



- (51) **International Patent Classification:**
F16H 57/04 (2010.01) *B60K 11/00* (2006.01)
- (21) **International Application Number:**
PCT/US2017/017176
- (22) **International Filing Date:**
9 February 2017 (09.02.2017)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
62/294,588 12 February 2016 (12.02.2016) US
- (71) **Applicant:** BORGWARNER INC. [US/US]; Patent Department, 3850 Hamlin Road, Auburn Hills, Michigan 48326 (US).
- (72) **Inventors:** LEE, Brett J.; 5734 NE Broadway Street, Portland, Oregon 97213 (US). ISHIHARA, Mitsuru; 40700 Village Wood Rd, Novi, Michigan 48375 (US).
- (74) **Agents:** WARN, Philip et al.; Warn Partners, 691 North Squirrel, Suite 140, Auburn Hills, Michigan 48326 (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.

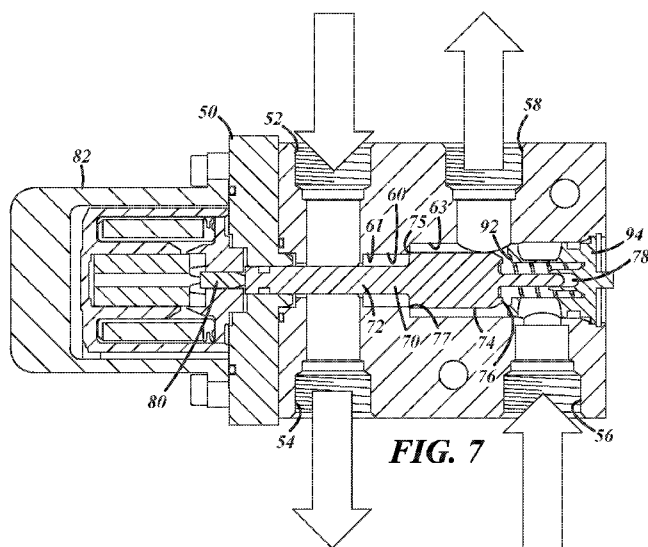
- (84) **Designated States** (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, 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).

Declarations under Rule 4.17:

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))
- of inventorship (Rule 4.17(iv))

[Continued on next page]

(54) **Title:** COOLANT SYSTEM FOR ENGINE TRANSMISSION



(57) **Abstract:** An automotive thermal energy management system is provided having an engine cooling system and a transmission oil heat exchanger. The heat exchanger has an oil inlet for fluid communication with a transmission oil outlet and a transmission oil outlet for fluid communication with a transmission oil inlet. A solenoid controlled bypass valve is provided juxtaposed between the transmission and the heat exchanger.



Published:

— *with international search report (Art. 21(3))*

COOLANT SYSTEM FOR ENGINE TRANSMISSION

FIELD OF THE INVENTION

The present invention relates to cooling systems for automotive vehicles.

- 5 More particularly the field of the present invention relates to cooling systems for automotive vehicles having a liquid fluid cooled engine torsionally coupled to an oil lubricated transmission.

BACKGROUND OF THE INVENTION

- 10 It is well known that automotive internal combustion engines create waste heat that must be removed to prevent the engine from overheating. Additionally many automotive oil lubricated transmissions also create waste heat. It has been known to provide engine coolant systems to prevent overheating of the engine. It is also been known to provide transmission oil coolers which have heat transfer
- 15 capabilities with the engine coolant system to provide removal of waste heat from the transmission oil to prevent the transmission oil from being damaged. Most prior transmission oil coolers had a thermostat that allowed cooling of the transmission oil upon the transmission oil reaching a predetermined temperature. The optimum transmission oil temperature can often be lower than the thermostat temperature
- 20 but is often above that of the environment that the vehicle has been stored in. If the transmission oil is lower than its optimum operating temperature, it will cause the transmission to be less efficient and therefore decrease the fuel economy of a vehicle upon start up. Therefore it is often desirable to heat the transmission oil (with thermal energy from the faster heating up engine coolant system) so that the
- 25 transmission oil may reach its optimum operating temperature faster.

- It is desirable to provide an engine thermal management system for an automotive vehicle that can heat or cool the engine as well as the transmission oil to a temperature that places them both at an optimal temperature range for optimum vehicle efficiency is as short as a time period that is possible. It is also
- 30 desirable to accomplish the above in as simple manner as possible.

