FUEL TANK SYSTEM AND METHOD FOR DETECTING AUTOMOTIVE FUEL SYSTEM LEAKS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application No. 62/381,362 filed on August 30, 2016. The disclosure of the above application is incorporated herein by reference.

FIELD

[0002] 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

[0003] 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.

[0004] 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.

[0005] 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.

SUMMARY

[0006] A fuel tank system according to the present disclosure includes a fuel tank, a purge canister a valve assembly and a controller. The valve assembly has an upstream canister valve that moves between an open position and a closed position to close an upstream vent line that fluidly connects the fuel tank and the purge canister. The controller (i) conducts a first pressure test that measures a pressure in the fuel tank over a time, (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.

[0007] According to additional features, the fuel tank system includes a filler pipe and cap assembly. The valve assembly can further include 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 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.

[0008] In other features, the fuel tank system further comprises a pressure sensor that senses a pressure in the fuel tank. The controller determines a measured pressure over time from the pressure sensor. 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. The fuel canister is adapted to collect fuel vapor emitted by the fuel tank and subsequently release the fuel vapor through a downstream canister vent line to an engine.

[0009] A fuel tank system constructed in accordance to another example of the present example includes a fuel tank, a filler pipe, a purge canister, a valve assembly and a controller. The valve assembly includes an upstream canister valve, a recirculation line valve and an inlet check valve. The upstream canister valve 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. The recirculation line valve moves between an open position and a closed position to open and close a recirculation line that fluidly connects the fuel tank and the filler pipe. The inlet check valve moves between an open position and a closed position to open and close a vapor line that fluidly connects the fuel tank and the filler pipe. The controller (i) conducts a first leak check wherein a first calculated pressure change is compared to a first measured pressure in the fuel tank, (ii) closes one of the upstream canister valve, recirculation line valve and inlet check valve, and (iii) conducts a second leak check wherein a second calculated pressure change is compared to a second measured pressure in the fuel tank, and (iii) determines a potential location of a leak based on the first and second leak checks.

[0010] According to other features, the controller (iv) conducts a third leak check wherein a third calculated pressure change is compared to a third measured pressure in the fuel tank, and (v) determines a potential location of a leak based on the first and third leak check. The third leak check can include closing the recirculation line valve. In another arrangement, the third leak check includes closing the inlet check valve. The controller (vi) conducts a fourth leak check wherein a fourth calculated pressure change is compared to a fourth measured pressure in the fuel tank, and (v) determines a potential location of a leak based on the first and fourth leak check. The fourth leak check includes closing the recirculation line valve. In another arrangement, the fourth leak check includes closing the inlet check valve. The upstream canister valve, the recirculation line valve and the inlet check valves are electrically actuated. The fuel canister can be adapted to collect fuel vapor emitted by the fuel tank and subsequently release the fuel vapor through a downstream canister vent line to an engine.

[0011] A method for detecting a leak in a fuel tank system includes providing a fuel tank system having a fuel tank, a purge canister and a valve assembly. The valve assembly has 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. A first pressure test that measures a pressure in the fuel tank over time is performed. The upstream canister valve is closed based on a determination that a leak exists. A second pressure test is performed that measures a pressure in the fuel tank over a time subsequent to closing the upstream canister valve. A location of the leak is determined based on comparing the first pressure test and the second pressure test.

[0012] According to additional features, 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. A third pressure test is performed that measures a pressure in the fuel tank over time. The recirculation line valve is closed based on a determination that a leak exists. A fourth pressure test is performed that measures a pressure in the fuel tank over a time subsequent to closing the recirculation line valve. A location of the leak is determined based on comparing the third pressure test and the fourth pressure test.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The present disclosure will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0014] 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

[0015] FIG. 2A is a pressure versus time plot for a first leak test wherein a calculated pressure change (dashed line) is plotted against an actual pressure change (solid line) indicating results consistent with no leak;

