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International application number:	<b>PCT/US2017/049485</b>
International filing date:	<b>30 August 2017 (30.08.2017)</b>
Document type:	<b>Certified copy of priority document</b>
Document details:	Country/Office: <b>US</b>
	Number: <b>62/381,362</b>
	Filing date: <b>30 August 2016 (30.08.2016)</b>
Date of receipt at the International Bureau:	<b>11 September 2017 (11.09.2017)</b>

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a),(b) or (b-bis)

877400



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**APPLICATION NUMBER: 62/381,362**

**FILING DATE: August 30, 2016**

**RELATED PCT APPLICATION NUMBER: PCT/US17/49485**

**THE COUNTRY CODE AND NUMBER OF YOUR PRIORITY APPLICATION, TO BE USED FOR FILING ABROAD UNDER THE PARIS CONVENTION, IS US62/381,362**



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Document Description: Provisional Cover Sheet (SB16)

PTO/SB/16 (11-08)

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### Provisional Application for Patent Cover Sheet

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c)

#### Inventor(s)

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Remove

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All Inventors Must Be Listed – Additional Inventor Information blocks may be generated within this form by selecting the **Add** button.

Add

Title of Invention

FUEL TANK SYSTEM AND METHOD FOR DETECTING AUTOMOTIVE FUEL SYSTEM LEAKS

Attorney Docket Number (if applicable)

16-FVS-427PROV1

#### Correspondence Address

Direct all correspondence to (select one):

The address corresponding to Customer Number

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Customer Number

112470

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

No.

Yes, the invention was made by an agency of the United States Government. The U.S. Government agency name is:

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Doc Code: **TR.PROV**

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**Applicant asserts small entity status under 37 CFR 1.27 or applicant certifies micro entity status under 37 CFR 1.29**

- Applicant asserts small entity status under 37 CFR 1.27
- Applicant certifies micro entity status under 37 CFR 1.29. Applicant must attach form PTO/SB/15A or B or equivalent.
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Signature	Brian D. Hollis/		Date (YYYY-MM-DD)	2016-08-30	
First Name	Brian	Last Name	Hollis	Registration Number (If appropriate)	51075

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## FUEL TANK SYSTEM AND METHOD FOR DETECTING AUTOMOTIVE FUEL SYSTEM LEAKS

### FIELD

**[0001]** The present disclosure relates generally to fuel tanks on passenger vehicles and more particularly to a system and method for detecting automotive fuel system leaks.

### BACKGROUND

**[0002]** Fuel vapor emission control systems are becoming increasingly more complex, in large part in order to comply with environmental and safety regulations imposed on manufacturers of gasoline powered vehicles. Along with the ensuing overall system complexity, complexity of individual components within the system has also increased. Certain regulations affecting the gasoline-powered vehicle industry require that fuel vapor emission from a fuel tank's ventilation system be stored during periods of an engine's operation. In order for the overall vapor emission control system to continue to function for its intended purpose, periodic purging of stored hydrocarbon vapors is necessary during operation of the vehicle.

**[0003]** All vehicles sold in the United States are required to check for and detect vapor leaks in the fuel system as part of On-Board Diagnostics (OBD) legislation. Starting with model year 2017 vehicles, all Tier 3 and LEV III vehicles certified by the environmental protection agency (EPA) must be able to identify, store and if required, signal any leaks equal to or greater than a 0.02 inch diameter. With current prior art systems, the ability to reliably detect a leak is low, with many leaks going undetected

and many false positive results. According to one EPA study, only 30% of vehicles with leaks had been identified by the on-board leak detection. There is a need in the art for improvement.

**[0004]** The background description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent it is described in this background section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly admitted as prior art against the present disclosure.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0005]** The present disclosure will become more fully understood from the detailed description and the accompanying drawings, wherein:

**[0006]** FIG. 1 is a schematic illustration of a fuel tank system having an evaporative emissions and leak detection control system constructed in accordance to one example of the present disclosure; and

**[0007]** FIG. 2 are various pressure versus time plots for sequential leak testing according to various examples of the present disclosure.

