



- (51) **International Patent Classification:**
F02M 25/08 (2006.01) *B60K 15/035* (2006.01)
- (21) **International Application Number:**
PCT/US2016/017341
- (22) **International Filing Date:**
10 February 2016 (10.02.2016)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
62/114,553 10 February 2015 (10.02.2015) US
- (71) **Applicant:** EATON CORPORATION [US/US]; Eaton Center, 1000 Eaton Blvd., Cleveland, Ohio 44122 (US).
- (72) **Inventor:** BENJEY, Robert P.; 7535 Walsh Road, Dexter, Michigan 48130 (US).
- (74) **Agents:** HOLLIS, Brian D. et al.; Remarck Law Group PLC, P.O. Box 210958, Auburn Hills, Michigan 48321 (US).
- (81) **Designated States** (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,

BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) **Designated States** (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

- with international search report (Art. 21(3))
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

(54) **Title:** SYSTEM AND METHOD FOR MONITORING HEALTH OF FUEL SYSTEM EVAPORATIVE EMISSION CANISTER

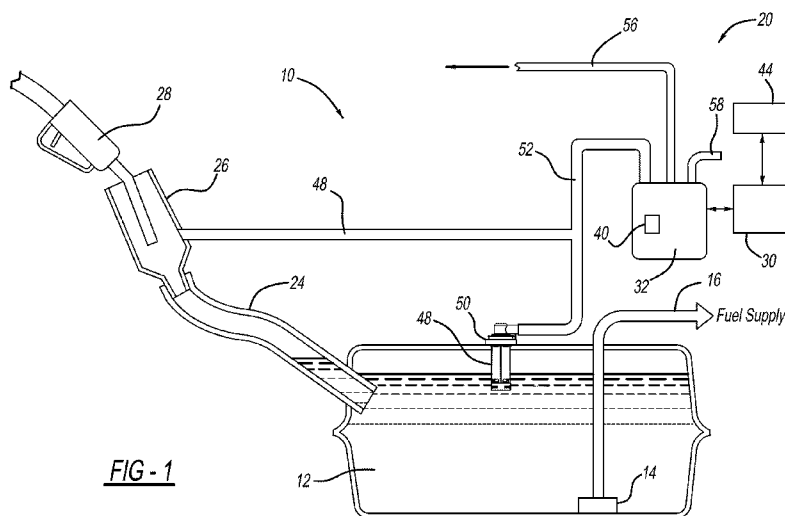


FIG - 1

(57) **Abstract:** An evaporative emissions control system for a fuel tank comprises a fuel tank, a vapor storage canister, a storage canister health sensing assembly and a control module. The vapor storage canister is configured to receive and store fuel vapor from the fuel tank. The storage canister health sensing assembly is configured to measure an operating characteristic of the vapor storage container. The control module can receive inputs including the operating characteristic from the canister health sensing assembly and communicates a signal to an electronic control unit related to an operating status of the vapor storage container.



SYSTEM AND METHOD FOR MONITORING HEALTH OF FUEL SYSTEM EVAPORATIVE EMISSION CANISTER

CROSS-REFERENCE TO RELETED APPLICATION

[0001] This application claims the benefit of U.S. Patent Application No. 62/114,553 filed on February 10, 2015. 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 fuel tank system that monitors a condition of a vapor canister.

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] Currently, production motor vehicles operating on gasoline or other highly volatile fuel employ a storage unit, typically a remotely located canister charged with charcoal, connected to receive fuel vapor from a float operated vent vale provided on the fuel tank. During periods of engine shutdown, vapor is absorbed in the canister and stored. Upon startup of the engine, the canister us purged by air and the fuel vapors are drawn from the canister into the engine inlet and comprise a portion of the engine combustion charge. When the engine is not operating, the canister must absorb all of the vapor from the fuel tank which is either displaced from the tank through vent valve by the rising fuel level during refueling, or from the tank when the vapor pressure rises above atmospheric.

[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] An evaporative emissions control system for a fuel tank comprises a fuel tank, a vapor storage canister, a storage canister health sensing assembly and a control module. The vapor storage canister is configured to receive and store fuel vapor from the fuel tank. The storage canister health sensing assembly is configured to measure an operating characteristic of the vapor storage container. The control module can receive inputs including the operating characteristic from the canister health sensing assembly and communicates a signal to an electronic control unit related to an operating status of the vapor storage container.

[0007] According to additional features, the operating characteristic comprises temperature. The storage canister health sensing assembly comprises a thermal strip disposed on the vapor storage container. The thermal strip can be formed of aluminum. The thermal strip can include a thermistor that is electrically connected to the control module through an electrical connection. The control module monitors temperature of the vapor storage canister at a first time and creates a thermal signature representative of a normally operating purge canister. The control module can monitor temperature of the vapor storage canister at a second time, after the first time. The control module can compare the second time with the thermal signature to determine the operating status of the vapor storage canister. The control module can trigger a purge event based on the operating status. In another example, the operating characteristic can be sound.