SUMMARY OF THE INVENTION

To make manifest the above noted and other desires, a revelation of the present invention is brought forth. The present invention endows a freedom of a

thermal energy management system for automotive vehicle having a liquid fluid cooled engine torsionally couple to an oil lubricated transmission. The thermal energy management system includes an engine cooling system. A transmission oil outlet and inlet are provided for the transmission. A heat exchanger is provided that

5 is fluidly connected with the engine coolant system. The heat exchanger has an oil inlet for fluid communication with the transmission oil outlet and an oil outlet for fluid communication with the transmission oil inlet. The heat exchanger provides for the exchange of thermal energy between the engine coolant and the transmission oil. A solenoid controlled bypass valve is provided juxtaposed between the

10 transmission and the heat exchanger. The solenoid controlled bypass valve has the first inlet directly connected with the transmission oil outlet and a first outlet directly connected with the heat exchanger oil inlet. The solenoid controlled bypass valve has a second inlet directly connected with the heat exchanger oil outlet and a second outlet directly connected to the transmission oil inlet. The solenoid

15 controlled bypass valve has a bypass flow path connecting its first inlet with its second outlet. The solenoid controlled bypass valve has at least a first position allowing thermal energy exchange between the transmission oil and the coolant system. The solenoid controlled bypass valve has additionally a second position fluidly connecting the solenoid controlled bypass valve transmission oil inlet with

20 the bypass flow path thereby thermally isolating the transmission oil from the engine coolant. A controller is provided for selectively positioning of the solenoid controlled bypass valve. The controller is cognizant of the temperatures of the transmission oil and of the engine coolant to order thermal energy interchange between the transmission oil and the engine coolant or to thermally isolate the transmission oil

25 from the engine coolant.

Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating the preferred embodiment of the invention, are intended for purposes of illustration only and are

30 not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

Fig. 1 is a schematic view of a preferred embodiment automotive vehicle thermal energy management system according to the present invention;

Fig. 2 is a schematic view of the automotive vehicle thermal energy management system shown in Fig. 1 wherein the engine coolant is warming up the transmission oil;

Fig. 3 is a schematic view of the automotive vehicle thermal energy management system shown in Fig. 1 wherein the engine coolant is cooling the transmission oil;

Fig. 4 is a schematic view of the automotive vehicle thermal energy management system wherein the transmission is heating up the vehicle engine;

Fig. 5 is sectional view of a solenoid controlled bypass valve in the automotive vehicle energy management system shown in Fig. 4;

Fig 6. is an enlargement of an encircled portion of Fig. 5;

Fig. 7 is a view similar to that of Figure 5 with the solenoid controlled bypass valve in a position to allow thermal energy transfer between the transmission oil and the engine coolant;

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following description of the preferred embodiment(s) is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses.

Referring to the Figures 1 through 7, a thermal energy management system 7 for an automotive vehicle is provided. The vehicle is powered by a liquid fluid cooled engine 10. The engine 10 is typically a reciprocating piston type engine. The engine 10 is torsionally coupled to a transmission 12. Transmission 12 is lubricated by oil and can be optionally oil pressure actuated.

The engine 10 has an engine coolant system. The engine coolant system includes a water pump 14. The water pump 14 pressurizes a coolant. The coolant is typically water mixed with an antifreeze like sodium glycol or other suitable alternatives. Heated water escapes the engine and is fluidly connected with a radiator bypass valve 16. The radiator bypass valve 16 is fluidly connected with an air cooled radiator 18. The radiator bypass valve 16 is also fluidly connected with a radiator bypass line 20. Radiator bypass line 20 and a radiator outlet 22 are fluidly connected to an inlet 24 of a transmission oil heat exchanger 26. The heat

exchanger 26 has a coolant outlet 28 that is fluidly connected with an inlet 30 of the water pump 14.

The transmission 12 has a transmission oil outlet 34. The transmission 12 also has a transmission oil inlet 36. The heat exchanger 26 has a transmission oil inlet 40 for fluid communication with the transmission oil outlet 34. The heat exchanger 26 also has a transmission oil outlet 42 for fluid communication with the transmission oil inlet 36. The heat exchanger 26 allows for an exchange of thermal energy between the engine 10 and transmission 12 via the engine coolant and the transmission oil.

A solenoid controlled bypass valve 50 is juxtaposed between the transmission 12 and the heat exchanger 26. The solenoid controlled bypass valve 50 has a first inlet 52 directly connected with the transmission oil outlet 34. The solenoid controlled bypass valve 50 has a first outlet 54 directly connected with the heat exchanger transmission oil inlet 40. The solenoid controlled bypass valve 50 has a second transmission oil inlet 56 directly connected with the heat exchanger transmission oil outlet 42. The solenoid controlled bypass valve 26 has a second outlet 58 directly connected with the transmission oil inlet 36. The solenoid controlled bypass valve 50 has a multi-diameter bypass flow path 60 connecting the first inlet 52 with the second outlet 58.