#### DETAILED DESCRIPTION

**[0008]** With initial reference to FIG. 1, a fuel tank system constructed in accordance to one example of the present disclosure is shown and generally identified at reference number 10. The fuel tank system 10 can generally include a fuel tank 12 configured as a reservoir for holding fuel to be supplied to an internal combustion engine via a fuel



delivery system, which includes a fuel pump (not specifically shown). The fuel tank 12 is operatively connected to an evaporative emissions and leak detection control system 14 that includes a controller 16, a pressure sensor 18, a valve assembly collectively identified at reference 20, a purge or fuel canister 22, and a filler pipe and cap assembly 30.

**[0009]** The valve assembly 20 can collectively include a recirculation line valve 20A, an inlet check valve 20B, an upstream canister valve 20C and a downstream canister valve 20D. As will become appreciated herein, each of the valves 20A, 20B, 20C and 20D can be independently open and closed by the controller 16. In one non-limiting example, the valves 20A, 20B, 20C and 20D can be electrically actuated. The recirculation line valve 20A can move between an open position and a closed position to open and close a recirculation line 40 fluidly connected between the fuel tank 12 and the filler pipe and cap assembly 30. The inlet check valve 20B can move between an open position and a closed position to open and close a vapor line 42 fluidly connected between the fuel tank 12 and the filler pipe and cap assembly 30. A liquid fuel line 32 can deliver fuel from the fuel tank 12 to the engine.

**[0010]** The upstream canister valve 20C can move between an open position and a closed position to open and close an upstream vent line 44 that fluidly connects the fuel tank 12 and the fuel canister 22. The downstream canister valve 20D can move between an open position and a closed position to open and close a downstream canister vent line 46 that fluidly connects the fuel canister 22 and the engine.

**[0011]** The fuel canister 22 is adapted to collect fuel vapor emitted by the fuel tank 12 and to subsequently release the fuel vapor through the downstream canister vent

line 46 to the engine. The controller 16 can also be configured to regulate the operation of evaporative emissions and leak detection control system 14 in order to recapture and recycle the emitted fuel vapor as well as determine if a leak is present. The fuel tank system 10 can be incorporated on traditional fuel tanks and on fuel tanks configured for use on hybrid electric vehicles.

**[0012]** With additional reference to FIG. 2, the evaporative emissions and leak detection control system 14 is configured to electronically seal the fuel tank 12 at the recirculation line 40, the vapor line 42, the upstream vent line 44, the downstream canister vent line 46 to measure the resulting pressure change over time that occurs as the fuel in the tank evaporates (raising pressure) or condenses (lowering pressure or inducing a vacuum). By comparing the pressure change over time to an expected value for given conditions, it's possible to determine if a leak is present in the fuel tank system.

**[0013]** External conditions 50 such as ambient temperature, atmospheric pressure, radiant heating, humidity, driving conditions (speed, turning) and vibration can be measured using sensors on the vehicle or in the fuel system 10. The volatility of the fuel in the tank (or RVP) can be inferred through tables or via engine calculations, or measured directly. The pressure inside the fuel tank 12 can be measured directly with a the pressure sensor 18 mounted on or in the fuel tank 12. From the available data, the expected change in pressure over a given time can be calculated. This can be compared to the measured actual pressure change. If a difference is observed, the evaporative emissions and leak detection control system 14 can infer that a leak may be present. By conducting a series of tests over time, see FIG. 2, noise factors such as

driving conditions, temporary changes in temperature or atmospheric pressure, etc., can be averaged out by the controller 16 and the presence of a leak can be determined with high confidence. Each of the valves 20A, 20B, 20C and 20D can be selectively closed and pressure tests done to determine a location of a leak, once detected.

**[0014]** Once the evaporative emissions and leak detection control system 14 detects a leak, the system 14 can isolate the fuel tank 12 from the fuel canister 22 by closing the valve 20C and perform a leak check again. If the pressure meets the expected performance, it can be determined that the leak is downstream of the valve 20C or somewhere in the canister circuit. Similar tests can be performed with the filler pipe and cap assembly 30 by closing the valve 20A and using the valve 20B. Additional confirmation testing can be done to confirm the leak, such as using the current method of Natural Vacuum Leak Detection, which runs when the engine is off and relies on the cooling of the fuel to create a vacuum. This can be a precise way to quantify the size of the leak, but may be limited to running in specific conditions only.

**[0015]** The foregoing description of the examples has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements or features of a particular example are generally not limited to that particular example, but, where applicable, are interchangeable and can be used in a selected example, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the disclosure, and all such modifications are intended to be included within the scope of the disclosure.