[0008] According to other features, the evaporative emissions control system can further comprise a vapor concentration sensor assembly that monitors sound. The vapor concentration sensor assembly can include a signal emitting system including a first control emitter receiver pair and a second control emitter receiver pair. The first control emitter receiver pair can be disposed in a control volume of clean dry air. The second

control emitter receiver pair can be disposed in a vapor volume corresponding to a volume within the vapor canister that stores hydrocarbon. The first signal is sent from the first control emitter to the first control receiver during a first time to establish a base level and wherein a second signal is sent from the second control emitter to the second control receiver during a second time. The control module compares the first and second times to control vapor purge flow to an engine. One of the control volume and the vapor volume can comprise a serpentine pathway. In another example, the vapor concentration sensor assembly can measure light.

[0009] A method of monitoring an operating characteristic of a vapor storage canister includes providing a storage canister health sensing assembly on the vapor storage container. A first operating characteristic of the vapor storage canister can be measured with the storage canister health sensing assembly. A first signal can be communicated to a control module based on the measured first operating characteristic. A predicted signature profile can be established based on the measured first operating characteristic of the vapor canister. A second operating characteristic of the vapor storage canister can be measured with the storage canister health sensing assembly. A second signal can be communicated to the control module based on the measured second operating characteristic. A second signature profile can be established based on the measured second operating characteristic of the vapor canister. The second signature profile can be compared with the predicted signature profile. A decision is made about the operation of the vapor storage canister based on the comparing.

[0010] According to one configuration the first and second operating characteristics comprise temperature of the vapor storage container. Measuring the first operating characteristic includes communicating a signal from a thermal strip disposed on the vapor storage container to the control module corresponding to a temperature of the vapor storage container. Making a decision about the operation of the vapor storage canister includes initiating a purge event in the vapor storage container. Making a decision about the operation of the vapor storage canister includes sending a signal to an electronic control unit corresponding to a reactionary measure.

[0011] According to addition features, sound is monitored with a vapor concentration sensor. Monitoring sound can include sending a first signal from a first control emitter in

a control volume. A first receiver receives the first signal. A first time is measured for the first signal to travel from the first control emitter to the first receiver. A second signal is sent from a second control emitter in a vapor volume. A second receiver receives the second signal. A second time is measured for the second signal to travel from the second control emitter to the second receiver. The first and second times are compared. Vapor purge flow is controlled to an engine based on the comparing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The present disclosure will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0013] FIG. 1 is a schematic illustration of a fuel tank system having a canister health sensing assembly and control system in accordance to one example of the present disclosure;

[0014] FIG. 2 is a schematic illustration of a vapor storage canister incorporating a canister health sensing assembly according to a first configuration;

[0015] FIG. 3A is a schematic illustration of a vapor concentration sensor assembly according to one configuration of the present disclosure;

[0016] FIG. 3B is a schematic illustration of an exemplary control system configured for use with vapor concentration sensor assembly of FIG. 3A;

[0017] FIG. 4 is a schematic illustration of a vapor concentration sensor assembly according to another configuration; and

[0018] FIG. 5 is a schematic illustration of a vapor concentration sensor assembly according to a yet another configuration.

DETAILED DESCRIPTION

[0019] 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 14. The fuel pump 14 can be configured to deliver fuel through a fuel supply line 16 to a vehicle engine. An evaporative emissions control system 20 can be configured to recapture and recycle the emitted fuel vapor. As will become appreciated from the following discussion, the evaporative emissions control system 20 manages the complete evaporative system for a vehicle. The fuel tank 12 includes a filler neck 24 attached thereto with a generally enlarged upper end 26. A refueling filler nozzle 28 is shown received in the filler neck 24. The filler nozzle 28 can provide fuel during a refueling event.

[0020] The control system 20 includes a control module 30, a vapor canister 32 and a canister health sensing assembly 40. In general and as will be described herein, the control module 30 can further include or receive inputs from the canister health sensing assembly 40. The control module 30 can receive the inputs from the canister health sensing assembly 40 based on a unit of measurement, such as temperature, to estimate the health of the vapor canister 32. "Health" as used herein can be any unit of measurement that relates to performance of the vapor canister 32. For example, the health can be related to units of hydrocarbon stored in the vapor canister 32. The canister health sensing assembly 40 is configured to measure an operating characteristic of the vapor storage canister.