Controlling the flow between the first inlet 52 and the second outlet 58 in the bypass flow path 60 is a valve spool 70. The valve spool 70 has a reduced diameter portion 72 connected to an enlarged valving portion or land 74. Rearward (to the right as shown in the figure) of the land 74 is a rear face seal portion 76. Radially inward from the face seal portion 76 is in alignment stem 78. The valve spool 70 is contacted by a plunger 80. The plunger 80 is acted upon by a solenoid actuator 82. A biasing spring 86 urges the valve spool 70 towards the solenoid actuator 82. As mentioned previously the valve spool 70 has a land 74. The land 74 creates a front seal portion 75 with a transition shoulder 77 from a reduced diameter portion 61 to an enlarged diameter portion 63 of the flow path 60. When the valve spool 70 is in the position is best shown in Figure 7, fluid is allowed to flow freely from the first inlet 52 to the second outlet 54 however fluid cannot flow to flow path 60 because of being blocked by the seal portion 75 being in a position to block flow at the transition shoulder 77. Therefore, transmission oil can pass to the heat exchanger 26 allowing thermal energy exchange between the transmission oil and the coolant

system. When the solenoid actuator 82 is energized as best shown Figures 5 and 6, the solenoid actuator 82 causes the plunger 80 (and valve spool 70) to go rightward compressing the spring 86. By its rightward movement the valve spool 70 causes its rear face seal portion 76 to engage with a valve seat 92 preventing
5 flow from the second inlet 56 to the second outlet 58 thereby thermally isolating the transmission oil from the heat exchanger 26 and thereby opening up the bypass flow path 60. If desired flow allowed through the bypass flow path can be throttled by allowing solenoid actuator 82 to be a proportional solenoid or to have pulse width modulation.

10 The valve seat 92 is formed on a plug 94. The plug 94 additionally has a bore 96 for receipt of the alignment stem 78 of the valve spool. Surrounding the bore 96 of the plug 94 there is a mount 95 for the biasing spring 86.

A controller 100 is also provided. The controller 100 is provided for selectively determining the position of the solenoid controlled bypass valve 50 by
15 controlling operation of the solenoid controlled bypass valve solenoid actuator 82. The controller 100 is also cognizant of the temperatures the transmission oil and of the engine coolant. The controller 100 determines whether the solenoid controlled bypass valve 50 will allow thermal exchange between the transmission oil and the engine coolant or thermally isolate the transmission oil from the engine coolant.
20 The controller 100 also controls operation of the radiator bypass valve 16.

In operation (see Fig. 1) typically if vehicle has set for a long period in inclement (cold) weather, it is desirable that the radiator bypass valve 16 be placed in the position (closed) causing the engine coolant flow coming from the engine to bypass the radiator 18 diverting to the radiator bypass line 20. The engine coolant
25 coming from the engine enters the heat exchanger inlet 24, leaves the heat exchanger coolant outlet 28 and is sucked in by the water pump inlet 30. Solenoid actuator 82 is energized, thereby opening up bypass path 60 causing the transmission oil from transmission outlet 34 to be cycled back to transmission inlet 36 causing the transmission oil to heat up as fast as possible. Typically the engine
30 coolant heats up faster than the transmission oil when the engine 10 is sufficiently heated. After the controller 100 senses the increased engine coolant temperature, the solenoid actuator 82 is de-energized (Fig. 2) allowing transmission oil to be heated by the engine coolant in the heat exchanger 26. The arrangement of Fig. 2 allows the transmission oil to be heated faster and thereby brings the transmission

oil to its optimum operating temperature faster than just being reliant upon friction generated heat in the transmission 12. The increased rate of rise in the temperature of the transmission oil will lower its viscosity faster thus lowering its friction and allowing the vehicle to have a slight increase overall fuel economy.

5 During normal engine operation at highway speed the radiator bypass valve 16 is opened to allow coolant to be cooled in radiator 18 (Fig. 3). The solenoid actuator 82 of the solenoid controlled bypass valve 50 is deenergized, allowing thermal exchange between the transmission oil and coolant thereby cooling the transmission oil.