## CLAIMS

What is claimed is:

1. A fuel tank system comprising:
  - a fuel tank;
  - a purge canister;
  - a valve assembly having an upstream canister valve that moves between an open position and a closed position to open and close an upstream vent line that fluidly connects the fuel tank and the purge canister; and
  - a controller that (i) conducts a first pressure test that measures a pressure in the fuel tank over a time, and (ii) closes the upstream canister valve based on a determination that a leak exists, (iii) conducts a second pressure test that measures a pressure in the fuel tank over a time subsequent to closing the upstream canister valve and (iv) determines a location of the leak based on comparing the first pressure test and the second pressure test.
2. The fuel tank system of claim 1, further comprising a filler pipe and cap assembly.
3. The fuel tank system of claim 2, wherein the valve assembly further comprises a recirculation line valve that moves between an open position and a closed position to open and close a recirculation line fluidly connected between the fuel tank and the filler pipe and cap assembly.

4. The fuel tank system of claim 3, wherein the controller (i) conducts a third pressure test that measures a pressure in the fuel tank over a time, and (ii) closes the recirculation line valve based on a determination that a leak exists, (iii) conducts a fourth pressure test that measures a pressure in the fuel tank over a time subsequent to closing the recirculation line valve and (iv) determines a location of the leak based on comparing the third pressure check and the fourth pressure check.

5. The fuel tank system of claim 1, further comprising a pressure sensor that senses a pressure in the fuel tank.

6. The fuel tank system of claim 5, wherein the controller determines a measured pressure over time from the pressure sensor.

7. The fuel tank system of claim 6, wherein the controller compares the measured pressure over time and an expected pressure over time and determines whether a leak exists based on comparing the measured and expected pressures over time.

8. A method for detecting a leak in a fuel tank system, the method comprising:

providing a fuel tank system having a fuel tank, a purge canister and a valve assembly, the valve assembly having an upstream canister valve that moves between an open position and a closed position to open and close an upstream vent line that fluidly connects the fuel tank and the purge canister;

performing a first pressure test that measures a pressure in the fuel tank over a time;

closing the upstream canister valve based on a determination that a leak exists;

performing a second pressure test that measures a pressure in the fuel tank over a time subsequent to closing the upstream canister valve; and

determining a location of the leak based on comparing the first pressure test and the second pressure test.

9. The method of claim 8, wherein the fuel tank system further includes a filler pipe and cap assembly and a recirculation line valve that moves between an open position and a closed position to open and close a recirculation line fluidly connected between the fuel tank and the filler pipe and cap assembly, the method further comprising:

performing a third pressure test that measures a pressure in the fuel tank over a time;

closing the recirculation line valve based on a determination that a leak exists;

performing a fourth pressure test that measures a pressure in the fuel tank over a time subsequent to closing the recirculation line valve; and

determining a location of the leak based on comparing the third pressure test and the fourth pressure test.

