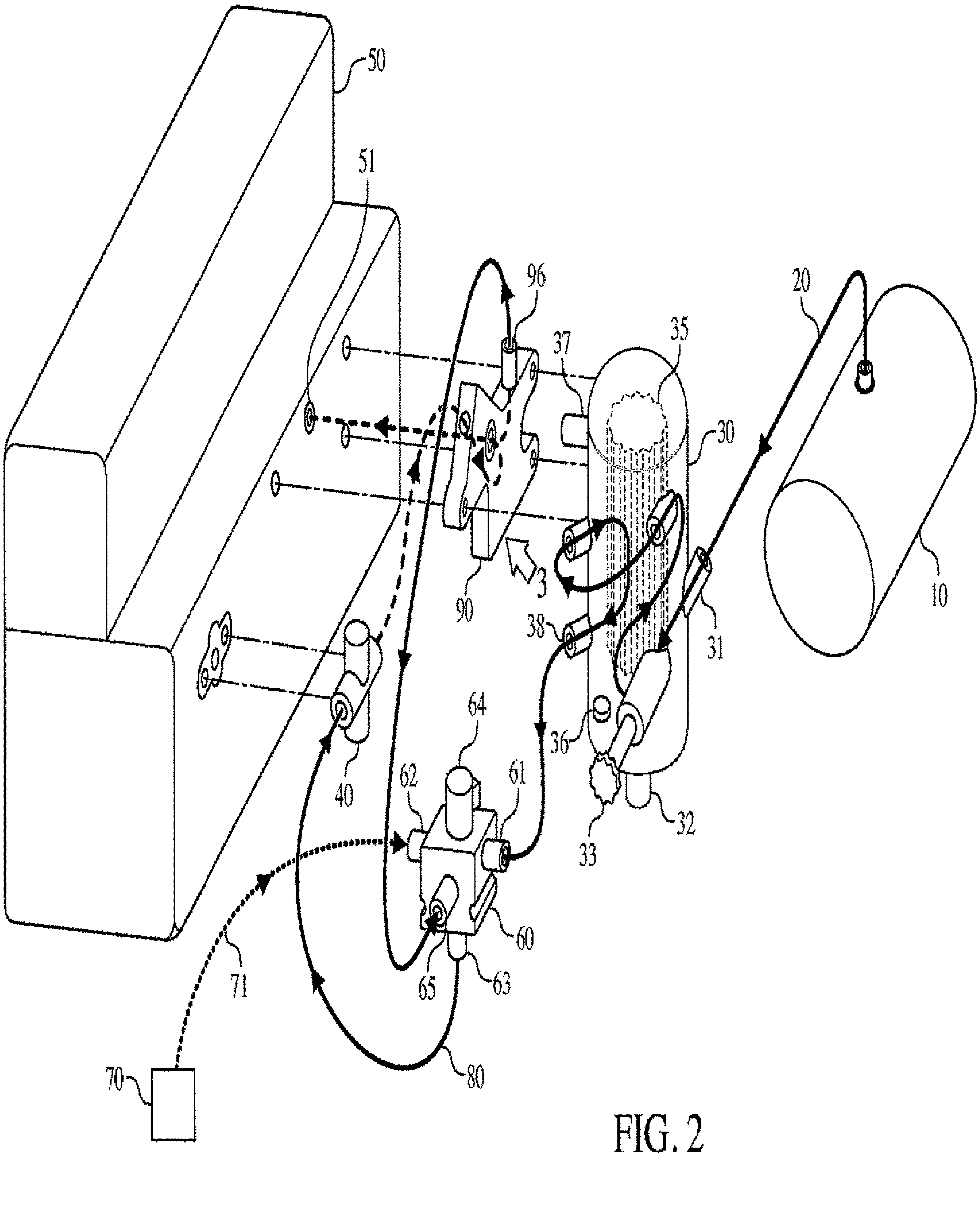


FIG. 2

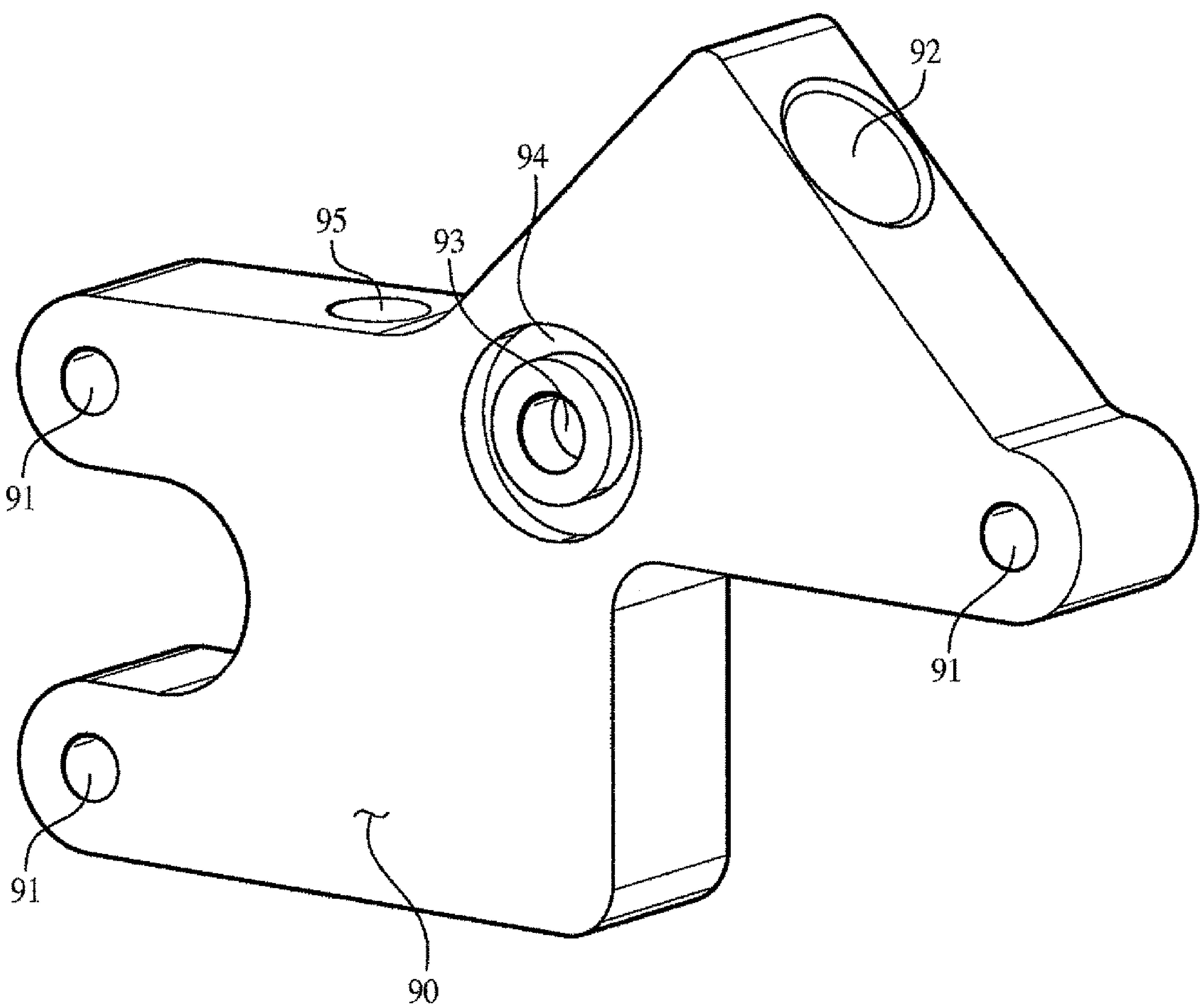


FIG. 3

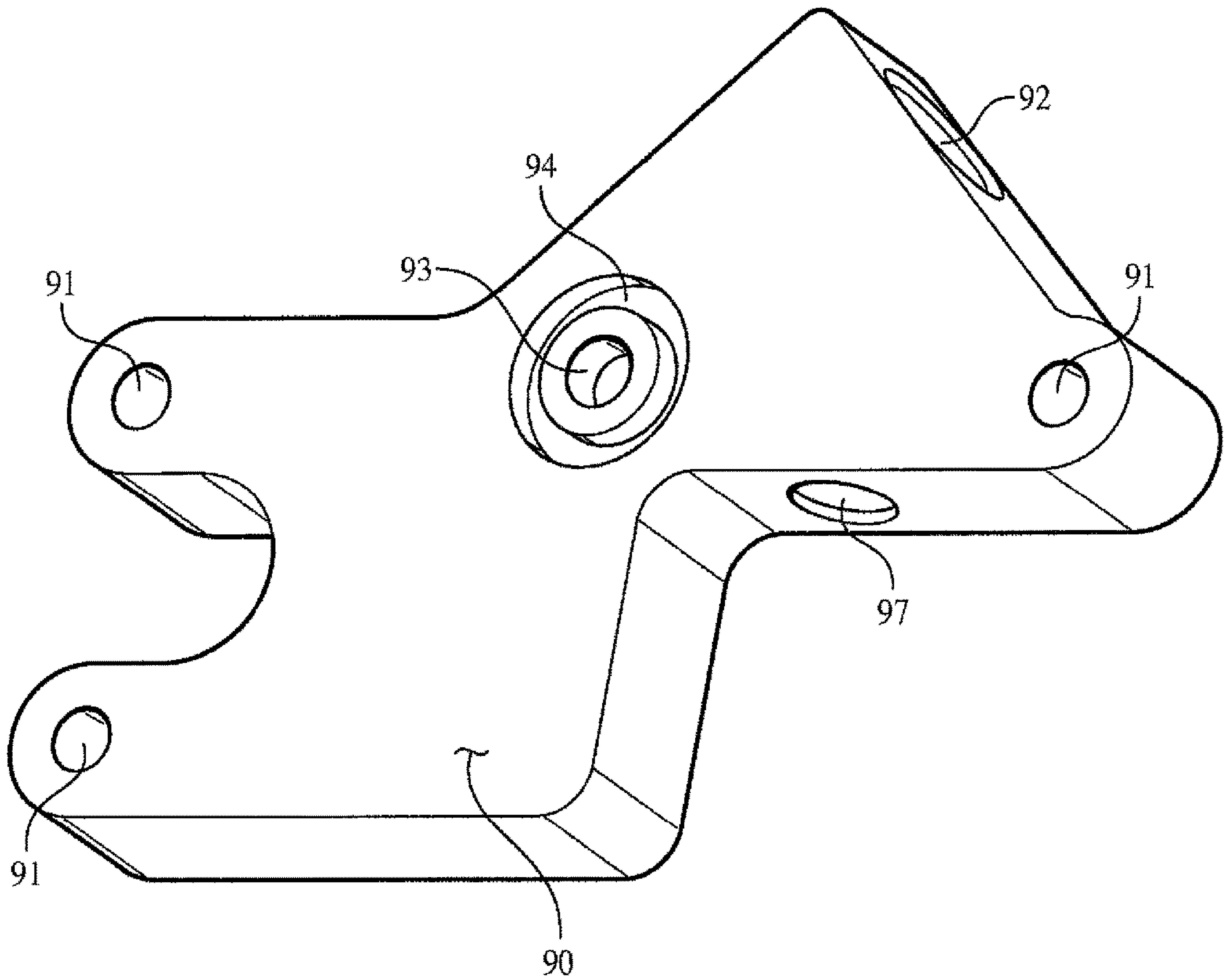


FIG. 4

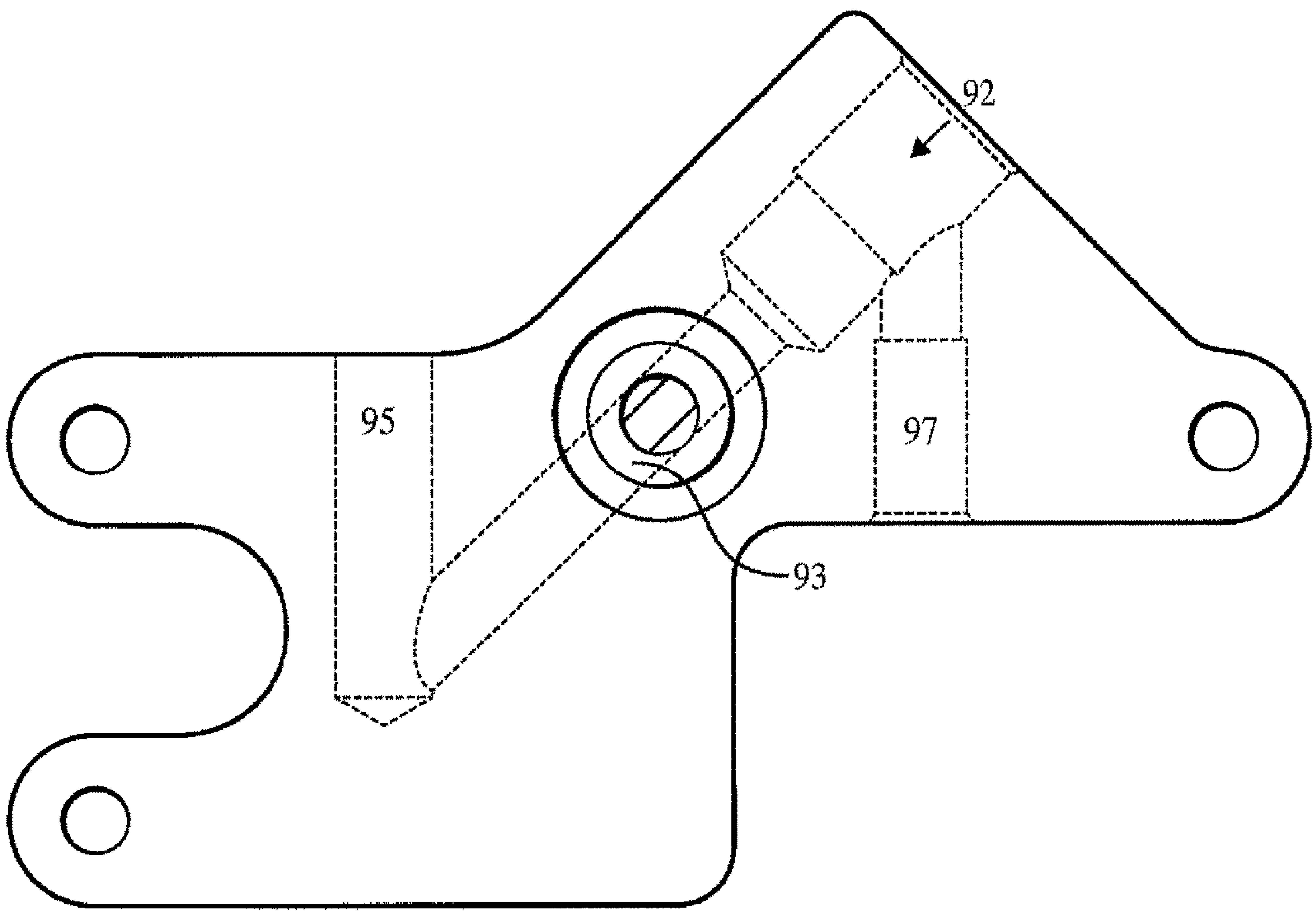