10 In certain circumstances (Fig. 4) especially when utilizing the vehicle in mountainous areas, the transmission oil can heat up before the engine coolant. To increase the engine temperature as fast as possible to bring the engine 10 to its maximum efficient temperature, the radiator bypass valve 16 will be signaled to a position bypassing the radiator 18 allowing the engine coolant to be as warm as
15 possible and the solenoid bypass valve 50 is energized to allow thermal exchange between the higher temperature transmission oil and the lower temperature engine coolant to transfer excess heat from the transmission oil to the engine coolant in order to warm the engine 10 faster thereby increasing overall engine efficiency and vehicle fuel economy.

20 The description of the invention is merely exemplary in nature and, thus, variations that do not depart from the gist of the invention are intended to be within the scope of the invention. Such variations are not to be regarded as a departure from the spirit and scope of the invention.

CLAIMS

What is claimed is:

1. A thermal energy management system for an automotive vehicle having a liquid fluid cooled engine torsionally couple to an oil lubricated transmission, said thermal energy management system comprising:
 - an engine coolant system;
 - a transmission oil outlet for said transmission;
 - a transmission oil inlet for said transmission;
 - a heat exchanger fluidly connected with said engine coolant system, said heat exchanger having an oil inlet for fluid communication with said transmission oil outlet and an oil outlet for fluid communication with said transmission oil inlet for exchanging thermal energy between engine coolant and transmission oil;
 - a solenoid controlled bypass valve juxtaposed between said transmission and said heat exchanger having a first inlet directly connected with said transmission oil outlet and a first outlet directly connected with said heat exchanger oil inlet, said solenoid controlled bypass valve having a second inlet directly connected with said heat exchanger oil outlet and a second outlet directly connected with said transmission oil inlet, and said solenoid controlled bypass valve having a bypass flow path connecting said first inlet with said second outlet, said solenoid controlled bypass valve having at least a first position allowing thermal energy exchange between the transmission oil and the coolant system, and said solenoid controlled bypass valve having a second position fluidly connecting said solenoid controlled bypass valve first inlet with said bypass flow path thereby thermally isolating the transmission oil from the engine coolant; and
 - a controller for selecting the position of said solenoid controlled bypass valve, said controller being cognizant of temperatures of the transmission oil and the engine coolant to allow thermal energy exchange between the transmission oil and the engine coolant or to thermally isolate the transmission oil from the engine coolant.
2. The thermal energy management system of claim 1 wherein said solenoid controlled bypass valve thermally isolates the transmission oil from the engine coolant by turning off flow through said solenoid controlled bypass valve second inlet

3. The thermal energy management system of claim 1 wherein said solenoid controlled bypass valve allows thermal energy exchange when a solenoid actuator of said solenoid controlled bypass valve is non-energized.

5

4. The thermal energy management system of claim 1 wherein said engine coolant system has a radiator bypass valve, said radiator bypass valve diverting engine heated water to a radiator or to a radiator bypass, said radiator and said radiator bypass both being fluidly connected with an engine coolant inlet
10 of said heat exchanger, and wherein said controller controls operation of said radiator bypass valve.

5. The thermal energy management system of claim 1 wherein when the vehicle transmission oil is cooler than desired, and the engine coolant is hotter
15 than the transmission oil, said controller causes said solenoid controlled bypass valve to allow thermal exchange between said transmission oil and said coolant.

6. The thermal energy management system of claim 1 wherein when the engine coolant is cooler than desired, the transmission oil is hotter than the
20 engine coolant, said controller causes said solenoid controlled bypass valve to allow thermal energy exchange between the transmission oil and the engine coolant.

7. The thermal energy management system of claim 4 wherein when the vehicle transmission oil is cooler than desired, and the engine coolant is hotter
25 than the transmission oil, said controller causes said radiator bypass valve to connect the engine coolant with said radiator bypass and to cause said solenoid controlled bypass valve to allow thermal energy exchange between the transmission oil and the engine coolant

30

8. The thermal energy management system of claim 4 wherein when the engine coolant is cooler than desired, and the engine coolant is cooler than the transmission oil, said controller causes said radiator bypass valve to connect the engine coolant with said radiator bypass and to cause said solenoid controlled

bypass valve to allow thermal energy exchange between the transmission oil and the engine coolant.

9. The thermal energy management system of claim 1 wherein said
5 solenoid controlled bypass valve has a proportional solenoid actuator to throttle the flow delivered to said heat exchanger and to said bypass flow path.

10. The thermal energy management system of claim 1 wherein said
10 solenoid controlled bypass valve has a pulse width modulated solenoid actuator to throttle the flow delivered to said heat exchanger and said bypass flow path.