[0021] The following discussion is directed to the operating characteristic as temperature of the vapor canister 32 although it is contemplated that the operating characteristic may include other parameters. In this regard, the health can be determined based on a measurement of temperature of the vapor canister 32. As will become appreciated from the following discussion, a temperature measurement of the vapor canister 32 can be performed during the life of the vehicle and compared with a predicted signature profile established from prior temperature measurements of the vapor canister

32 to make decisions on the performance of the vapor canister 32. The results can be used by the control module 30 and be compatible for two-way communication with a vehicle electronic control unit 44. In this regard, the health or estimated hydrocarbon measurement can be determined or estimated based on the measurement of temperature of the vapor canister 32. The health can therefore be provided to the electronic control unit 44 related to an operating status of the vapor canister 32. The electronic control unit 44 can compare current measured temperature profiles with a previously established predicted signature profile and then make estimates and decisions about loading of the vapor canister 32 to more efficiently manage a purge event. The control system 20 with the canister health sensing assembly 40 can function as an on-board diagnostics (OBD) tool that provides information regarding the life of the vapor canister 32.

[0022] The fuel tank 12 includes a float operated vent valve 48 disposed in the top wall thereof through an access opening and has a flange 50 thereon registered against the exterior surface of the tank top for attachment thereto and sealing therearound in a manner known in the art. The outlet of the valve 48 is connected through a conduit 52 to the inlet of the vapor canister 32. The vapor canister 32 further includes a purge line 56 connected thereto which is adapted for connection to the air inlet of an engine (not shown) for enabling flow of vapor therethrough upon engine startup. An atmospheric air inlet 58 is provided in the vapor canister 32 to provide purge flow of air into the vapor canister 32 upon engine startup.

[0023] When the vapor canister 32 absorbs fuel vapor, its temperature rises. According to the present teachings, the control module 30 of the evaporative emission control system 20 monitors the temperature of the vapor canister 32 such as during a refueling event and creates a profile or thermal signature that is representative of normal, satisfactory operation of the vapor canister 32. An initial or baseline profile can be established from measurements when the vehicle is new. The baseline profile can include grams of hydrocarbon stored over a timeframe and/or heat generated over a timeframe to simulate a typical refueling event. Additionally or alternatively, the control system 20 may be set with various predetermined thresholds. The thresholds may be pre-programmed or created from initial actual measurements of the evaporative emission control system 20.

[0024] Correlations may be made between fuel volume, fuel vapor, and heat of the vapor canister 32 such that expected signatures may be made. For instance, the control module 30 may develop models that correlate a volume of new fuel corresponding to an amount of vapor travelling through the conduit 52 into the vapor canister 32. Further, the control module 30 can expect a given amount of vapor to raise the temperature of the vapor canister 32 to a predetermined temperature based on the signatures. Temperatures can be measured throughout the life of the vapor canister 32 from which real-time profiles can be created. If the real-time profiles from the measured temperatures do not match the predicted signatures, the control module 30 may send a signal to the electronic control unit 44 corresponding to a reactionary measure. For example, it may be determined that the vapor canister is failing and it is time to replace the vapor canister 32. Additionally or alternatively the electronic control unit 44 may send a signal to an instrument cluster indicating it is time to inspect the fuel tank system 10. Of course the information can also be used to initiate a purge event or other action within the evaporative emission control system 20.

[0025] In some examples the control module 30 can send a signal to the electronic control module 44 to illuminate a telltale on a vehicle instrument cluster (not shown). Moreover, the thermal signature can be used to provide data to the engine control unit 44 related to a volume of storage vapor in the vapor canister 32. Such information could be used to trigger a purge event. While the above description is focused on creating thermal signatures based on introducing vapor into the vapor canister 32, it is also contemplated that a thermal signature may be created based on vapor being removed from the vapor canister 32. In other words, thermal signatures may be additionally or alternatively created based on a cooling event of the vapor canister 32.

[0026] With particular reference to FIG. 2, the canister health sensing assembly 40 according to a first example will be described. The canister health sensing assembly 40 includes a thermal strip 70. The thermal strip 70 can be formed of aluminum or other thermally conductive material. The thermal strip 70 can be coupled to the vapor canister 32 and be configured to change temperature with the vapor canister 32. The thermal strip 70 can include a thermistor 72 that is electrically connected to the control module 30 through an electrical connection 74.

[0027] With reference to FIGS. 3A and 3B, a vapor concentration sensor assembly 140 according to one example of the present disclosure will be described. The vapor concentration sensor assembly 140 can be used to help control vapor purge flow the engine. The vapor concentration sensor assembly 140 can be used in conjunction with the canister health sensing assembly 40. The vapor concentration sensor assembly 140 can be configured for use with the fuel tank system 10 and evaporative emission control system 20 described above. The vapor concentration sensor assembly 140 can be a signal emitting system 144. The signal emitting system 144 can include a first control emitter/receiver pair 150 and a second control emitter/receiver pair 152. The first emitter/receiver pair 150 can be configured in a control volume 154 and include a first control emitter 160 and a first control receiver 162. The control volume 154 can be a sealed volume with clean dry air inside.