FIG. 5

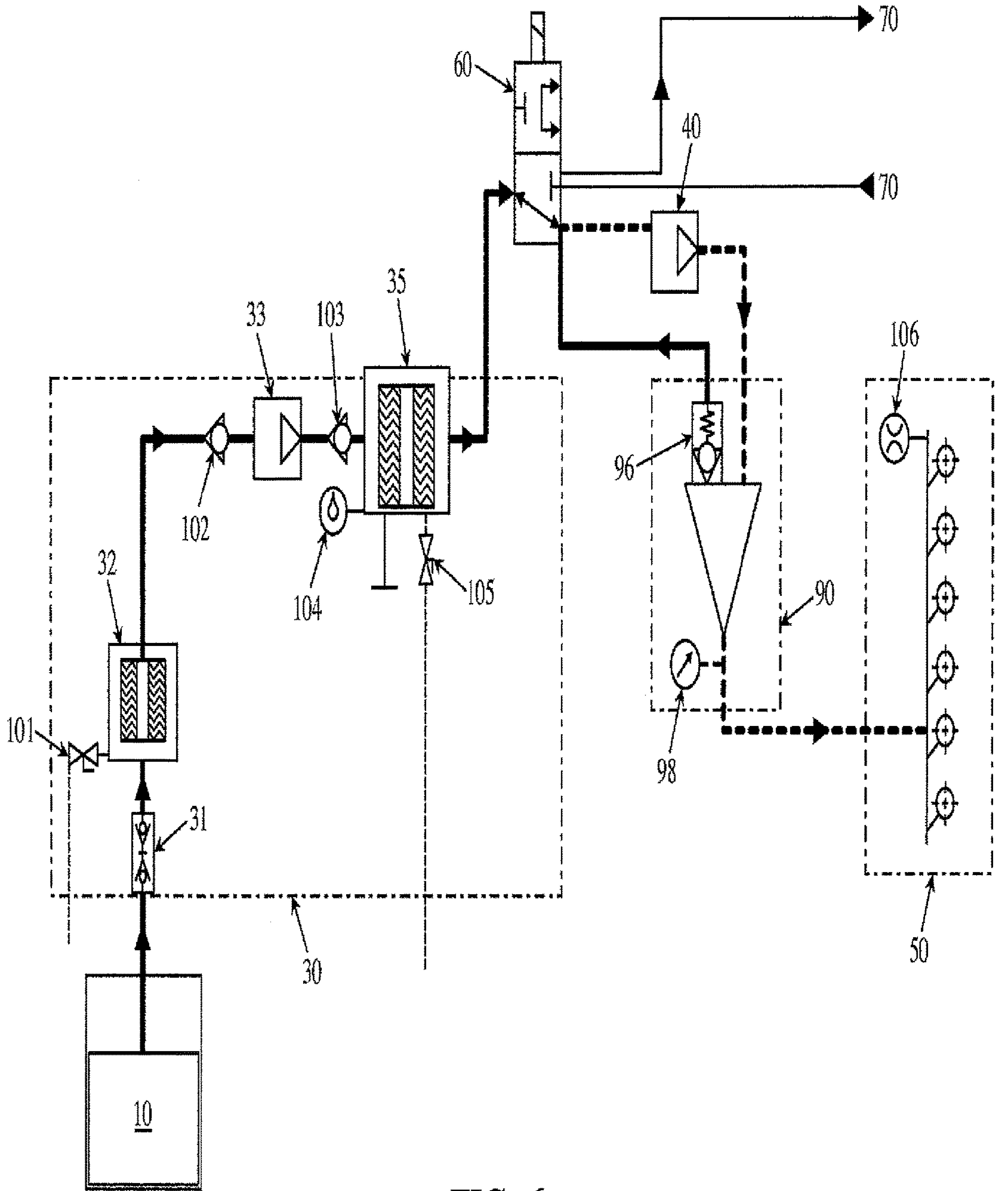


FIG. 6

METHOD AND APPARATUS FOR MODIFYING AN OEM FUEL SYSTEM FOR BI-FUEL USE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a divisional application of, and claims priority from, pending U.S. application Ser. No. 15/330,975, having a filing date of Apr. 2, 2015, which claims the benefit of U.S. Provisional Patent Application Ser. No. 61/973,890 entitled "Plate for Integration of Bi-Fuel System" filed on Apr. 2, 2014. The contents of both of these prior applications are incorporated by reference as if fully set forth herein.