[0016] FIG. 2B is a pressure versus time plot for a second leak test wherein a calculated pressure change (dashed line) is plotted against an actual pressure change (solid line) indicating results consistent with no leak;

[0017] FIG. 2C is a pressure versus time plot for a third leak test wherein a calculated pressure change (dashed line) is plotted against an actual pressure change (solid line) indicating results consistent with a possible leak;

[0018] FIG. 2D is a pressure versus time plot for a fourth leak test wherein a calculated pressure change (dashed line) is plotted against an actual pressure change (solid line) indicating results consistent with a possible leak; and

[0019] FIG. 2E is a pressure versus time plot for a fifth leak test wherein a calculated pressure change (dashed line) is plotted against an actual pressure change (solid line) indicating results consistent with a possible leak.

DETAILED DESCRIPTION

[0020] 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.

[0021] 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.

[0022] 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.

[0023] 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 the 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.

[0024] With additional reference to FIGS. 2A-2E, 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 and 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.

[0025] 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 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 FIGS. 2A-2E, 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 conducted to determine a location of a leak, once detected.

[0026] 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.

[0027] An exemplary sequence of performing leak checks will be described with reference to FIGS. 2A-2E. In FIG. 2A, a first leak check is conducted wherein a calculated pressure change (dashed line) is compared to an actual pressure change (solid line). In one example, the actual pressure change can be provided by the pressure sensor 18. The controller 16 can determine that the variance between the calculated pressure change and the actual pressure change is within a predetermined tolerance and no leak is present. In FIG. 2B, a second leak check is conducted wherein a calculated pressure change (dashed line) is compared to an actual pressure change (solid line). Again, the actual pressure change can be provided by the pressure sensor 18. The controller 16 can determine that the variance between the calculated pressure change and the actual pressure change is still within a predetermined tolerance and no leak is present.

[0028] In FIGS. 2C, a third leak check is conducted wherein a calculated pressure change (dashed line) is compared to an actual pressure change (solid line). Again, the actual pressure change can be provided by the pressure sensor 18. The controller 16 can determine that the variance between the calculated pressure change and the actual pressure change is not within a predetermined tolerance and a leak is likely. Once the controller 16 determines that a leak is likely, further diagnostics can be performed. In one example, control closes the upstream canister valve 20C and conducts a subsequent leak check. If a subsequent leak check reveals that the calculated and actual pressure changes are within the tolerance (such as FIGS. 2A or 2B), control can identify the leak as being located downstream of the upstream canister valve 20C in the canister circuit. If, alternatively, a subsequent leak check reveals that the calculated and actual pressure changes remain outside an allowable tolerance (such as FIGS. 2D or 2E), control can determine that the leak is not located in the canister circuit.

[0029] In a subsequent test, control can open the upstream canister valve 20C and close the recirculation line valve 20A. If a subsequent leak check reveals that the calculated and actual pressure changes are within the tolerance (such as FIGS. 2A or 2B), control can identify the leak as being located downstream of the recirculation line valve 20A in the recirculation line 40. If, alternatively, a subsequent leak check reveals that the calculated and actual pressure changes remain outside an allowable tolerance (such as FIGS. 2D or 2E), control can determine that the leak is not located in the recirculation line 40.

[0030] In a subsequent test, control can open the recirculation line valve 20C and close the inlet check valve 20B. If a subsequent leak check reveals that the calculated and actual pressure changes are within the tolerance (such as FIGS. 2A or 2B), control can identify the leak as being located downstream of the inlet check valve 20B. If, alternatively, a subsequent leak check reveals that the calculated and actual pressure changes remain outside an allowable tolerance (such as FIGS. 2D or 2E), control can determine that the leak is not located downstream of the inlet check valve 20B. It will be appreciated that additional leak tests can be conducted within the scope of the present disclosure. It is further appreciated that the sequence of closing and opening the respective valves 20 is merely exemplary and the controller 16 may prioritize the closing and opening of the respective valves 20 differently. In this regard, the controller 16 may assign a priority to a particular valve 20A, 20B, 20C, 20D based on operating conditions or other criteria.