11. A thermal energy management system for an automotive vehicle
having a liquid fluid cooled engine torsionally coupled to an oil lubricated
transmission, said thermal energy management system comprising:

15 an engine coolant system;
a transmission oil outlet for said transmission;
a transmission oil inlet for said transmission;
a heat exchanger fluidly connected with said engine coolant system, said
heat exchanger having an oil inlet for fluid communication with said transmission
20 oil outlet and an oil outlet for fluid communication with said transmission oil inlet for
exchanging thermal energy between engine coolant and transmission oil;
an air cooled radiator fluidly connected with said heat exchanger;
a radiator bypass line fluidly connected with said heat exchanger;
a radiator bypass valve fluidly connected with said engine, said radiator and
25 said radiator bypass line for diverting engine coolant to said radiator or to said
radiator bypass line;
a solenoid controlled bypass valve juxtaposed between said transmission
and said heat exchanger having a first inlet directly connected with said
transmission oil outlet and a first outlet directly connected with said heat exchanger
30 oil inlet, said solenoid controlled bypass valve having a second inlet directly
connected with said heat exchanger oil outlet and a second outlet directly
connected with said transmission oil inlet, and said solenoid controlled bypass
valve having a bypass flow path connecting said first inlet with said second outlet,
said solenoid controlled bypass valve having at least a first position allowing

thermal energy exchange between the transmission oil and said coolant system and said solenoid controlled bypass valve having a second position fluidly connecting said bypass valve first transmission oil inlet with said bypass flow path thereby thermally isolating said transmission oil from said engine coolant and
5 wherein a solenoid actuator for said solenoid controlled bypass valve when non-energized places said solenoid controlled bypass valve in said first position; and
a controller for selecting the position of said solenoid controlled bypass valve and said radiator bypass valve, said controller being cognizant of temperatures of the transmission oil and the engine coolant to allow thermal energy exchange
10 between the transmission oil and the coolant or to thermally isolate the transmission oil from the engine coolant.

12. A thermal energy management system for an automotive vehicle having a liquid fluid cooled engine torsionally coupled to an oil lubricated transmission,
15 said thermal energy management system comprising:
an engine coolant system;
a transmission oil outlet for said transmission;
a transmission oil inlet for said transmission;
a heat exchanger fluidly connected with said engine coolant system, said
20 heat exchanger having an oil inlet for fluid communication with said transmission oil outlet and an oil outlet for fluid communication with said transmission oil inlet for exchanging thermal energy between engine coolant and transmission oil;
an air cooled radiator fluidly connected with said heat exchanger;
a radiator bypass line fluidly connected with said heat exchanger;
25 a radiator bypass valve fluidly connected with said engine, said radiator and said radiator bypass line for diverting engine coolant to said radiator or to said radiator bypass line;
a solenoid controlled bypass valve juxtaposed between said transmission and said heat exchanger having a first inlet directly connected with said
30 transmission oil outlet and a first outlet directly connected with said heat exchanger oil inlet, said solenoid controlled bypass valve having a second inlet directly connected with said heat exchanger oil outlet and a second outlet directly connected with said transmission oil inlet, and said solenoid controlled bypass valve having a bypass flow path connecting said first inlet with said second outlet,

said solenoid controlled bypass valve having at least a first position allowing thermal energy exchange between the transmission oil and said coolant system and said solenoid controlled bypass valve having a second position fluidly connecting said bypass valve first transmission oil inlet with said bypass flow path

