



- (51) International Patent Classification:
B60K 15/035 (2006.01) *B60K 15/03* (2006.01)
F02M 25/08 (2006.01)
- (21) International Application Number:
PCT/US2017/027730
- (22) International Filing Date:
14 April 2017 (14.04.2017)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
62/323,356 15 April 2016 (15.04.2016) US
62/350,309 15 June 2016 (15.06.2016) US
- (71) Applicant: **EATON CORPORATION** [US/US]; Eaton Center, 1000 Eaton Blvd., Cleveland, Ohio 44122 (US).
- (72) Inventor: **DAYTON, Robert Andrew**; 255 North Lake George Road, Attica, Michigan 48412 (US).
- (74) Agents: **BALDRIDGE, Lukas M.** et al.; Remarck Law Group PLC, P.O. Box 210958, Auburn Hills, 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, DJ, 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, KH, KN, KP, KR, KW, 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))

[Continued on next page]

(54) Title: VAPOR IMPERMEABLE SOLENOID FOR FUEL VAPOR ENVIRONMENT

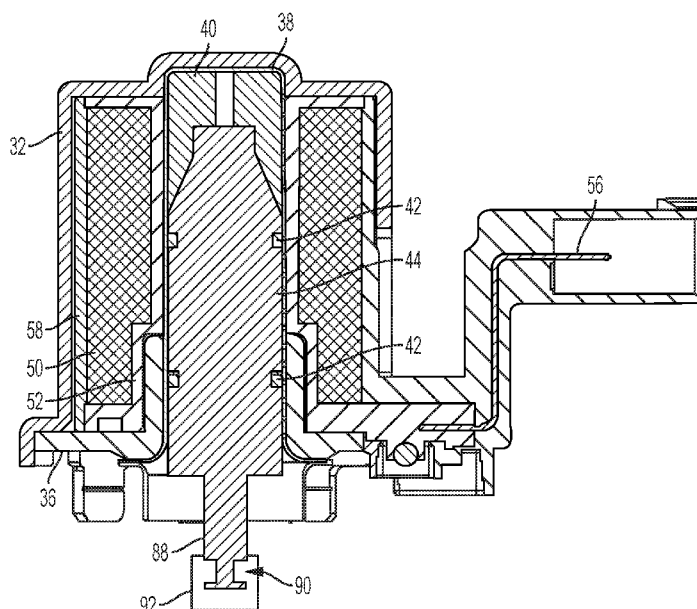


FIG. 4

(57) Abstract: A vapor impermeable solenoid includes an outer housing fabricated from a vapor impermeable material configured to prevent fuel vapor molecules from passing therethrough; windings configured to generate a magnetic flux when energized, a flux collector configured to direct the magnetic flux, a pole piece, and a magnetic armature disposed within the housing and coupled to a seal configured to selectively seal a passage that allows fuel vapor to pass to a purge canister. The magnetic armature is configured to move from a first position to a second position when an electric current is applied to the windings.



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- *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))*

VAPOR IMPERMEABLE SOLENOID FOR FUEL VAPOR ENVIRONMENT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 62/323,356, filed April 15, 2016, and U.S. Provisional Application No. 62/350,309, filed June 15, 2016, the contents of which are incorporated herein by reference thereto.

FIELD

[0002] The present disclosure relates generally to vehicle fuel tank systems and, more particularly, to a fuel tank isolation valve assembly having a vapor impermeable solenoid assembly.

BACKGROUND

[0003] Some vehicles include specifically designed evaporative emissions systems to prevent fuel vapors from escaping a fuel system of the vehicle. In some systems, valves are utilized to prevent fuel vapors from venting directly to the atmosphere. In typical evaporative emissions systems, vented vapors from the fuel system are directed to a purge canister containing activated charcoal. The activated charcoal can be extremely porous, which provides a large surface area for adsorption of fuel vapors and/or chemical reactions. During some engine operational modes, with the help of specifically designed control valve, the fuel vapors are adsorbed within the canister. Subsequently, during other engine operational modes, and with additional control valves, fresh air is drawn through the canister to pull the stored fuel vapor into the engine for combustion thereof.

[0004] In hybrid vehicles having both electric and gas engines, the electric engine may be used for extended periods of time and the purge canister may be become overwhelmed by fuel vapor. A fuel tank isolation valve assembly may be utilized to prevent fuel vapors from traveling to and overwhelming the purge canister. While such systems work for their intended purpose, there remains a need for an improved fuel tank isolation valve assembly.

[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] According to various aspects of the present disclosure a vapor impermeable solenoid for a fuel tank isolation valve assembly is provided. The vapor impermeable solenoid includes an outer housing fabricated from a vapor impermeable material configured to prevent fuel vapor molecules from passing therethrough; windings configured to generate a magnetic flux when energized, a flux collector configured to direct the magnetic flux, a pole piece, and a magnetic armature disposed within the housing and coupled to a seal configured to selectively seal a passage that allows fuel vapor to pass to a purge canister. The magnetic armature is configured to move from a first position to a second position when an electric current is applied to the windings.