FIELD OF INVENTION

The present invention relates to fuel delivery systems for internal combustion engines and more particularly, fuel delivery systems utilizing more than one type of fuel for internal combustion.

BACKGROUND OF INVENTION

A bi-fuel delivery system is understood to be any engine system that is capable of operating on two different types of fuel. Conversion from a mono-fuel system, such as a diesel fuel combustion engine commonly found in heavy-duty trucks and buses sold by large-scale manufacturers of such vehicles, to a bi-fuel system is advantageous because it typically results in the reduction of total fuel costs and lower vehicle emissions. There are, however, several challenges to converting a mono-fuel system into a bi-fuel system. In a standard, OEM configuration fuel system for an internal combustion engine, known in the art, the fuel systems are arranged for the use of only one type of fuel. For production efficiency, the components of the standard fuel delivery system are not manufactured with any intention for the system to contain or handle more than one type of fuel. Additionally, due to ever increasingly cramped engine compartments, retrofitting and adding new or modified components to a fuel system has become increasingly challenging. As a result, there is a need for reusing/repurposing as many OEM components as possible to allow for the installation of a bi-fuel delivery system on a cost-effective basis.

For compression ignition engines that are designed to run on diesel fuel, the fuel system generally has a diesel fuel tank, a fuel strainer, a fuel filter/water separator, and fuel lift pump that pressurizes the diesel fuel before it enters the engine via a fuel rail inlet port. These components are all designed without the intention to operate in a bi-fuel system environment, and as the present invention shows, these components require substantial modification and repurposing to run in the bi-fuel environment. One particular concern when adapting a system to run in a bi-fuel environment is minimizing cross contamination of the fuels to maximize the efficiency of how each fuel burns in the engine. As a result, converting a mono-fuel system to a bi-fuel system requires substantial repurposing and custom modification in order for the system to run in a fuel efficient manner.

SUMMARY OF INVENTION

The present invention comprises a bi-fuel delivery system that repurposes existing OEM components of a mono-fuel delivery system in order to minimize both cross contamination of fuel and engine space needed for conversion. In particular, the system utilizes a specialized integration plate that allows the existing engine fuel inlet port to be repurposed for bi-fuel delivery. Additionally, the present invention repurposes a fuel lift pump and fuel filter, where the fuel filter is modified to run under vacuum pressure and is mounted to the integration plate such that it is in substantially the same location as in its OEM configuration. Furthermore, the present invention minimizes the amount of shared fuel line due to the placement of the fuel selector valve within the system. Finally, the bi-fuel system of the present invention has the advantage of having a fuel pressure relief valve situated within an integration plate that may be tied to the fuel selector valve in order to maintain optimal operating pressure when either fuel source is in use.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a prior art fuel delivery system that the present invention improves upon.

FIG. **2** is a perspective view of an exemplary embodiment of the fuel delivery system of the present invention.

FIG. **3** is a perspective view of an exemplary embodiment of an integration plate of the fuel system, taken along line **3** in FIG. **2**.

FIG. **4** is an angled view of an exemplary embodiment of an integration plate of the fuel system.

FIG. **5** is a frontal view displaying the internal portions of an exemplary embodiment of an integration plate of the present invention.

FIG. **6** is schematic diagram of an alternative embodiment of a bi-fuel delivery system.

DETAILED DESCRIPTION OF THE INVENTION

The following detailed description includes the best currently contemplated modes of carrying out exemplary embodiments of the invention. The description is not to be taken in a limiting sense, but is made merely for the purpose of illustrating the general principles of the invention, since the scope of the invention is best defined by the claims included herein.

In order to best understand the modifications and improvements made to create a bi-fuel delivery system, a detailed description of an existing mono-fuel delivery system is necessary. FIG. **1** depicts a standard diesel fuel delivery system that may consist of a diesel tank **10**, a diesel fuel line **20**, a fuel filter housing **30**, a quick coupling **31**, a mesh strainer/fuel heater **32**, a manual pressure pump **33**, a fuel regulation value **34**, a fuel lift pump **40**, a primary fuel filter/water separator element **35**, a fuel inlet port **51**, and an engine **50**. In the mono-fuel system, the fuel lift pump **40** may create a negative pressure in the diesel fuel line **20** from the diesel fuel tank **10** to the fuel lift pump **40**, and a positive pressure from the fuel lift pump **40** to the engine **50**. The diesel fuel may flow from the diesel tank **10** into the fuel filter housing **30**, through the quick coupling **31** then through the mesh strainer/fuel heater **32** and into the manual pressure pump **33**. The manual pressure pump **33** may be used to prime the system if fuel system is not currently pressurized prior to operation of the system. The manual pressure pump **33** may be a hand pump such as a piston driven pump. After the diesel fuel flows through the manual pressure pump **33**, the diesel fuel may flow out of the fuel filter housing **30** and into the fuel lift pump **40**. The fuel lift pump **40** may be powered by being connected to a gearbox that is coupled with the camshaft or the gearshaft of the engine (not shown).