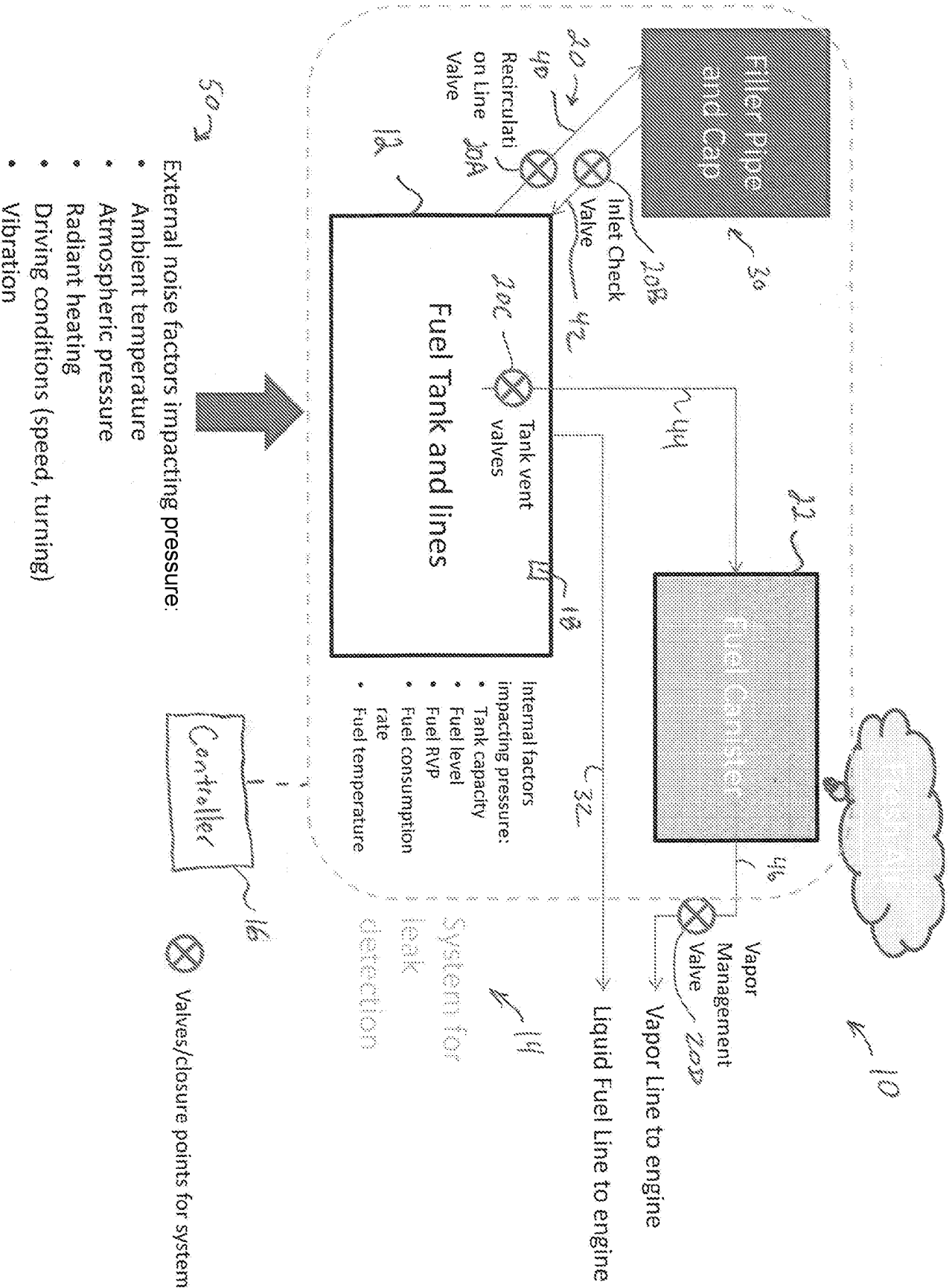
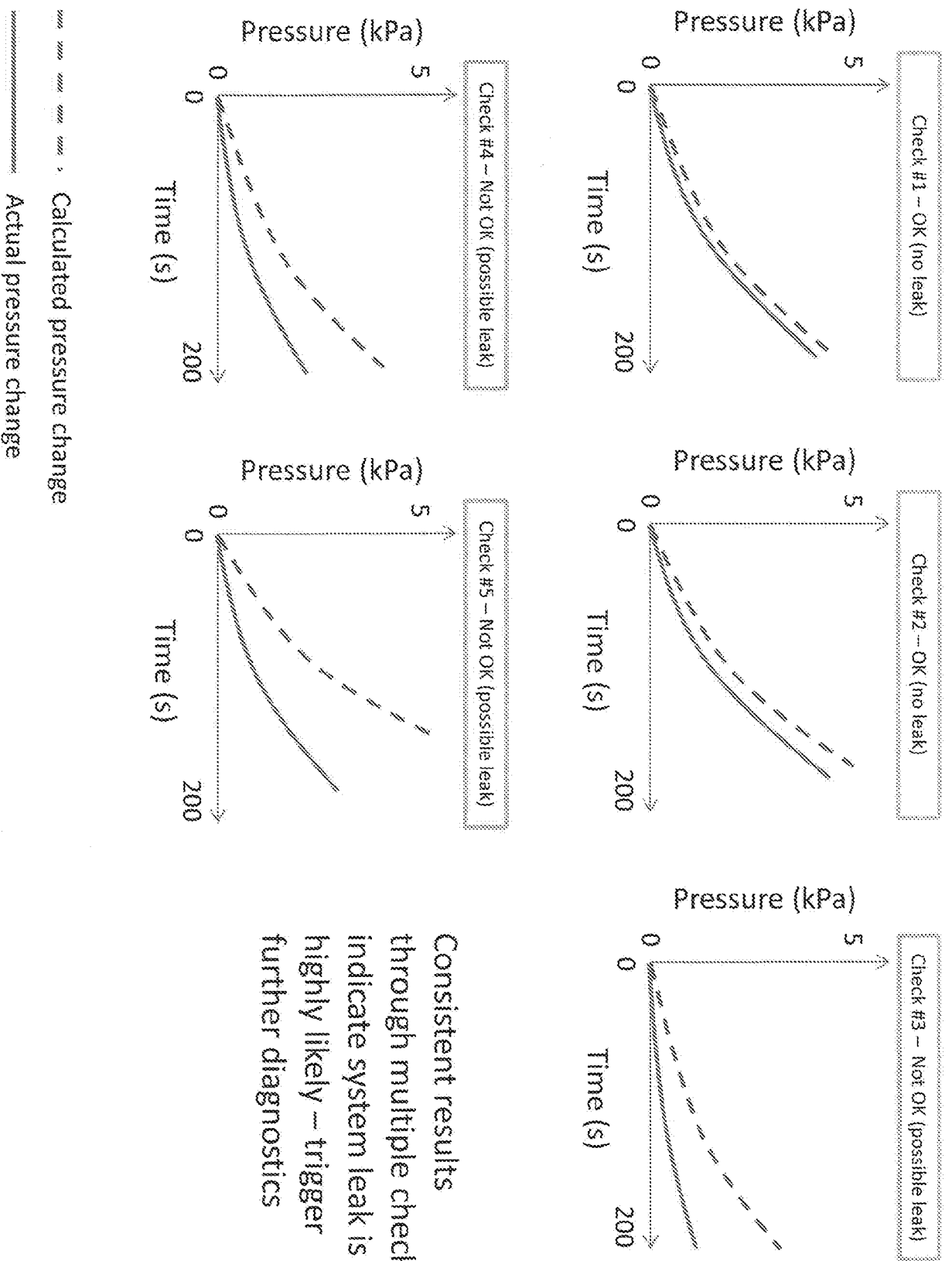