[0028] The second control emitter/receiver pair 152 can be configured in a vapor volume 164 and include a first measurement emitter 170 and a second measurement receiver 172. The vapor volume corresponds to a volume within the vapor canister 32 that stores hydrocarbons. The first control emitter 160 can be used to send a first signal or pulse through the control volume that is received by the first control receiver 162 which establishes a base level. A first time required for the first signal to reach the first control receiver 162 may be measured. The first measurement emitter 170 can be used to send a second signal or pulse through the vapor volume 164. A second time required for the second signal to reach the second measurement receiver may be measured. The first and second times can be compared. As can be appreciated, as more fuel vapor is housed in the vapor volume 164, the second time correspondingly increases.

[0029] The control module 30 can compare the time difference and make conclusions to assist with controlling vapor purge flow. The vapor purge flow information can be communicated to the engine control unit 44 to prepare the engine for vapor traveling from the vapor canister 32 to the engine. Further, the vapor concentration in conjunction with the float operated vent valve 48 can be used to limit flow from the fuel tank 12 during vehicle purge events. The signal emitters 160 and 170 can be configured to emit sound or light. The signal receivers 162 and 172 can be configured to receive sound or light. In

this regard, the signal emitters 160 and 170 can be speakers while the signal receivers 162 and 172 can be microphones.

[0030] FIG. 4 illustrates an additional configuration that may be used in conjunction with the vapor concentration sensor assembly 140 described above with respect to FIGS. 3A and 3B. An emitter 210 can emit a signal that is received by a receiver 212. The vapor concentration sensor assembly 140 can include a serpentine pathway 220 that can increase time required for the signal to travel from the emitter 210 to the receiver 212. The increased distance created by the serpentine pathway 220 can increase resolution. The serpentine pathway 220 can be provided in the control volume 154 and/or the vapor volume 164.

[0031] FIG. 5 illustrates another configuration that incorporates a first emitter 310 and a pair of receivers 312, 314. The additional receiver can be used to create an additional data point and improve resolution. It will be appreciated that other configurations having multiple emitters and receivers may be provided to improve performance.

[0032] 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 particular examples 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. An evaporative emissions control system for a fuel tank, the evaporative emissions control system comprising:
 - a fuel tank;
 - a vapor storage canister configured to receive and store fuel vapor from the fuel tank;
 - a storage canister health sensing assembly configured to measure an operating characteristic of the vapor storage canister; and
 - a control module that receives inputs including the operating characteristic from the canister health sensing assembly and communicates a signal to an electronic control unit related to an operating status of the vapor storage canister.
2. The evaporative emissions control system of claim 1 wherein the operating characteristic is temperature.
3. The evaporative emissions control system wherein the storage canister health sensing assembly comprises a thermal strip disposed on the vapor storage container.
4. The evaporative emissions control system of claim 3 wherein the thermal strip is formed of aluminum.
5. The evaporative emissions control system wherein the thermal strip includes a thermistor that is electrically connected to the control module through an electrical connection.
6. The evaporative emissions control system of claim 2 wherein the control module monitors temperature of the vapor storage canister at a first time and creates a thermal signature representative of a normally operating purge canister.

7. The evaporative emissions control system of claim 6 wherein the control module monitors temperature of the vapor storage canister at a second time, after the first time and compares it with the thermal signature to determine the operating status of the vapor storage canister.

8. The evaporative emissions control system of claim 7 wherein the control module triggers a purge event based on the operating status.

9. The evaporative emissions control system of claim 1, further comprising a vapor concentration sensor assembly that monitors sound.

10. The evaporative emissions control system of claim 9 wherein the vapor concentration sensor assembly includes a signal emitting system comprising:

a first control emitter receiver pair disposed in a control volume of clean dry air; and

a second control emitter receiver pair disposed in a vapor volume corresponding to a volume within the vapor canister that stores hydrocarbon;

wherein a first signal is sent from the first control emitter to the first control receiver during a first time to establish a base level and wherein a second signal is sent from the second control emitter to the second control receiver during a second time; and

wherein the control module compares the first and second times to control vapor purge flow to an engine.

11. The evaporative emissions control system of claim 10 wherein at least one of the control volume and the vapor volume comprises a serpentine pathway.

12. The evaporative emissions control system of claim 1, further comprising a vapor concentration sensor assembly that monitors light.