In this configuration, the revolutions per minute (RPM) of the engine **50** determines the proportional speed that the fuel lift pump **40** may pump the diesel fuel. From the fuel lift pump **40**, the diesel fuel flow into the fuel filter housing **30**, and into the primary fuel filter/water separator element **35**. The primary fuel filter/water separator element **35**, may remove contaminates and water from the diesel fuel prior to entering the engine **50**. After the diesel fuel is filtered, the diesel fuel enter the engine **50** via a fuel inlet port **51** and then flows into the engine fuel rail, If the pressure of the fuel is beyond a set threshold, the diesel fuel may pass from the from the primary fuel filter/water separator element **35** through a fuel regulation valve **34** into the fuel filter housing **30** between the quick coupling **31** connection and the mesh strainer **32**. This mono-fuel system may also contain various pressure check sensors and drain ports throughout the system.

FIG. **2** depicts an embodiment of the present invention where the standard mono-fuel system has been modified to work within a bi-fuel environment. In the modified configuration of a mono-fuel system converted to a bi-fuel system, there may be a diesel tank **10**, a diesel fuel line **20**, a fuel filter housing **30**, a quick coupling **31**, a mesh strainer/fuel heater **32**, a manual priming pump **33**, a bypass plug **36**, a filter outlet plug **37**, a primary fuel filter/water separator element **35**, a bypass outlet port **38**, a fuel selection value **60**, a bio fuel line **71**, a shared fuel line **80**, a fuel lift pump **40**, an integration plate **90**, a fuel inlet port **51**, a fuel regulation valve **91**, and an engine **50**.

In one embodiment, the diesel tank **10** may be an OEM diesel tank designed to hold diesel fuel in a mono-fuel designed fuel system. The diesel fuel line **20** may be an OEM diesel fuel line designed for a mono-fuel system. The fuel filter system may consist of a fuel filter housing **30**, quick coupling **31**, mesh strainer/fuel heater **32**, manual priming pump **33**, bypass plug **36**, filter outlet plug **37**, bypass outlet port **38**, and a primary fuel filter/water separator element **35**. In one embodiment, the fuel filter system is a modified OEM component. The fuel filter system may be modified from its OEM configuration such that the fluid flow is redirected after the manual priming pump **33** by a bypass plug **36** and fluid is redirected through a bypass coupling into the primary fuel filter/water separator element **35**. In one embodiment the fuel filter bypass may be modified such that the fluid flows out of the fuel filter system from the OEM vacuum fluid outlet port, into the OEM pressurized inlet port, through the filter media and out through a repurposed water valve check port converted into a bypass outlet port **38**. In one embodiment, the fuel filter system may be modified such that the entire system operates under a negative pressure created by the fuel lift pump **40**. The OEM outlet port may be blocked by a plug **37**. In one embodiment, the OEM outlet port may be blocked by the integration plate **90**.

The fuel selection valve **60** may be connected to a diesel fuel line **20** via an inlet to the diesel tank **61**, a bio fuel line **70** via an inlet to the bio fuel tank **62** and a shared fuel line **80** via an outlet **63** to the engine **50**. The fuel selection valve **60** may be actuated by an electronically controlled solenoid **64**. The electronic control may be connected to an ECU (not shown) that is programmed to monitor the engine and fuel conditions required to efficiently run either diesel fuel or bio fuel through the engine. The fuel selection valve **60** may either be open to the diesel fuel line **20** or the bio fuel line **80** to allow either diesel fuel or bio fuel to flow to the engine **50**. In one embodiment, the fuel selection valve **60** is designed such that mixing of the different fuel sources is minimized by rapidly switching the valve. In such an embodiment, only one fuel source is utilized by the engine at a time. In one embodiment, the fuel selection valve **60** may also contain a bio fuel loop valve that allows bio fuel to flow back to the bio fuel tank **70** when the fuel selection valve **60** is closed to bio fuel. The bio fuel line **71** may be pressurized by a fuel pump (not shown) that allows the bio fuel to flow in the closed loop when the fuel selection valve **60** is closed to the bio fuel side of the system. This secondary fuel pump's speed may be set manually by a set-screw or may be electronically controlled by an ECU.