[0007] In addition to the foregoing, the described vapor impermeable solenoid may include one or more of the following features: wherein the first position is a sealed position preventing flow of the fuel vapor to the purge canister, and the second position is an unsealed position allowing flow of the fuel vapor to the purge canister; wherein the magnetic armature includes a first end having a generally frustoconical shape; wherein the magnetic armature includes a second end having an arm extending therefrom, and a seal coupled to the arm, the seal configured to selectively block a passage to prevent fuel vapor from passing through the passage; an encapsulated coil assembly that includes the windings; wherein the encapsulated coil assembly further includes a bobbin having an armature portion and a terminal portion; wherein the windings are disposed about the armature portion, and a terminal is coupled to the terminal portion, the terminal electrically coupled to the windings; a voltage suppressor disposed within a recess formed in the terminal portion; an encapsulation material disposed about and at least partially encapsulating the windings, the bobbin, and the terminal; an armature tube disposed inboard of the bobbin and the flux collector; wherein the pole piece is disposed inside the armature tube; wherein the magnetic armature includes at least one groove formed therein configured to receive a bearing to facilitate sliding movement of the magnetic armature

within the armature tube; wherein the outer housing is a metal liner configured to prevent fuel vapor molecules from passing therethrough.

[0008] According to various aspects of the present disclosure a fuel tank isolation valve assembly for a fuel tank system having a fuel tank coupled to a purge canister via a fuel vapor vent line is provided. The fuel tank isolation valve assembly includes a vent passage having a vapor inlet port and a vapor outlet port, and a vapor impermeable solenoid assembly operably coupled to the vent passage. The vapor impermeable solenoid assembly includes an outer housing fabricated from a vapor impermeable material configured to prevent fuel vapor molecules from passing therethrough, windings configured to generate a magnetic flux when energized, a flux collector configured to direct the magnetic flux, a pole piece, and a magnetic armature disposed within the housing and coupled to a seal configured to selectively seal a passage that allows fuel vapor to pass to a purge canister, the magnetic armature configured to move from a first position to a second position when an electric current is applied to the windings.

[0009] In addition to the foregoing, the described fuel tank isolation valve assembly may include one or more of the following features: wherein the first position is a sealed position preventing flow of the fuel vapor to the purge canister, and the second position is an unsealed position allowing flow of the fuel vapor to the purge canister; wherein the magnetic armature includes a first end having a generally frustoconical shape, a second end having an arm extending therefrom, and a seal coupled to the arm, the seal configured to selectively block the vent passage to prevent fuel vapor from passing through the vent passage; and an encapsulated coil assembly that includes the windings, a bobbin having an armature portion and a terminal portion, and an encapsulation material disposed about and at least partially encapsulating the windings, the bobbin, and the terminal, the windings being disposed about the armature portion, and a terminal is coupled to the terminal portion, the terminal electrically coupled to the windings; an armature tube disposed inboard of the bobbin and the flux collector, wherein the pole piece is disposed inside the armature tube, wherein the magnetic armature includes at least one groove formed therein configured to receive a bearing to facilitate sliding movement of the magnetic armature within the armature tube; and wherein the outer housing is a metal liner configured to prevent fuel vapor molecules from passing therethrough.

[0010] According to various aspects of the present disclosure a vehicle fuel tank system is provided. The vehicle fuel tank system includes a fuel tank, a purge canister, a conduit fluidly coupling the fuel tank and the purge canister, and a fuel tank isolation valve assembly disposed within the conduit and configured to selectively fluidly isolate the fuel tank from the purge canister. The valve assembly includes a vent passage having a vapor inlet port and a vapor outlet port, and a vapor impermeable solenoid assembly operably coupled to the vent passage. The vapor impermeable solenoid assembly includes an outer housing fabricated from a vapor impermeable material configured to prevent fuel vapor molecules from passing therethrough, windings configured to generate a magnetic flux when energized, a flux collector configured to direct the magnetic flux, a pole piece, and a magnetic armature disposed within the housing and coupled to a seal configured to selectively seal a passage that allows fuel vapor to pass to a purge canister, the magnetic armature configured to move from a first position to a second position when an electric current is applied to the windings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The present disclosure will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0012] FIG. 1 is a schematic illustration of a fuel tank system constructed in accordance to one example of the present disclosure;

[0013] FIG. 2 is a perspective view of a vapor impermeable solenoid assembly that may be used in the system shown in FIG. 1, in accordance to one example of the present disclosure;

[0014] FIG. 3 is an exploded view of the solenoid assembly shown in FIG. 2;

[0015] FIG. 4 is a cross-sectional view of the solenoid assembly shown in FIG. 2 and taken along line 4-4;

[0016] FIG. 5 is an exploded view of an encapsulated coil assembly shown in FIG. 3, in accordance to one example of the present disclosure; and

[0017] FIG. 6 is a cross-sectional view of the encapsulated coil assembly shown in FIG. 3 and taken along line 6-6.

DETAILED DESCRIPTION

[0018] The present teachings provide for the prevention of vapor permeation in an inner cavity of a solenoid. In one example, the solenoid is constructed in such a way as to be lined with a deep-drawn metal liner, as shown in accordance with the present teachings in FIGS. 1-6. It will be appreciated in light of the disclosure that fuel vapor molecules cannot pass through the metal liner. Because the interior cavity of the solenoid can be constructed to be exposed to fuel vapor, there are many further circumstances where the solenoid must also be constructed so that vapor cannot escape. Were the fuel vapors to permeate the device, undesirably, the fuel vapors could further escape into the atmosphere.

[0019] It will also be appreciated in light of the disclosure that there can be several ways to form a fuel vapor permeation barrier, however many such constructions are not magnetically efficient and therefore can require additional copper windings to ensure the same performance. Accordingly, the present teachings can be shown to provided the needed performance without additional copper windings while preventing permeation of fuel vapor outside the solenoid.

[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 10. The fuel tank system 10 can generally include a fuel tank 12 fluidly coupled to an internal combustion engine 14 by a fuel supply line 16. A fuel vapor vent line 18 selectively supplies fuel vapor from fuel tank 12 to a purge canister 20 for storage therein. The stored fuel vapor may be subsequently supplied via a purge line 22 to the vehicle engine 14 for combustion therein.