Figure 1 – System Schematic





Consistent results  
 through multiple checks  
 indicate system leak is  
 highly likely – trigger  
 further diagnostics

Figure 2 – Sequential Leak Testing

## Electronic Acknowledgement Receipt

<b>EFS ID:</b>	26790623
<b>Application Number:</b>	62381362
<b>International Application Number:</b>	
<b>Confirmation Number:</b>	5616
<b>Title of Invention:</b>	FUEL TANK SYSTEM AND METHOD FOR DETECTING AUTOMOTIVE FUEL SYSTEM LEAKS
<b>First Named Inventor/Applicant Name:</b>	Matthew Memmer
<b>Customer Number:</b>	112470
<b>Filer:</b>	Brian Douglas Hollis/Alex Wroblewski
<b>Filer Authorized By:</b>	Brian Douglas Hollis
<b>Attorney Docket Number:</b>	16-FVS-427PROV1
<b>Receipt Date:</b>	30-AUG-2016
<b>Filing Date:</b>	
<b>Time Stamp:</b>	16:35:23
<b>Application Type:</b>	Provisional

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1	Provisional Cover Sheet (SB16)	Provisional_Transmittal.pdf	1477114	no	3
			ad1fe6663ae9c5c4399bb45398cc2c32adb4e720		
<b>Warnings:</b>					
<b>Information:</b>					
2		4311-000333-US-PS1-App.pdf	45897	yes	9
			5a7b62728d2ffe39751c2d3215f73e7c4c0a622		
	<b>Multipart Description/PDF files in .zip description</b>				
	<b>Document Description</b>		<b>Start</b>	<b>End</b>	
	Specification		1	5	
	Claims		6	9	
<b>Warnings:</b>					
<b>Information:</b>					
3	Drawings-other than black and white line drawings	Final_FIGS_4311-000333-US-PS1.pdf	3184351	no	2
			c4c1e21b4ce24791c2d0e9b707d50d8892fc2254		
<b>Warnings:</b>					
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4	Fee Worksheet (SB06)	fee-info.pdf	30471	no	2
			ca47c9bc037e18f15874b13b4def4b18edaec30		
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