13. A method of monitoring an operating characteristic of a vapor storage canister, the method comprising:

providing a storage canister health sensing assembly on the vapor storage canister;

measuring a first operating characteristic of the vapor storage canister with the storage canister health sensing assembly and communicating a first signal to a control module based on the measured first operating characteristic;

establishing a predicted signature profile based on the measured first operating characteristic of the vapor canister;

measuring a second operating characteristic of the vapor storage canister with the storage canister health sensing assembly and communicating a second signal to the control module based on the measured second operating characteristic;

establishing a second signature profile based on the measured second operating characteristic of the vapor canister;

comparing the second signature profile with the predicted signature profile;
and

making a decision about the operation of the vapor storage canister based on the comparing.

14. The method of claim 13 wherein the first and second operating characteristics comprise temperature of the vapor storage canister.

15. The method of claim 14 wherein measuring the first operating characteristic comprises:

communicating a signal from a thermal strip disposed on the vapor storage container to the control module corresponding to a temperature of the vapor storage container.

17. The method of claim 13 wherein making the decision about the operation of the vapor storage canister comprises:

initiating a purge event in the vapor storage canister.

18. The method of claim 13 wherein making the decision about the operation of the vapor storage canister comprises:

 sending a signal to an electronic control unit corresponding to a reactionary measure.

19. The method of claim 13, further comprising:

 monitoring sound with a vapor concentration sensor.

20. The method of claim 13, wherein monitoring sound further comprises:

 sending a first signal from a first control emitter in a control volume;

 receiving the first signal at a first receiver;

 measuring a first time for the first signal to travel from the first control emitter to the first receiver;

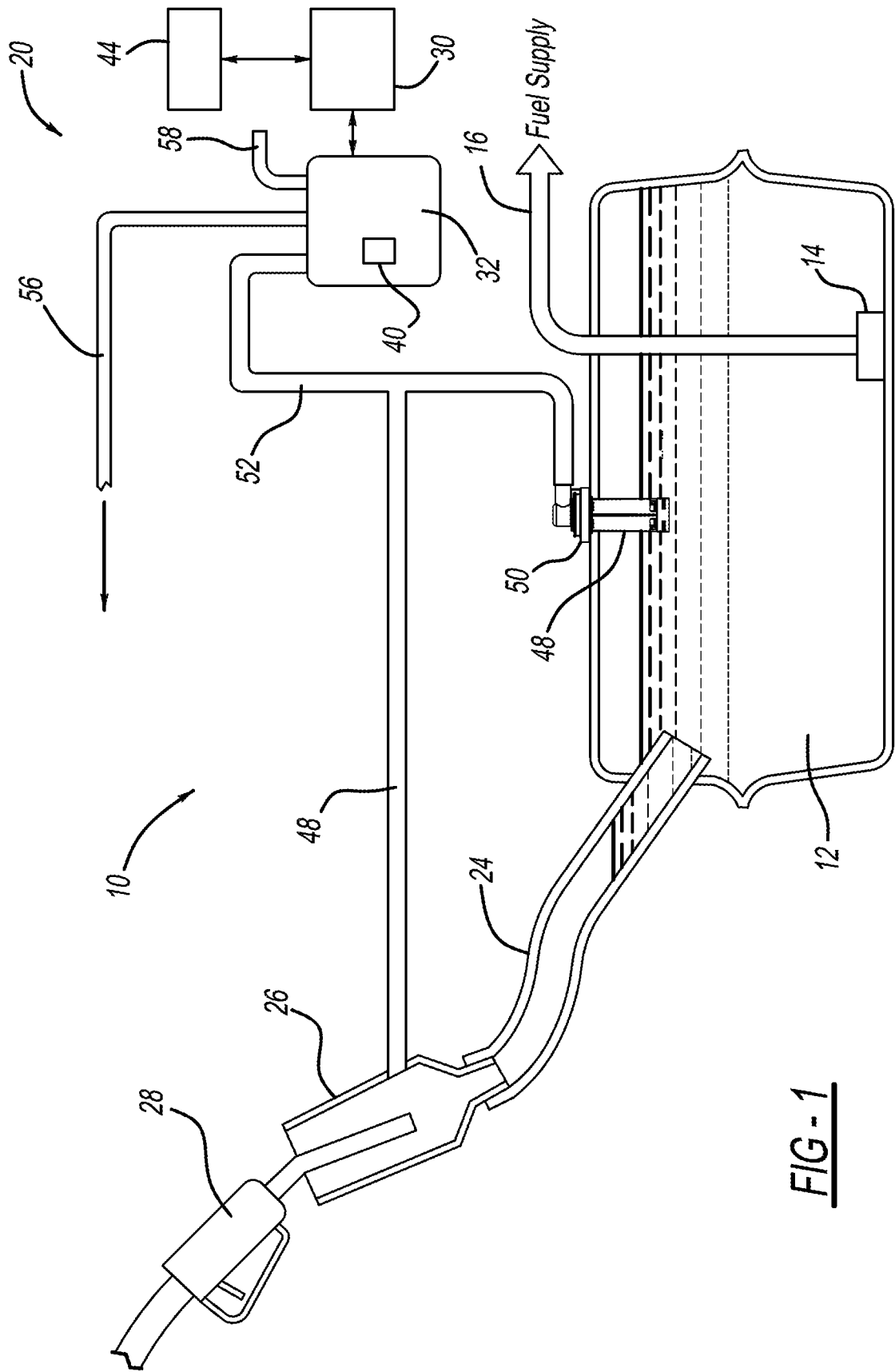
 sending a second signal from a second control emitter in a vapor volume;