[0021] A fuel tank isolation valve assembly 24 can be disposed in fuel vapor vent line 18 to selectively prevent fuel vapor from traveling from the fuel tank 12 to the purge canister 20. Accordingly, the fuel tank isolation valve assembly 24 selectively isolates fuel vapor within the fuel tank 12. In the example embodiment, isolation valve assembly 24 is configured to control vapor flow between fuel tank 12 and purge canister 20 via an inlet port 26 and an outlet port 28. Inlet port 26 can be fluidly coupled to fuel vapor vent line 18.

[0022] With further reference to FIGS. 2-4, the fuel tank isolation valve assembly 24 can include a solenoid assembly 30. As shown in FIG. 3, solenoid assembly 30 can generally include an outer housing 32, an encapsulated coil

assembly 34, a flux collector 36, an armature tube 38, a pole piece 40, one or more bearings 42, and a magnetic armature 44.

[0023] In the example embodiment, the outer housing 32 is a metal liner configured to prevent fuel vapor molecules from passing therethrough. In one example, the outer housing 32 is fabricated from a corrosion resistant material such as stainless steel. However, outer housing 32 may be fabricated from any suitable material that enables housing 32 to function as described herein.

[0024] With additional reference to FIGS. 5 and 6, encapsulated coil assembly 34 is described in more detail. In the example embodiment, encapsulated coil assembly 34 generally includes coils or windings 50, a bobbin 52, a transient voltage suppressor 54, a terminal 56, and encapsulation material 58. Windings 50 may be copper and can be disposed about bobbin 52, which can be configured to support and/or space windings 50, flux collector 36, and/or armature tube 38.

[0025] Bobbin 52 can generally include an armature portion 60 and a terminal portion 62. Armature portion 60 includes an inner wall 64 that defines an armature receiving aperture 66, and an outer wall 67 that receives windings 50. Terminal portion 62 includes a recess or pocket 68 that receives voltage suppressor 54, and terminal 56 is inserted into terminal portion 62 for electrically coupling to windings 50. The encapsulation material 58 can then be disposed about the windings 50, bobbin 52, voltage suppressor 54, and terminal 56 once assembled.

[0026] In the example embodiment, the flux collector 36 is configured to collect flux at the outer diameter of the housing 32 and route the flux to the magnetic armature 44. The armature tube 38 can be disposed inboard of the bobbin 52 and the flux collector 36. In one example, the armature tube 38 is fabricated from a corrosion resistant material to facilitate preventing a corrosive surface from forming on the inside diameter due to exposure to water dissolved into the fuel. For example, armature tube 38 may be fabricated from a ferritic stainless steel such as allow 430 SST.

[0027] The pole piece 40 can be disposed within an upper portion of the armature tube 38. In one example, the pole piece 40 includes a groove 70 formed in an outer surface 72 thereof. During installation, a portion of the armature tube 38 can be crimped or pressed into the groove 70 to secure the pole piece 40 in a desired location within the armature tube 38. However, alternative methods of securing the pole piece 40 within the armature tube 38 are envisioned (e.g., via welding or fasteners). As shown, pole piece 40 can include a receiving aperture 74 (FIG. 3)

configured to selectively receive a portion of the magnetic armature 44. In some examples, receiving aperture 74 can have a shape that is complementary to or generally complementary to a shape of a portion of the magnetic armature 44.

[0028] The magnetic armature 44 can be slidably disposed within the armature tube 38 and can generally include a body 80 having a first end 82 and a second end 84. The body 80 can include one or more grooves 86 (FIG. 3) configured to each receive one bearing 42 that facilitates movement of the magnetic armature 44 sliding up and down within the armature tube 38. As discussed herein, the first end 82 can have a shape configured to be received within receiving aperture 74 of pole piece 40. In the illustrated example, receiving aperture 74 and first end 82 can have a frustoconical or generally frustoconical shape. However, receiving aperture 74 and first end 82 can have various shapes and sizes.

[0029] The second end 84 can include an arm 88 extending from the body 80. The arm 88 can include a groove 90 or other feature configured to receive a seal or other feature 92 that is configured to block a passage (not shown) and prevent fuel vapor from passing from the fuel tank 12 to the purge canister 20. As such, arm 88 can couple to portions of the fuel tank isolation valve assembly 24, and movement of the armature 44 can selectively unplug conduit 18 to let fuel vapor travel to the purge canister 20.

[0030] In operation, the fuel tank isolation valve assembly 24 is generally moved between a sealed position and an unsealed position. In the sealed position, valve assembly 24 prevents fuel vapor from passing from the fuel tank 12 to the purge canister 20. In the unsealed position, the valve assembly 24 enables fuel vapor to pass from the fuel tank 12 to the purge canister. In one example, the valve assembly 24 is in the sealed position by default.

[0031] Upon providing electric current to the windings 50 via the terminals 56, a magnetic flux path is induced, which travels up the flux collector 36, across the armature tube 38, and to the armature 44. The magnetic flux causes the armature 44 to close the gap to the pole piece 40, thereby moving the armature 44 upwards and drawing the arm 88 upwards. This movement opens the fuel tank isolation valve assembly 24 and allows fuel vapor to travel to the purge canister 20. In some examples, valve assembly 24 is energized (i.e., moved to the unsealed position) during car refueling (e.g., when the lever pulled to open fuel door) and when the vehicle is transitioned to operating the internal combustion engine 14. The valve assembly 24

may be deenergized (i.e., moved to the sealed position) when, for example, an electric motor (not shown) is being utilized.