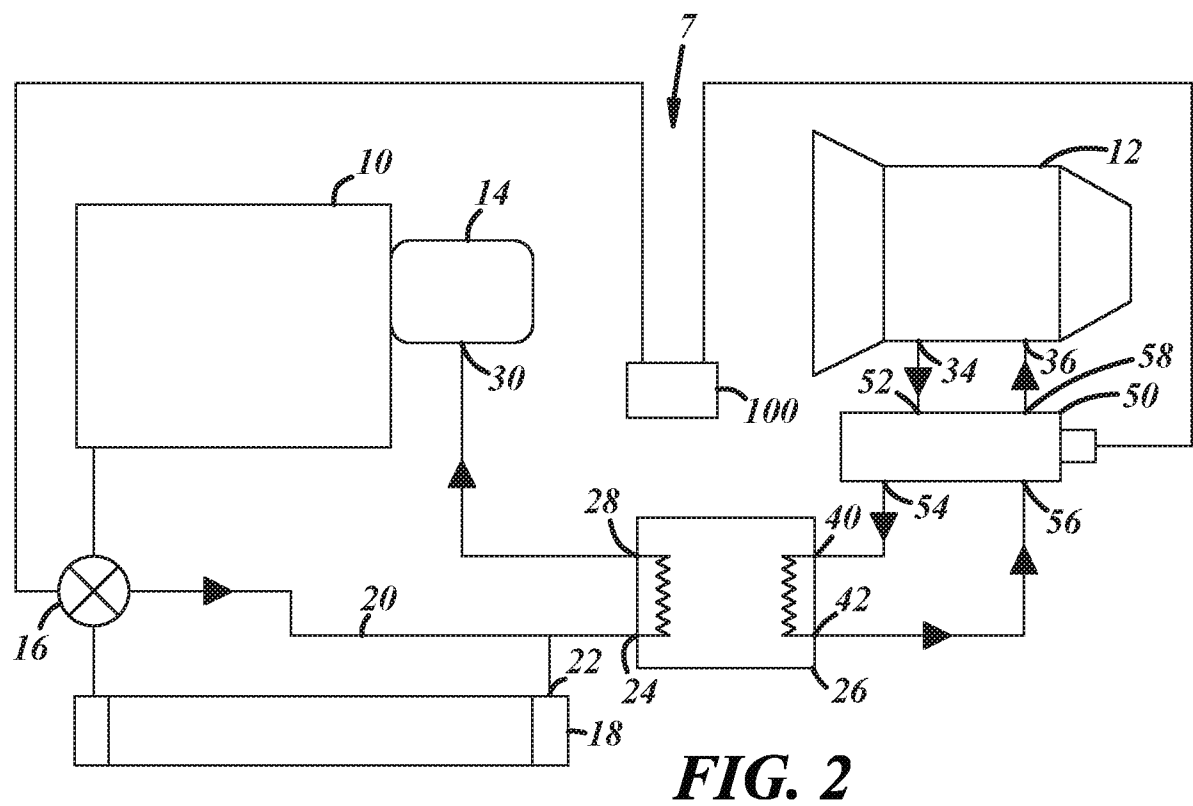
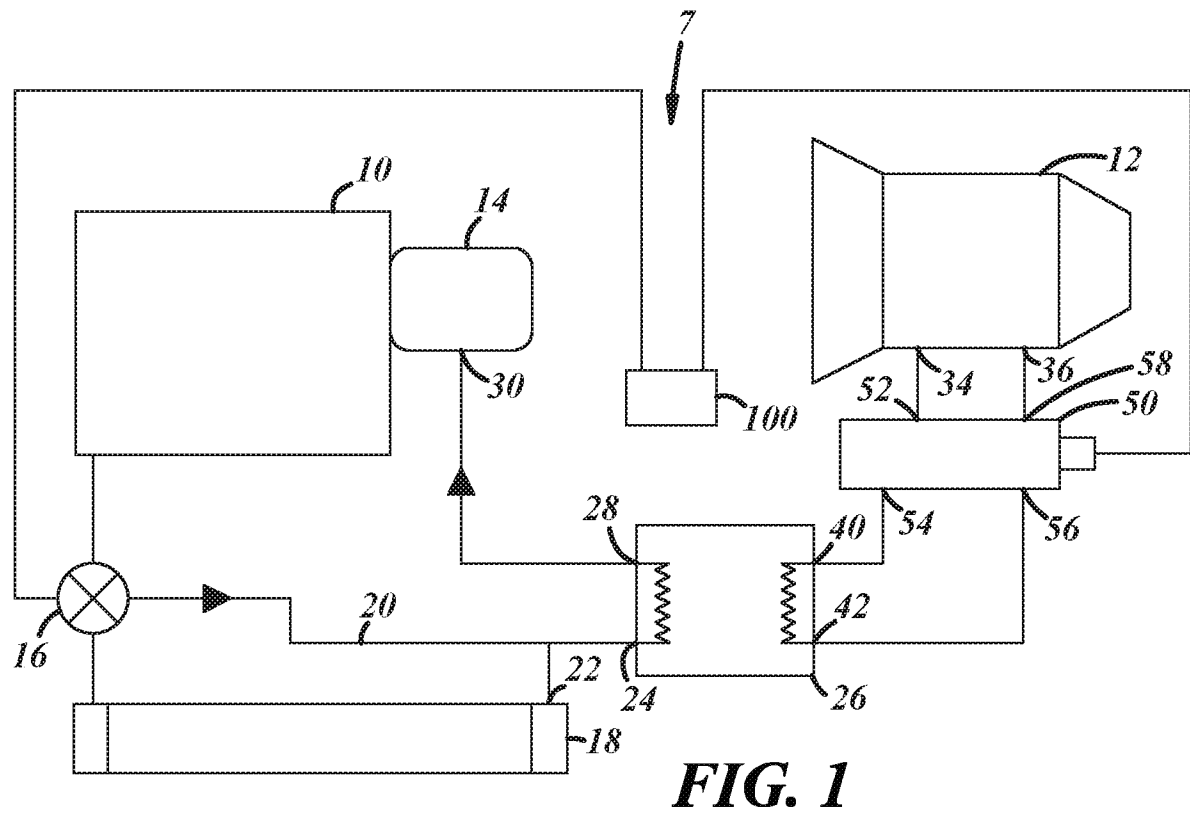
5 thereby thermally isolating said transmission oil from said engine coolant and wherein a solenoid actuator for said solenoid controlled bypass valve when non-energized places said solenoid controlled bypass valve in said first position; and