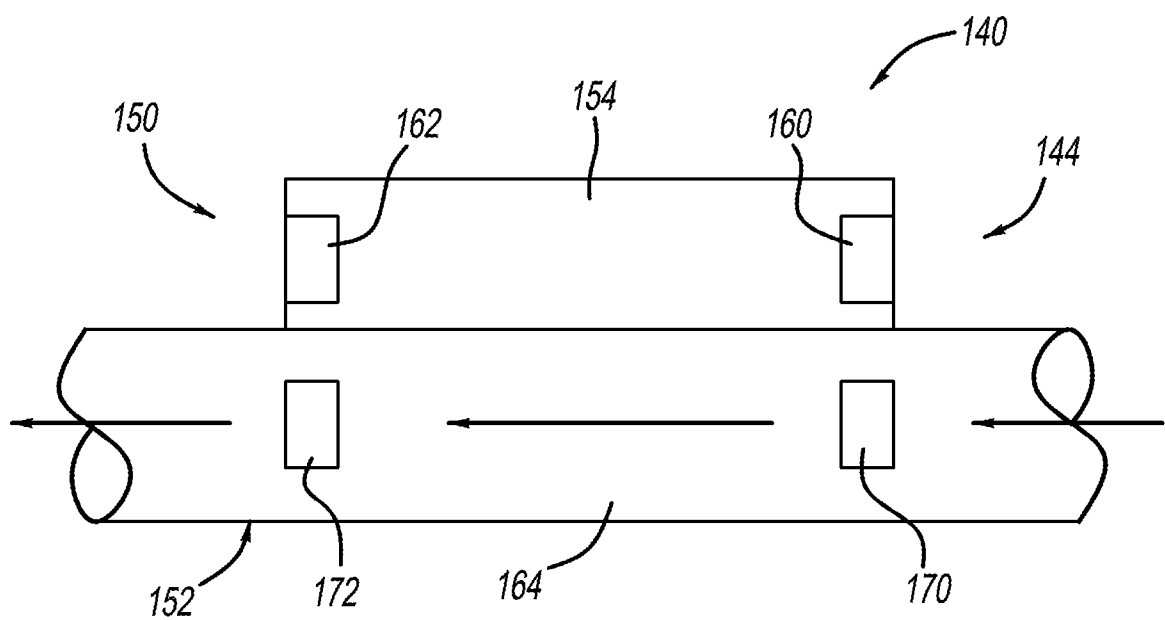
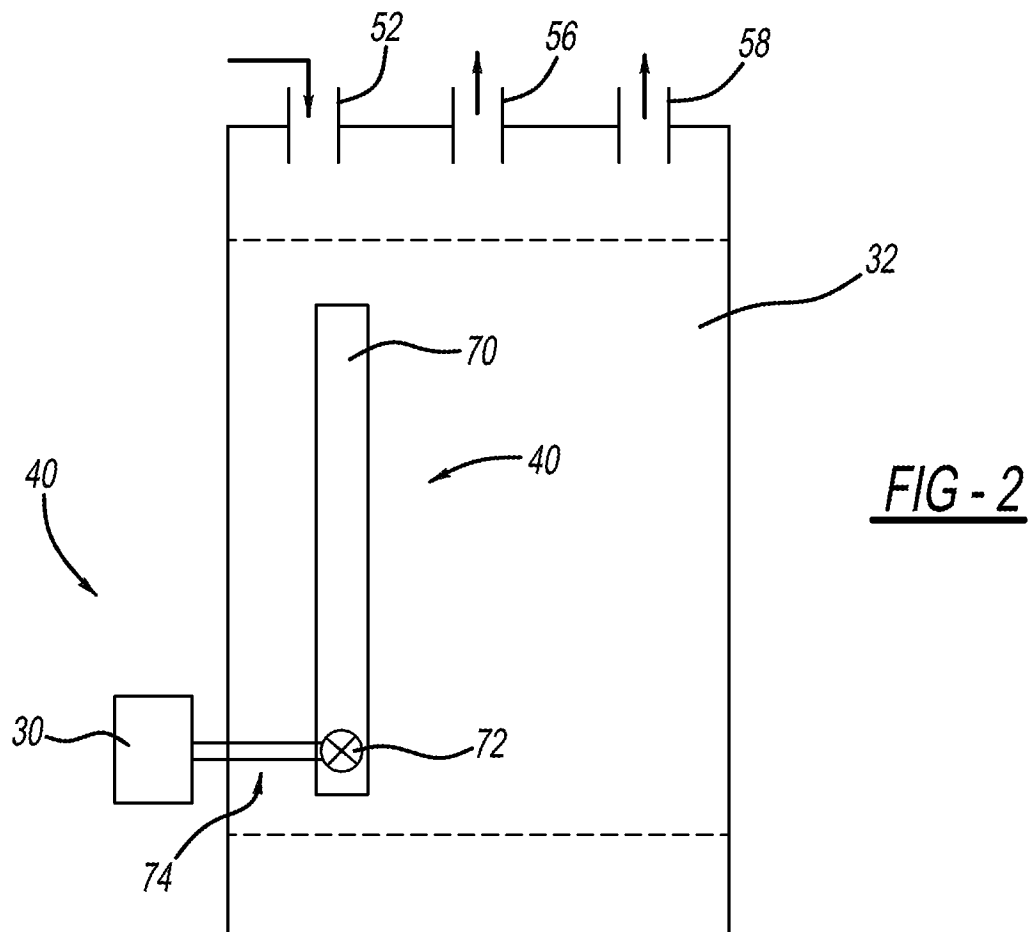
 receiving the second signal at a second receiver;