[0031] 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, (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. The fuel tank system of claim 1 wherein the fuel canister is adapted to collect fuel vapor emitted by the fuel tank and subsequently release the fuel vapor through a downstream canister vent line to an engine.

9. A fuel tank system comprising:

a fuel tank having a pressure sensor that measures a pressure in the fuel tank;

a filler pipe;

a purge canister;

a valve assembly including:

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;

a recirculation line valve that moves between an open position and a closed position to open and close a recirculation line that fluidly connects the fuel tank and the filler pipe; and

an inlet check valve that moves between an open position and a closed position to open and close a vapor line that fluidly connects the fuel tank and the filler pipe; and

a controller that (i) conducts a first leak check wherein a first calculated pressure change is compared to a first measured pressure in the fuel tank, (ii) closes one of the upstream canister valve, recirculation line valve and inlet check valve, and (iii) conducts a second leak check wherein a second calculated pressure change is compared to a second measured pressure in the fuel tank, and (iii) determines a potential location of a leak based on the first and second leak checks.

10. The fuel tank system of claim 9 wherein the controller (iv) conducts a third leak check wherein a third calculated pressure change is compared to a third measured pressure in the fuel tank, and (v) determines a potential location of a leak based on the first and third leak check.

11. The fuel tank system of claim 10 wherein the third leak check includes closing the recirculation line valve.

12. The fuel tank system of claim 10 wherein the third leak check includes closing the inlet check valve.

13. The fuel tank system of claim 10 wherein the controller (vi) conducts a fourth leak check wherein a fourth calculated pressure change is compared to a fourth measured pressure in the fuel tank, and (v) determines a potential location of a leak based on the first and fourth leak check.

14. The fuel tank system of claim 13 wherein the fourth leak check includes closing the recirculation line valve.

15. The fuel tank system of claim 13 wherein the fourth leak check includes closing the inlet check valve.

16. The fuel tank system of claim 9 wherein the upstream canister valve, recirculation line valve and inlet check valves are electrically actuated.

17. The fuel tank system of claim 9 wherein the fuel canister is adapted to collect fuel vapor emitted by the fuel tank and subsequently release the fuel vapor through a downstream canister vent line to an engine.

18. 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.

19. The method of claim 18, 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; and

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

20. The method of claim 19, further comprising:

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.

ABSTRACT

A fuel tank system according to the present disclosure includes a fuel tank, a purge canister a valve assembly and a controller. The valve assembly has an upstream canister valve that moves between an open position and a closed position to close an upstream vent line that fluidly connects the fuel tank and the purge canister. The controller (i) conducts a first pressure test that measures a pressure in the fuel tank over a time, (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.