The fuel lift pump **40** may be an OEM component designed to run in a mono-fuel system. In one embodiment, the fuel lift pump **40** may be powered by the engine via a gearbox (not shown) coupled to the flywheel of the engine and as a result the pumping speed of the fuel lift pump is determined by and proportional to the RPM's of the engine. In one embodiment, the fuel lift pump **40** may be the primary means of pressurizing the fuel system by creating a negative pressure on the diesel tank/bio fuel tank side and a positive pressure towards the engine. The fuel lift pump **40** may be connected to the shared fuel lines **80** on both the negative and positive pressure sides of the pump. In this embodiment, the fuel lift pump **40** may be exposed to both diesel fuel as well as bio fuel. It is contemplated in alternative embodiments that the fuel lift pump **40** may be located prior to the fuel selector valve **60** where the fuel lift pump **40** may only be exposed to one of the fuel sources.

In one embodiment, the integration plate **90** may be connected to the fuel lift pump **40** via a shared fuel line **80**. The integration plate **90** may allow for the flow of fuel into the engine **50** using the OEM fuel intake port **51**. FIG. **3-5** provides a detailed view of one embodiment of an integration plate **90** used in the present invention. The integration plate have mounting holes **91** situated such that they line up with OEM mounting points **52** on the engine **50**. In one embodiment, the mounting holes **91** line up with the mounting points **52** that are designed to be used with the OEM fuel filter housing **30**. In this embodiment, the integration plate **90** is adapted to provide mounting points for the OEM fuel filter housing **30**. In one embodiment, the integration plate **90** is mounted between the engine **50** and the fuel filter housing **30** such that the fuel filter housing **30** is located in substantially the same location as in the OEM configuration. In such an embodiment, the integration plate **90** may fit flush to the fuel filter outlet **37** in order to block the passage of any fluid through the outlet. It is contemplated that the design of the integration plate **90** and location of the mounting points **91** may vary by engine configuration. The asymmetrical design shown in FIG. **3-5** provides that the integration plate **90** conform to the engine fuel rail and remain as unobtrusive to the engine compartment as possible. In one embodiment, a single set of bolts may be used to attach the fuel filter housing **30** and the integration plate **90** to the engine **50** by passing the bolts though the integration plate mounting points **91**.

The integration plate **90** may have a shared fuel inlet **92** and a fuel exit port **93** which may be the final delivery port before the engine **50** is introduced with either the primary or alternative fuels. In one embodiment, the integration plate **90** may have a gasket gland **94** which may house an o-ring which may create a sealing surface against the engine fuel intake port **51**. The gasket may vary extensively in alternative embodiments in make and shape as determined by the engine configuration. The gasket that is seated may create a face seal around the engine fuel rain inlet port **51** which may prevent leakage of the primary or alternative fuel. In an alternative embodiment, the fuel exit port **93** may be configured to screw into a threaded engine fuel intake port **51** such that it forms a threaded coupling. The integration plate **90** may also have relief port **95** that may house a regulation value **96**. The regulation valve **96** may have a cracking pressure set according to the specifications of the engine being utilized in the system. In one embodiment, if the fuel pressure is beyond the cracking pressure, the regulation valve **96** may open and allows fuel to flow to a fuel regulation port **65** in the fuel selector valve **60**. The integration plate may be created out of a material that will be suitably non-reactive to the alternative fuels that the integration plate may be exposed to, such as aluminum and stainless steel.

FIG. **4** depicts an embodiment where the integration plate **90** may contain a pressure sensor port **97**. The pressure sensor **98** may allow for analysis and measurement of the fuel system pressure prior to the fuel entering the engine fuel rail. The pressure sensor port **97** may accommodate a pressure sensor of an equivalent size of the port In alternative embodiments, the pressure sensor port **97** may be absent or plugged with an equivalent sized sealing device. FIG. **5** depicts an internal perspective of the integration plate **90** that shows the passage where fuel may flow from the integration plate inlet port **92** to the fuel exit port **93** or the fuel relief port **95**.

FIG. **6** depicts a schematic of an alternative embodiment with the placement of additional check valves, sensors, drain ports and test ports. A strainer valve **101** may be connected before the mesh strainer/fuel heater **32**. There may be a first check valve **102** prior to the manual priming pump **33** and a second check valve **103** between the manual priming pump **33** and the primary fuel filter/water separator element **35**. The primary fuel filter/water separator element **35** may be connected to a water-in-filter sensor **104**, and a water drain **105**. An engine fuel pressure sensor **98** may be connected to the integration plate **90**. An air bleed pressure test point **106** may be connected to the engine **50**. In one embodiment the air bleed pressure test point **106** may be a Schrader valve.