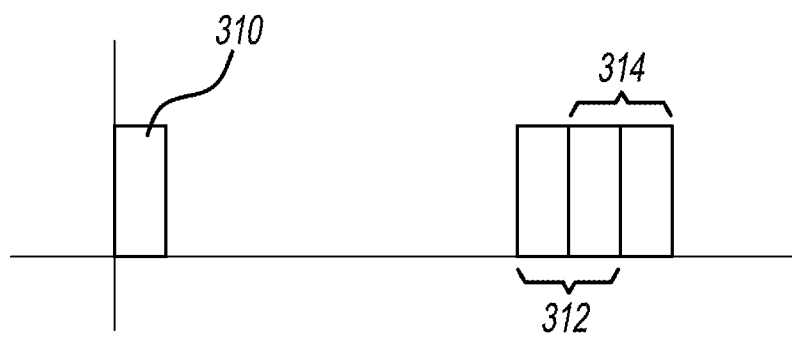
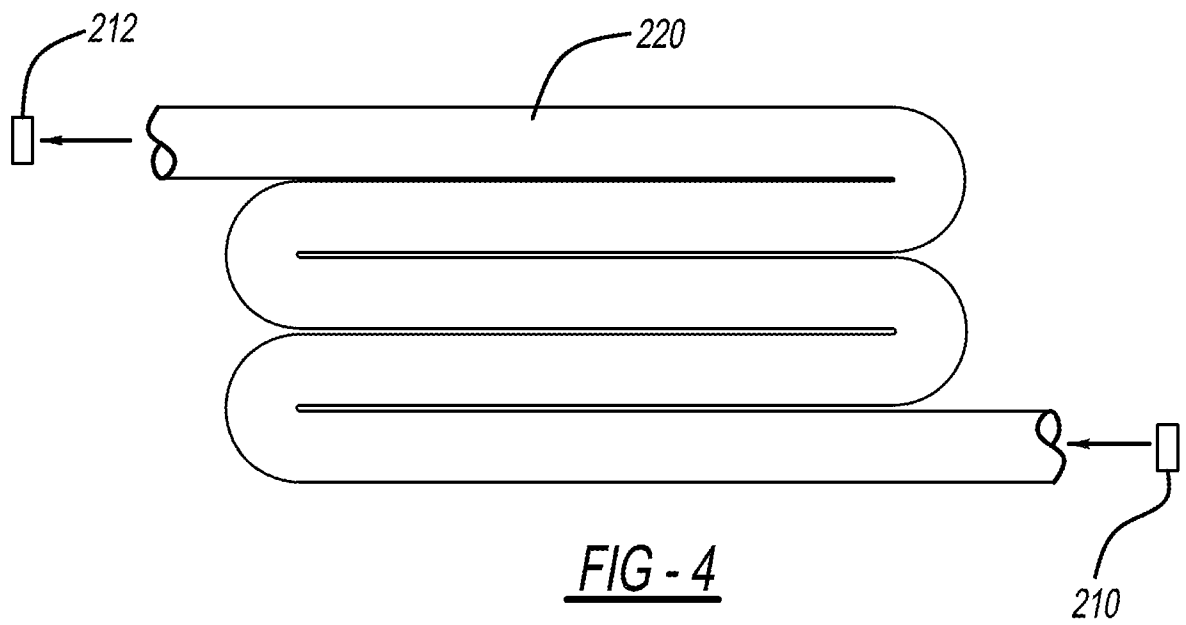
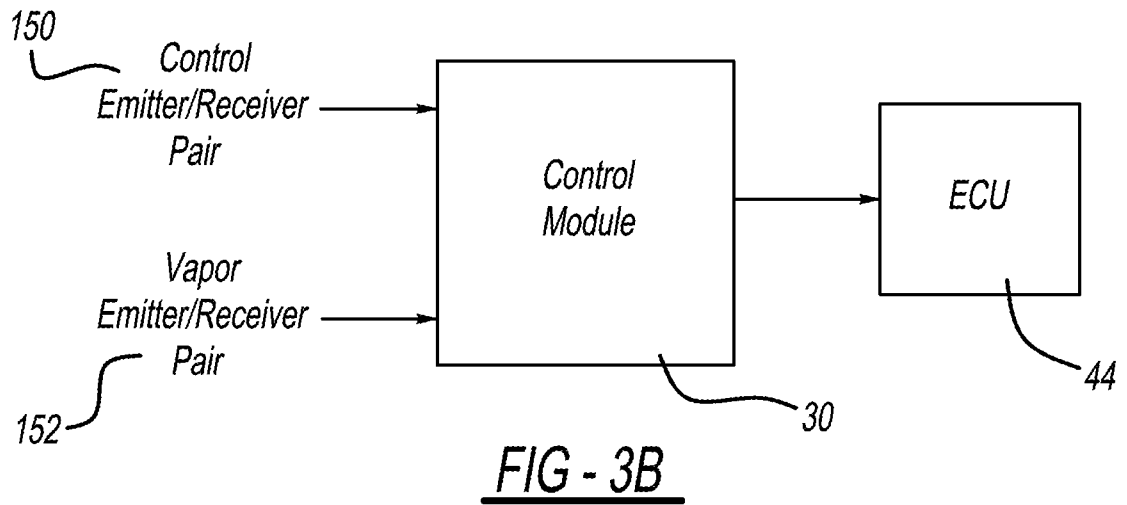
 measuring a second time for the second signal to travel from the second control emitter to the second receiver;