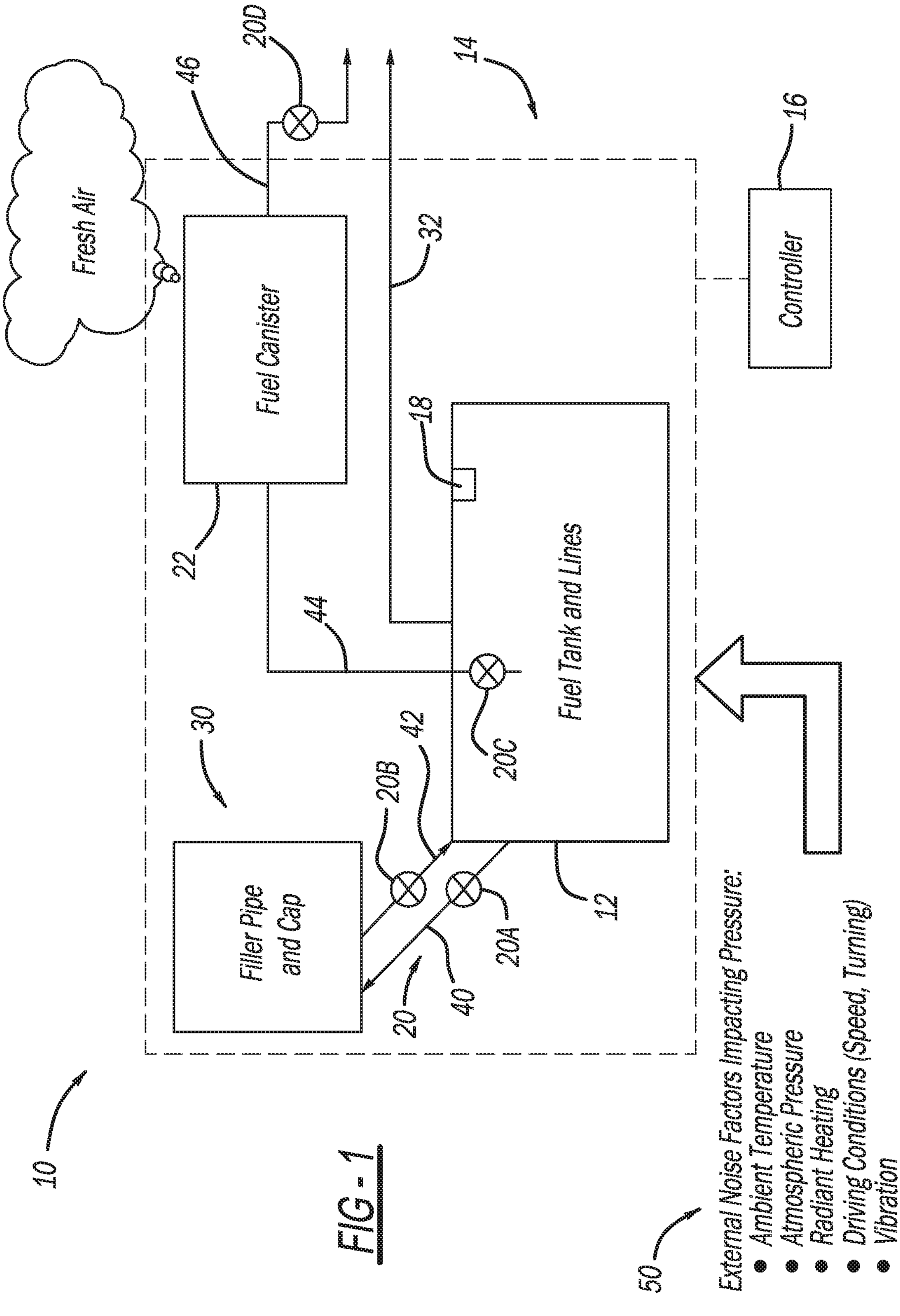
Fresh Air
Fuel Canister
Fuel Tank and Lines
Filler Pipe and Cap
Controller
10
12
14
16
18
20
20A
20B
20C
20D
22
30
32
40
42
44
46
50
External Noise Factors Impacting Pressure:
• Ambient Temperature
• Atmospheric Pressure
• Radiant Heating
• Driving Conditions (Speed, Turning)
• Vibration