[0032] Described herein are systems and methods for a fuel vapor impermeable solenoid assembly. The systems include a vapor impermeable housing disposed about an encapsulated coil assembly, a flux collector, an armature tube, a pole piece, and a magnetic armature. The interior cavity of the solenoid assembly can be exposed to fuel vapor without allowing the fuel vapor to escape. Accordingly, the system prevents vapor from permeating the device to the environment.

[0033] 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 vapor impermeable solenoid for a fuel tank isolation valve assembly, the impermeable solenoid comprising:
 - an outer housing fabricated from a vapor impermeable material configured to prevent fuel vapor molecules from passing therethrough;
 - windings configured to generate a magnetic flux when energized;
 - a flux collector configured to direct the magnetic flux;
 - a pole piece; and
 - a magnetic armature disposed within the housing and coupled to a seal configured to selectively seal a passage that allows fuel vapor to pass to a purge canister, the magnetic armature configured to move from a first position to a second position when an electric current is applied to the windings.
2. The vapor impermeable solenoid of claim 1, wherein the first position is a sealed position preventing flow of the fuel vapor to the purge canister, and the second position is an unsealed position allowing flow of the fuel vapor to the purge canister.
3. The vapor impermeable solenoid of claim 1, wherein the magnetic armature includes a first end having a generally frustoconical shape.
4. The vapor impermeable solenoid of claim 3, wherein the magnetic armature includes a second end having an arm extending therefrom, and a seal coupled to the arm, the seal configured to selectively block a passage to prevent fuel vapor from passing through the passage.
5. The vapor impermeable solenoid of claim 1, further comprising an encapsulated coil assembly that includes the windings.
6. The vapor impermeable solenoid of claim 5, wherein the encapsulated coil assembly further includes a bobbin having an armature portion and a terminal portion.

7. The vapor impermeable solenoid of claim 6, wherein the windings are disposed about the armature portion, and a terminal is coupled to the terminal portion, the terminal electrically coupled to the windings.

8. The vapor impermeable solenoid of claim 7, further comprising a voltage suppressor disposed within a recess formed in the terminal portion.

9. The vapor impermeable solenoid of claim 7, further comprising an encapsulation material disposed about and at least partially encapsulating the windings, the bobbin, and the terminal.

10. The vapor impermeable solenoid of claim 1, further comprising an armature tube disposed inboard of the bobbin and the flux collector.

11. The vapor impermeable solenoid of claim 10, wherein the pole piece is disposed inside the armature tube.

12. The vapor impermeable solenoid of claim 10, wherein the magnetic armature includes at least one groove formed therein configured to receive a bearing to facilitate sliding movement of the magnetic armature within the armature tube.

13. The vapor impermeable solenoid of claim 1, wherein the outer housing is a metal liner configured to prevent fuel vapor molecules from passing therethrough.

14. A fuel tank isolation valve assembly for a fuel tank system having a fuel tank coupled to a purge canister via a fuel vapor vent line, the fuel tank isolation valve assembly comprising:

a vent passage having a vapor inlet port and a vapor outlet port; and

a vapor impermeable solenoid assembly operably coupled to the vent passage, the vapor impermeable solenoid assembly comprising:

an outer housing fabricated from a vapor impermeable material configured to prevent fuel vapor molecules from passing therethrough;

windings configured to generate a magnetic flux when energized;

a flux collector configured to direct the magnetic flux;
a pole piece; and

a magnetic armature disposed within the housing and coupled to a seal configured to selectively seal a passage that allows fuel vapor to pass to a purge canister, the magnetic armature configured to move from a first position to a second position when an electric current is applied to the windings.

15. The isolation valve assembly of claim 14, wherein the first position is a sealed position preventing flow of the fuel vapor to the purge canister, and the second position is an unsealed position allowing flow of the fuel vapor to the purge canister.

16. The isolation valve assembly of claim 14, wherein the magnetic armature includes a first end having a generally frustoconical shape, a second end having an arm extending therefrom, and a seal coupled to the arm, the seal configured to selectively block the vent passage to prevent fuel vapor from passing through the vent passage.

17. The isolation valve assembly of claim 14, further comprising an encapsulated coil assembly that includes the windings, a bobbin having an armature portion and a terminal portion, and an encapsulation material disposed about and at least partially encapsulating the windings, the bobbin, and the terminal,

wherein the windings are disposed about the armature portion, and a terminal is coupled to the terminal portion, the terminal electrically coupled to the windings.

18. The isolation valve assembly of claim 14, further comprising an armature tube disposed inboard of the bobbin and the flux collector,

wherein the pole piece is disposed inside the armature tube,

wherein the magnetic armature includes at least one groove formed therein configured to receive a bearing to facilitate sliding movement of the magnetic armature within the armature tube.

19. The isolation valve assembly of claim 14, wherein the outer housing is a metal liner configured to prevent fuel vapor molecules from passing therethrough.

20. A vehicle fuel tank system comprising:
- a fuel tank;
 - a purge canister;
 - a conduit fluidly coupling the fuel tank and the purge canister; and
 - a fuel tank isolation valve assembly disposed within the conduit and configured to selectively fluidly isolate the fuel tank from the purge canister, the valve assembly comprising:
 - a vent passage having a vapor inlet port and a vapor outlet port; and
 - a vapor impermeable solenoid assembly operably coupled to the vent passage, the vapor impermeable solenoid assembly comprising:
 - an outer housing fabricated from a vapor impermeable material configured to prevent fuel vapor molecules from passing therethrough;
 - windings configured to generate a magnetic flux when energized;
 - a flux collector configured to direct the magnetic flux;
 - a pole piece; and
 - a magnetic armature disposed within the housing and coupled to a seal configured to selectively seal a passage that allows fuel vapor to pass to a purge canister, the magnetic armature configured to move from a first position to a second position when an electric current is applied to the windings.