In one embodiment, the diesel fuel line **20** is under a negative pressure created by the fuel lift pump **40**. If the fuel selector valve **60** is open to allow diesel fuel pass through the valve, then diesel fuel may flow from the diesel fuel tank **10** through the quick coupling **31** and into the fuel filter housing **30**. In one embodiment, the diesel fuel may flow within the fuel filter housing **30** such that it passes through the mesh strainer/fuel heater **32**, manual priming pump **33**, and though a bypass routed from the manual priming pump **33** through the primary filter/water separator element **35** and out of the fuel filter housing **30**. In this embodiment, the diesel fuel passes through the entire fuel filter housing **30** while under a negative pressure created by the fuel lift pump **40**. After passing the through the fuel filter housing **30**, the diesel fuel may pass though the fuel selector valve **60**, so long as the valve is open to allow diesel fuel to pass. After passing through the fuel selector valve **60**, the diesel fuel may pass though the fuel lift pump **40** and then may be pumped into the integration plate **90**. The diesel fuel may flow through the integration plate **90** through the integration plate inlet port **92**, and may exit through the fuel outlet port **93** where the diesel fuel may then pass into the engine fuel inlet port **51** and into the engine fuel rail.

In one embodiment, bio fuel is used if the fuel selector valve **60** is open to the bio fuel side **63**, and closed to the diesel side **61** and the bio fuel may flow toward the engine **50**. The bio fuel system **70** may consist of a fuel tank, fuel heater, fuel pumps and other necessary components to condition the bio fuel to be burned in the engine **50**. These necessary conditions may be the reaching a given operating temperature of the engine, and reaching a threshold temperature of the bio fuel and/or maintaining a desired fuel pressure. In one embodiment, the bio fuel may flow to the fuel selector valve **60** via a bio fuel line **71** and into the fuel lift pump **40** via a shared fuel line **80**. The fuel lift pump **40** may then pump the bio fuel into the integration plate **90** via the inlet port **92**. The bio fuel may then flow through the integration plate **90** and out to the engine fuel intake port **51** via the integration plate fuel exit port **93**. If the pressure of the bio fuel is too high, the fuel pressure regulation valve **96** may open and allow the bio fuel to pass back to the fuel selector valve **60** via a fuel regulation port **65**.

While the principal embodiment of the present invention utilizes diesel and bio fuel as the two fuels, it should be understood the methodology and inventive techniques utilized with the present invention could be used with alternative disparate fuel sources and different engine types, such as, but not limited to: gasoline, liquid natural gas, liquefied petroleum gas, straight vegetable oil, waste vegetable oil and other common fuels used in internal combustion engines.

It should be understood, of course, that the foregoing relates to exemplary embodiments of the invention and that modifications may be made without departing from the sprit and scope of the invention as set forth in the following claims.

We claim:

1. A fuel delivery system for an internal combustion engine where a plurality of fuels are optionally delivered to the engine comprising:

a fuel filter;

a fuel lift pump coupled to the fuel filter,

a fuel selector valve coupled to the fuel filter; and

a fuel integration plate coupled to the fuel filter wherein the fuel integration plate is adapted to enable the engine to accept a plurality of fuels.

2. The fuel delivery system of claim **1**, wherein the fuel filter is located in an OEM fuel filter position and the fuel lift pump is located in an OEM lift pump position and both the fuel filter and the lift pump are located in their OEM positions after the fuel integration plate is installed.

3. The fuel delivery system of claim **1**, wherein the plurality of fuels comprises an OEM recommended fuel and a secondary fuel.

4. The fuel delivery system of claim **3**, wherein the fuel integration plate is coupled with a pressure relief valve in order to maintain optimal operating pressure of the system while the engine operates on the secondary fuel.

5. The fuel delivery system of claim **3**, wherein the fuel lift pump is operable with only the OEM recommended fuel.

6. The fuel delivery system of claim **1**, wherein the fuel integration plate is coupled to a fuel selector having a shared fuel line.

7. The fuel delivery system of claim **1**, wherein the internal combustion engine further comprises an OEM engine fuel intake port and the plurality of fuels are delivered to the engine using the OEM engine fuel intake port.

8. The fuel delivery system of claim **7**, wherein the integration plate further comprises a gasket gland to create a sealed connection with the OEM engine fuel intake port.

9. The fuel delivery system of claim **1**, wherein the integration plate fits flush to the fuel filter outlet to block passage of any fuel through the outlet.

10. The fuel delivery system of claim 1, wherein the engine further comprises a fuel rail having an OEM shape and the integration plate conforms to the OEM shape of the fuel rail.

11. The fuel delivery system of claim 1, wherein the fuel integration plate further comprises a fuel exit port.

12. The fuel delivery system of claim 11, wherein the fuel exit port is matingly attached to an OEM engine fuel intake port.

13. The fuel delivery system of claim 1, wherein the fuel integration plate further comprises a relief port.

14. The fuel delivery system of claim 13, wherein the relief port further comprises a regulation valve.

15. The fuel delivery system of claim 14, wherein the regulation valve has a set cracking pressure.

16. The fuel delivery system of claim 1, wherein the integration plate further comprises a pressure sensor port to measure fuel system pressure.

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