 comparing the first and second times; and

 controlling vapor purge flow to an engine based on the comparing.





FIG - 5

A. CLASSIFICATION OF SUBJECT MATTER**F02M 25/08(2006.01)i, B60K 15/035(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F02M 25/08; F02M 33/04; F02D 41/04; F02M 33/02; F02G 5/00; B60K 15/035

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: EVAP, canister, temperature, thermal strip, thermistor, vapor concentration, acoustic signal and control module

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004-0129257 A1 (KONISHI et al.) 08 July 2004 See paragraphs [0049]-[0052], [0061]-[0064], [0069]-[0074] and figures 1-2.	1-5, 12-15, 18
Y		6-9, 17, 19
A		10-11, 20
Y	US 2004-0237945 A1 (VEINOTTE, ANDRE) 02 December 2004 See paragraphs [0011], [0030] and figures 1-2.	6-8, 17
Y	US 2013-0152905 A1 (CONTINENTAL AUTOMOTIVE SYSTEMS, INC.) 20 June 2013 See paragraphs [0015]-[0016], [0018] and figures 1-3.	9, 19
A	US 2009-0138173 A1 (LIU, CHING-PO) 28 May 2009 See abstract; paragraphs [0038]-[0052]; and figures 3-4.	1-15, 17-20
A	US 6279548 B1 (REDDY, SAM RAGHUMA) 28 August 2001 See abstract; column 3, line 36 - column 5, line 43; and figures 1-2. Note: Claim 16 is missing in the application.	1-15, 17-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

03 June 2016 (03.06.2016)

Date of mailing of the international search report

07 June 2016 (07.06.2016)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

Facsimile No. +82-42-481-8578

Authorized officer

LEE, Jong Kyung

Telephone No. +82-42-481-3360



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/017341

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2004-0129257 A1	08/07/2004	JP 2004-060442 A JP 3931755 B2 US 6817346 B2	26/02/2004 20/06/2007 16/11/2004
US 2004-0237945 A1	02/12/2004	CN 1761810 A JP 2006-514723 A WO 2004-083620 A1	19/04/2006 11/05/2006 30/09/2004
US 2013-0152905 A1	20/06/2013	CN 104010908 A DE 112012005342 T5 WO 2013-096168 A1	27/08/2014 11/09/2014 27/06/2013
US 2009-0138173 A1	28/05/2009	CN 101503982 A CN 101503982 B DE 102009006150 A1 US 7717095 B2	12/08/2009 10/08/2011 08/10/2009 18/05/2010
US 6279548 B1	28/08/2001	None	