FIG - 1

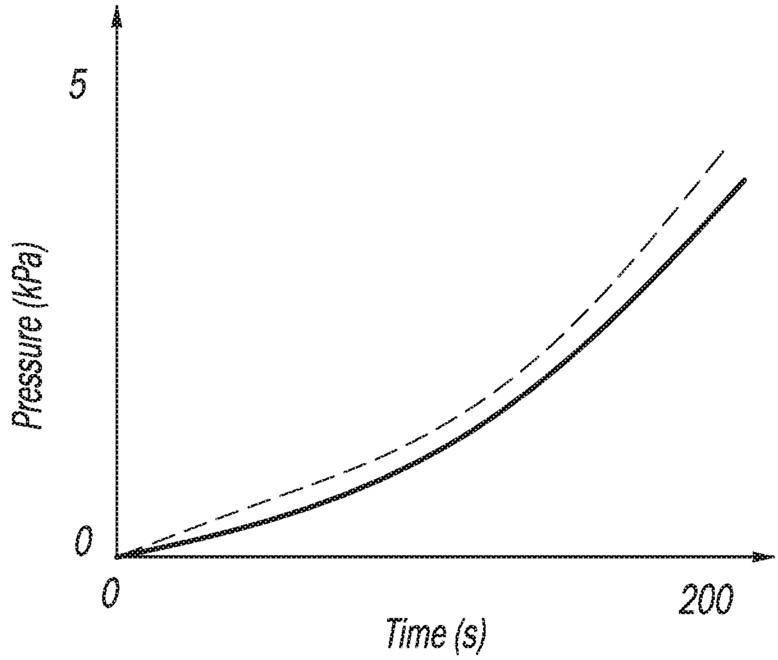

FIG - 2A

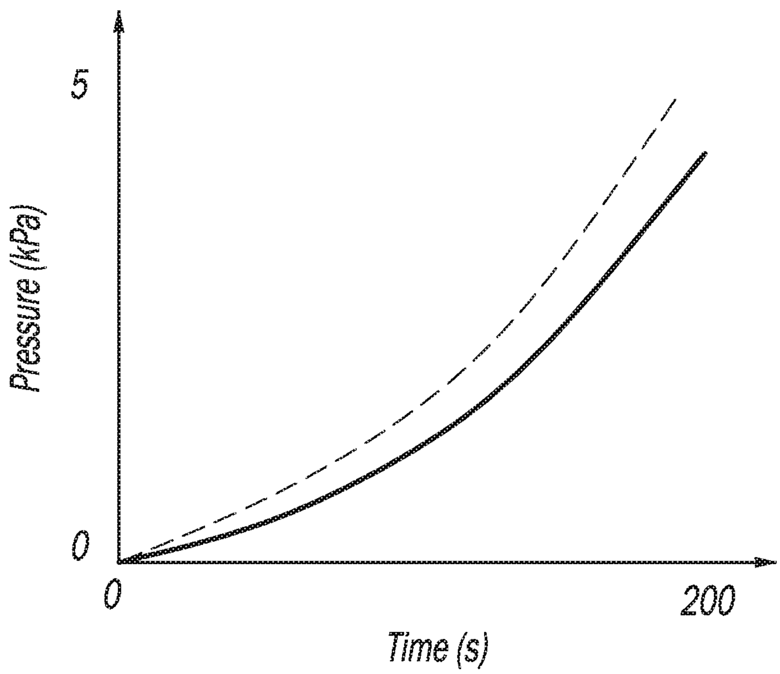

FIG - 2B

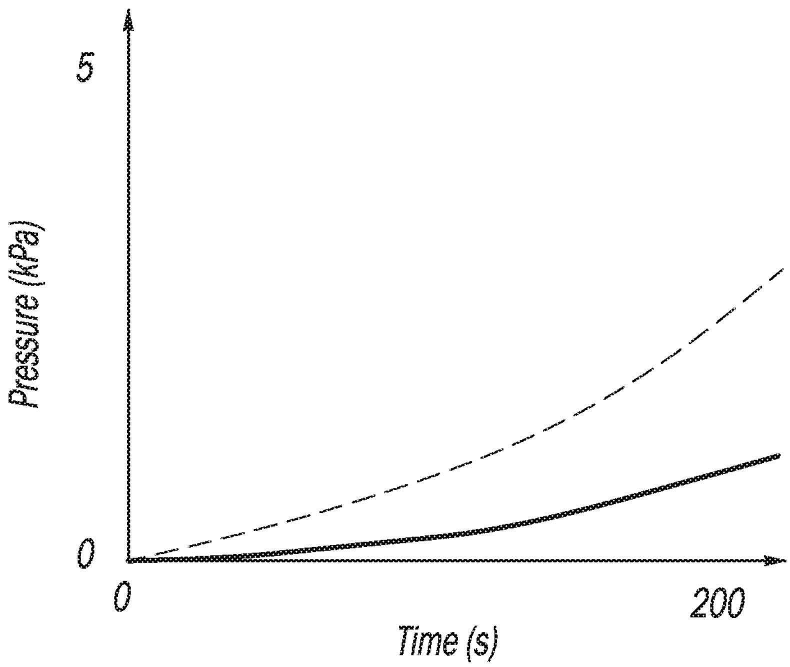