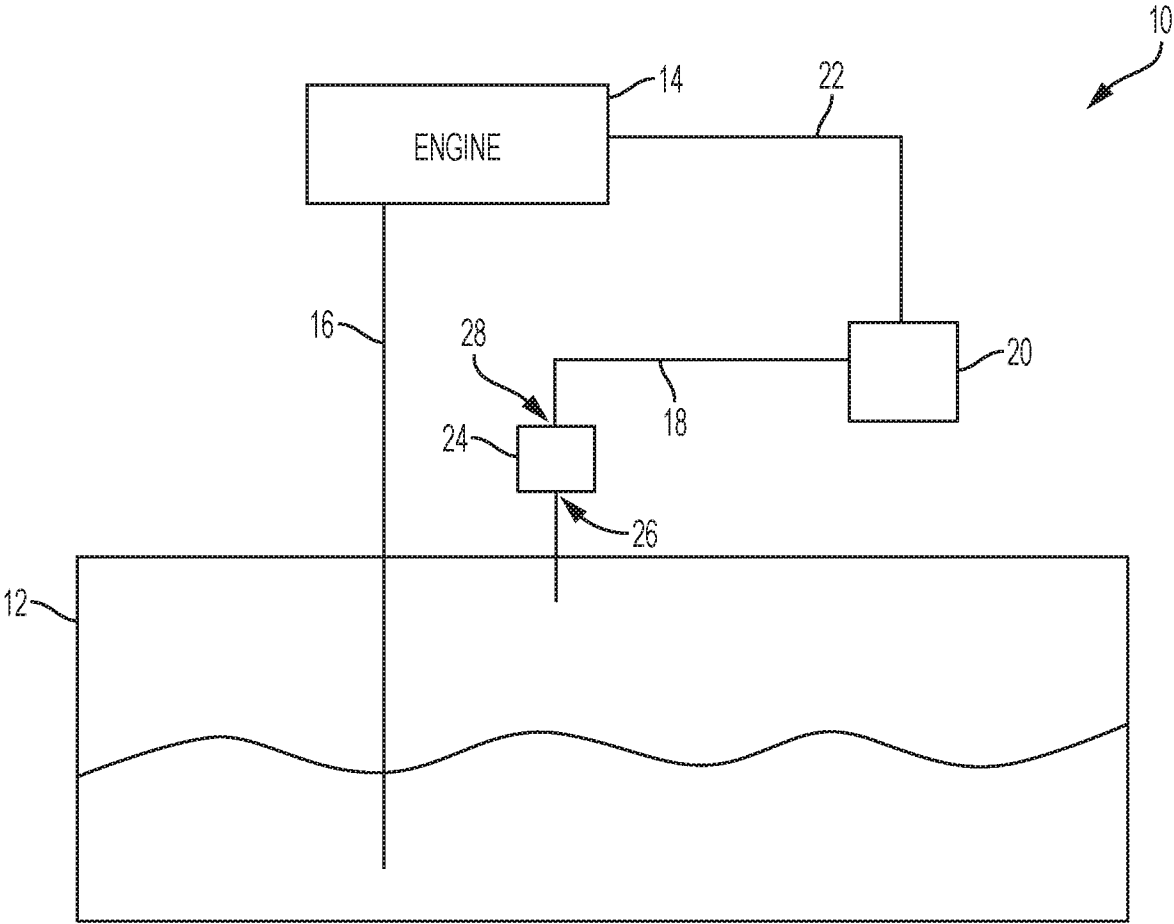


FIG. 1

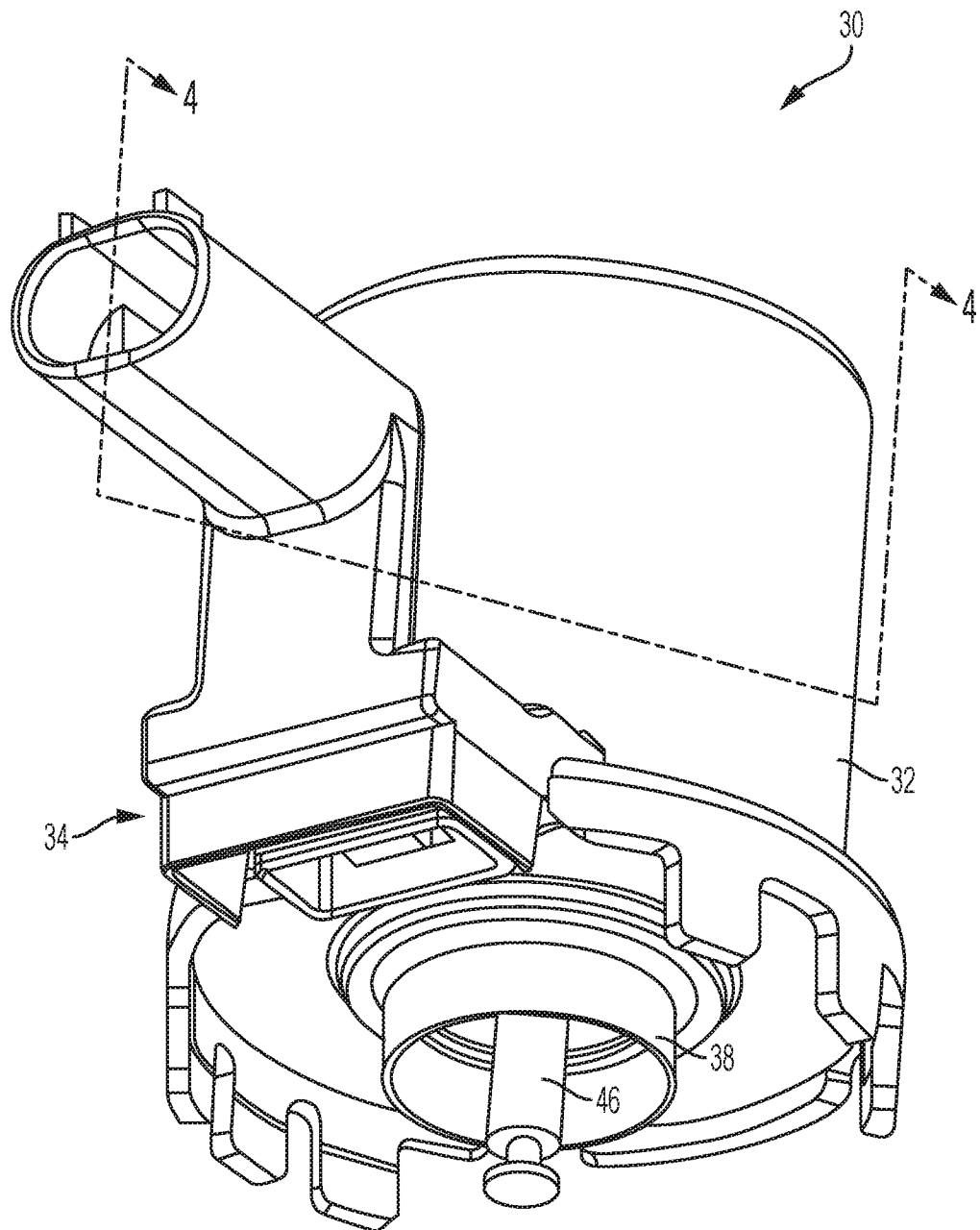


FIG. 2

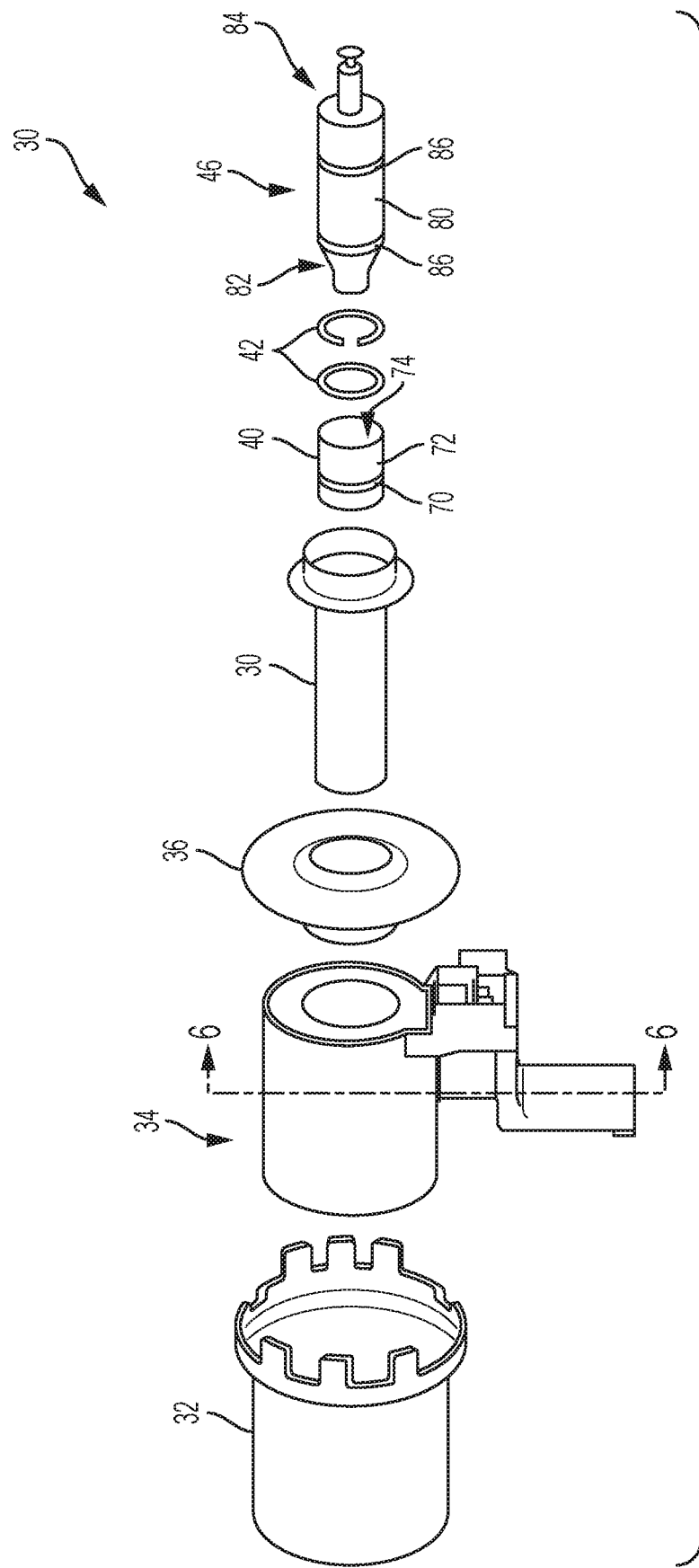


FIG. 3

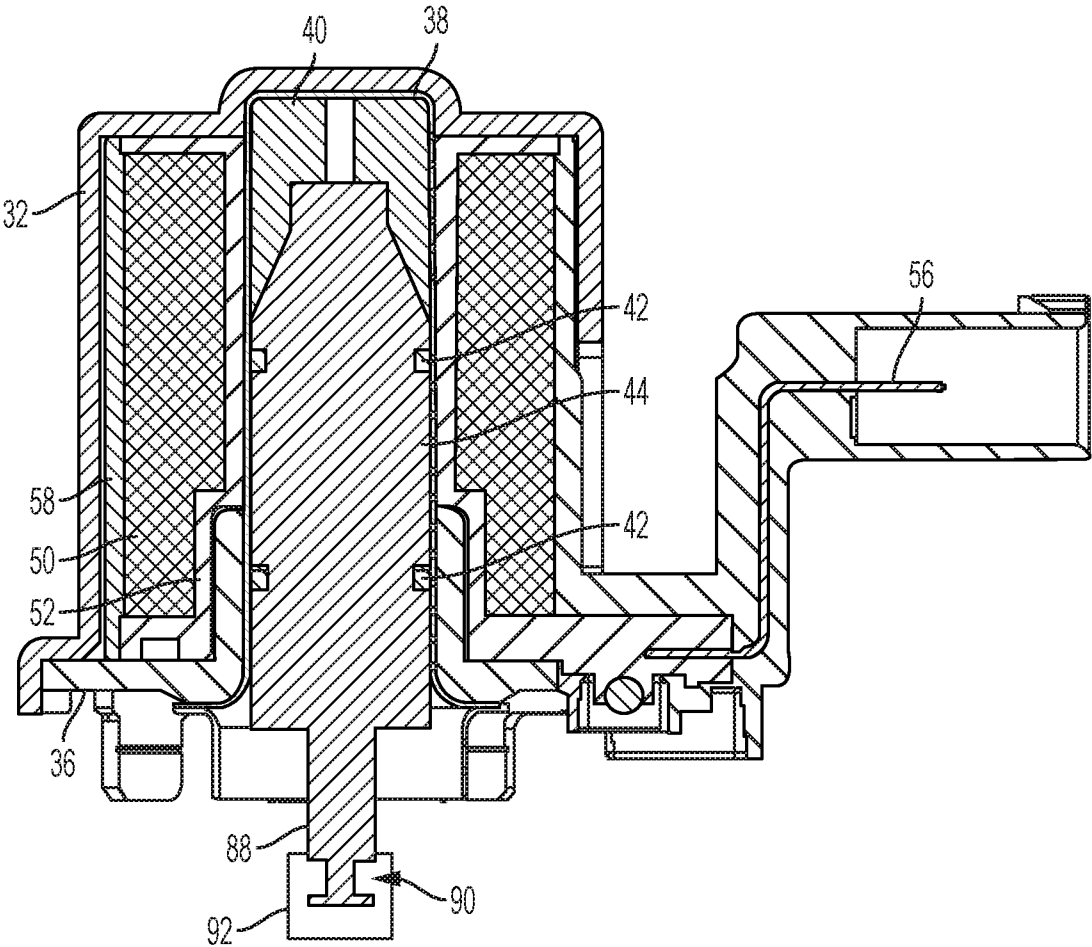


FIG. 4

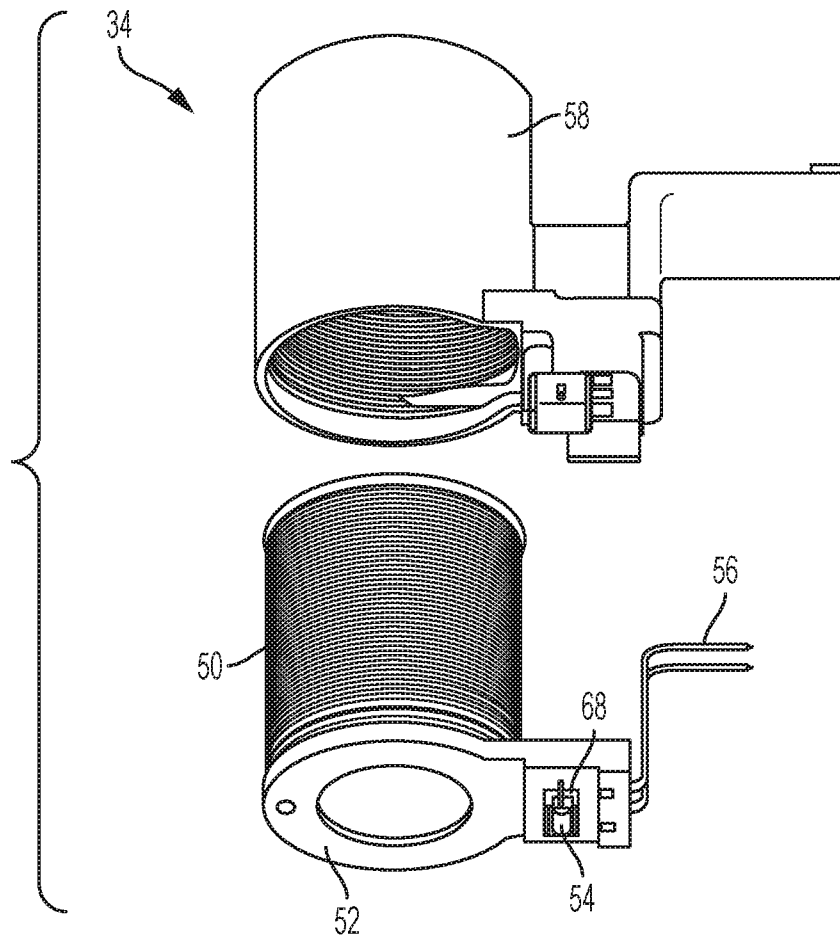


FIG. 5

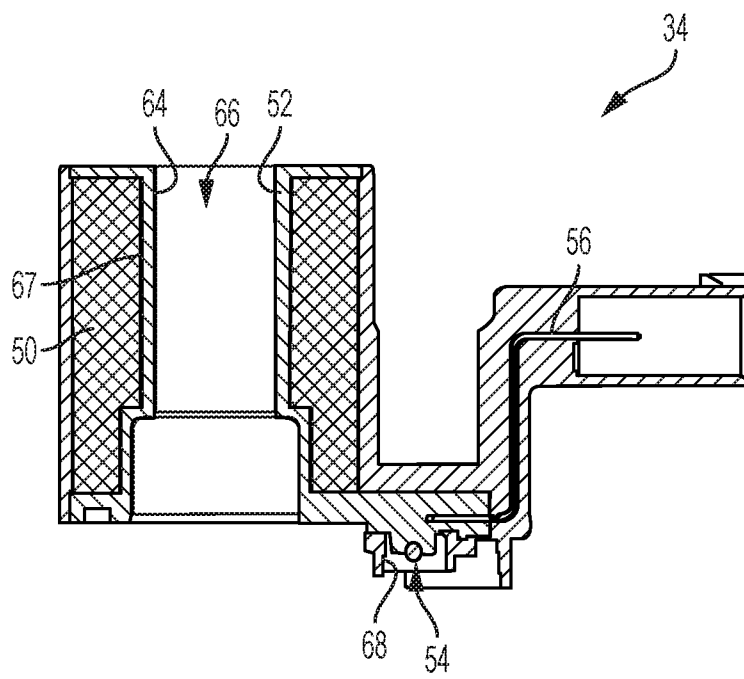


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/027730**A. CLASSIFICATION OF SUBJECT MATTER****B60K 15/035(2006.01)i, F02M 25/08(2006.01)i, B60K 15/03(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)

B60K 15/035; H01F 3/00; F16K 31/06; F02M 25/08; F02M 37/04

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: fuel tank, isolation valve, canister, impermeable, solenoid, housing, winding, flux collector, pole piece, armature, bobbin, terminal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2015-0144819 A1 (EATON CORPORATION) 28 May 2015 See paragraphs [0017]- [0026] and figures 1-5B.	1-20