FIG - 2C

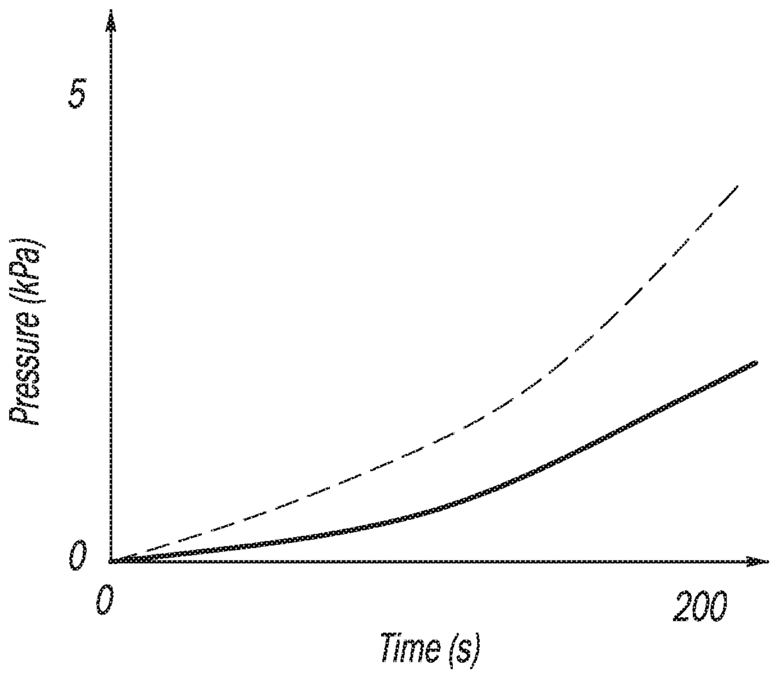

FIG - 2D

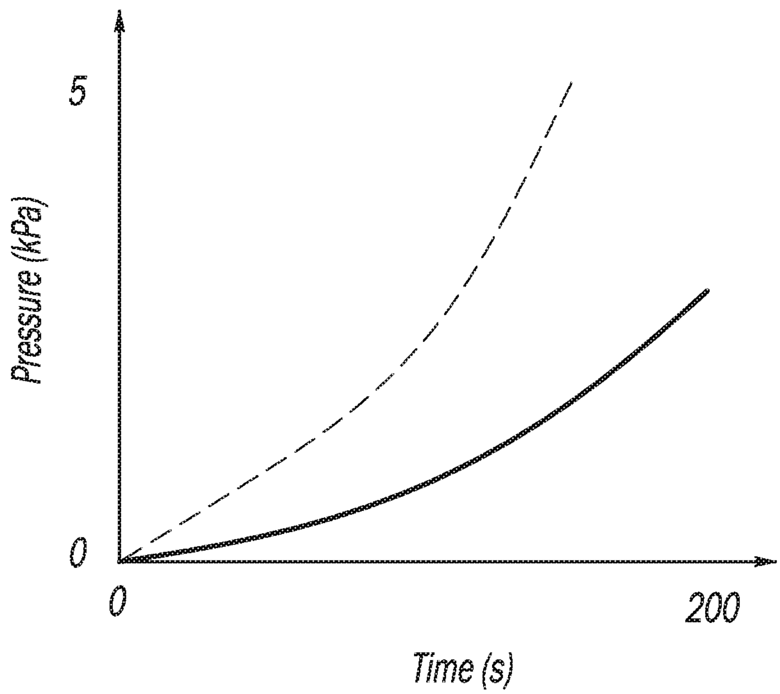

FIG - 2E