Y	US 2015-0048270 A1 (EATON CORPORATION) 19 February 2015 See paragraphs [0019]-[0021], [0028]-[0032] and figures 2, 6-7.	1-20
Y	CN 203374938 U (RUAN, HONGDING) 01 January 2014 See claims 1, 3 and figures 1-3.	8
Y	US 5788213 A (KANDA et al.) 04 August 1998 See column 3, line 48 - column 4, line 25 and figures 1-2.	10-12, 18
A	US 6247456 B1 (EVERINGHAM et al.) 19 June 2001 See column 2, line 20 - column 3, line 61 and figure 1.	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

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"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

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Date of the actual completion of the international search

19 September 2017 (19.09.2017)

Date of mailing of the international search report

19 September 2017 (19.09.2017)

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

PARK, Tae Wook

Telephone No. +82-42-481-3405



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2017/027730

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2015-0144819 A1	28/05/2015	CN 103328805 A	25/09/2013
		CN 103328805 B	13/01/2016
		CN 103402806 A	20/11/2013
		CN 103402806 B	04/05/2016
		CN 105857059 A	17/08/2016
		EP 2422121 A1	29/02/2012
		EP 2422121 B1	16/01/2013
		EP 2665614 A1	27/11/2013
		EP 2665614 B1	18/03/2015
		EP 2665913 A2	27/11/2013
		EP 2665913 B1	22/04/2015
		JP 2012-524878 A	18/10/2012
		JP 2014-508239 A	03/04/2014
		JP 5749250 B2	15/07/2015
		JP 5905029 B2	20/04/2016
		KR 10-1629055 B1	09/06/2016
		KR 10-2014-0007376 A	17/01/2014
		KR 10-2014-0051134 A	30/04/2014
		US 2010-0269921 A1	28/10/2010
		US 2011-0162728 A1	07/07/2011
		US 2011-0240145 A1	06/10/2011
		US 2014-0020663 A1	23/01/2014
		US 2014-0041737 A1	13/02/2014
		US 2015-0096633 A1	09/04/2015
		US 2016-0123490 A1	05/05/2016
		US 8573255 B2	05/11/2013
		US 8584704 B2	19/11/2013
		US 8944100 B2	03/02/2015
		US 8944101 B2	03/02/2015
		US 9371803 B2	21/06/2016
		US 9500291 B2	22/11/2016
		WO 2010-122414 A1	28/10/2010
		WO 2012-098460 A2	26/07/2012
		WO 2012-098460 A3	18/10/2012
		WO 2012-100058 A1	26/07/2012
US 2015-0048270 A1	19/02/2015	CN 103292003 A	11/09/2013
		CN 203322446 U	04/12/2013
		EP 2820660 A1	07/01/2015
		JP 2015-510276 A	02/04/2015
		KR 10-2014-0135714 A	26/11/2014
		US 9423046 B2	23/08/2016
		WO 2013-130316 A1	06/09/2013
CN 203374938 U	01/01/2014	None	
US 5788213 A	04/08/1998	CA 2219030 C	28/01/2003
		EP 0844624 A1	27/05/1998
		EP 0844624 B1	24/04/2002

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2017/027730

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6247456 B1	19/06/2001	CN 1190451 A	12/08/1998
		EP 0826105 A1	12/05/1999
		EP 0826105 B1	08/03/2000
		JP 11-505584 A	21/05/1999
		KR 10-0328956 B1	10/05/2002
		US 5727532 A	17/03/1998
		WO 96-36806 A3	09/01/1997