a controller for selecting the position of said solenoid controlled bypass valve and said radiator bypass valve, said controller being cognizant of temperatures of

10 the transmission oil and the coolant to allow thermal energy exchange between the transmission oil and the coolant or to thermally isolate the transmission oil from the coolant, wherein when the vehicle transmission oil is cooler than desired, and the engine coolant is hotter than the transmission oil, said controller causes said radiator bypass valve to connect the engine coolant with said radiator bypass and

15 to cause said solenoid controlled bypass valve to allow thermal energy exchange between the transmission oil and the engine coolant and when the engine coolant is cooler than desired, and the engine coolant is cooler than the transmission oil, said controller causes said radiator bypass valve to connect coolant with said radiator bypass and to cause said solenoid controlled bypass valve to allow thermal

20 exchange between the transmission oil and the engine coolant.



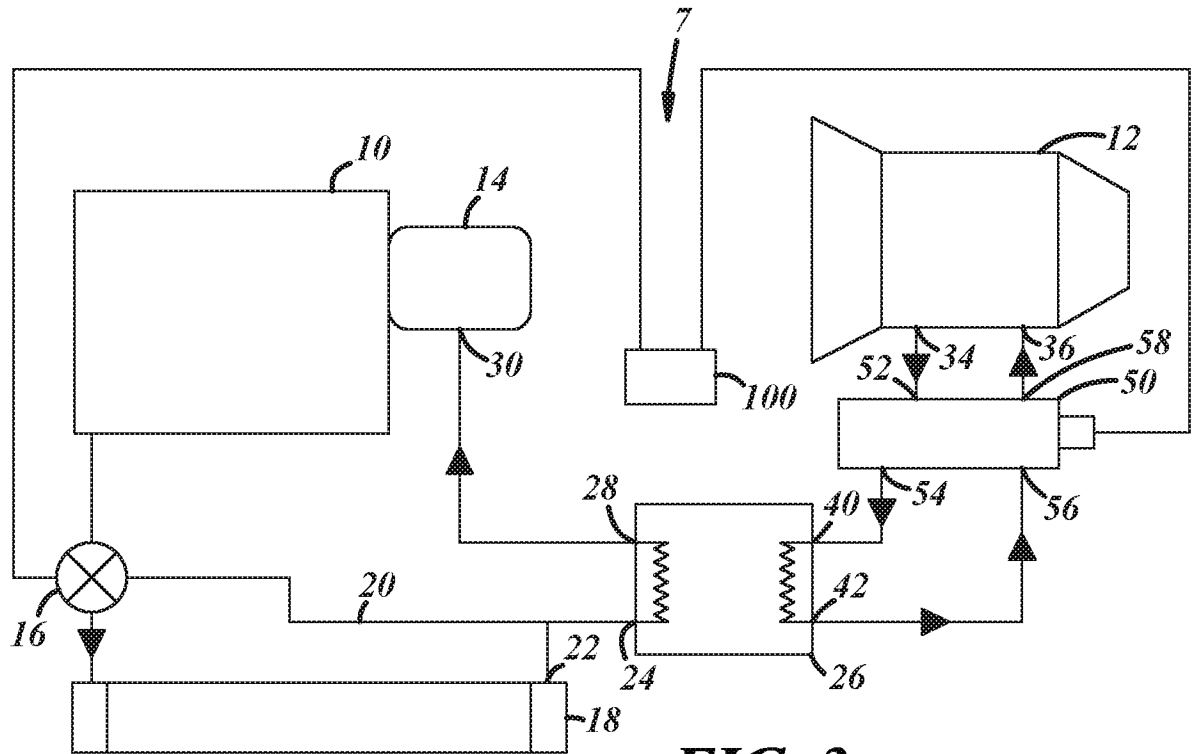


FIG. 3

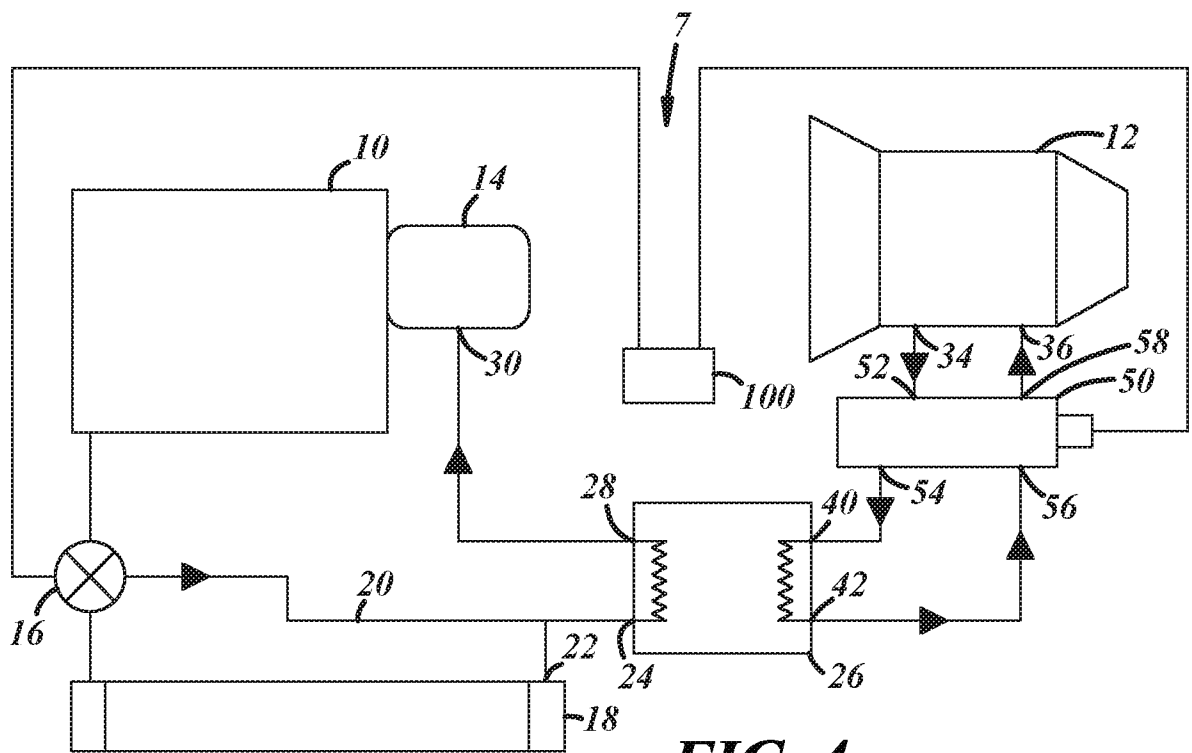
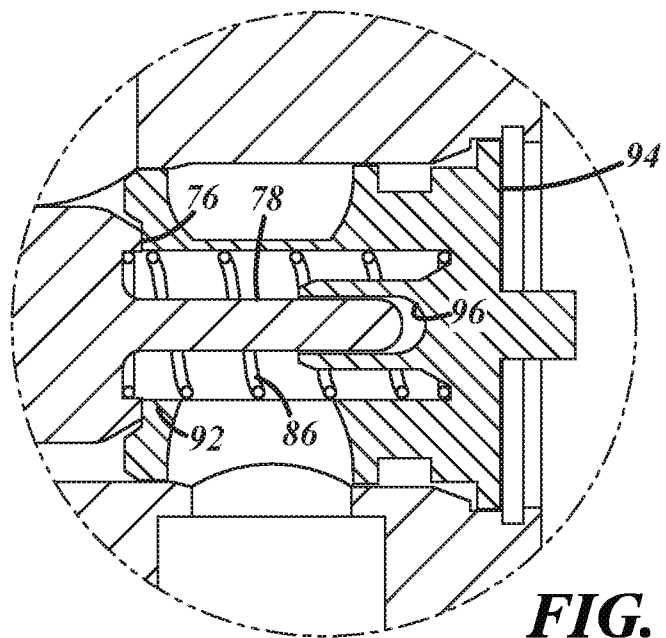
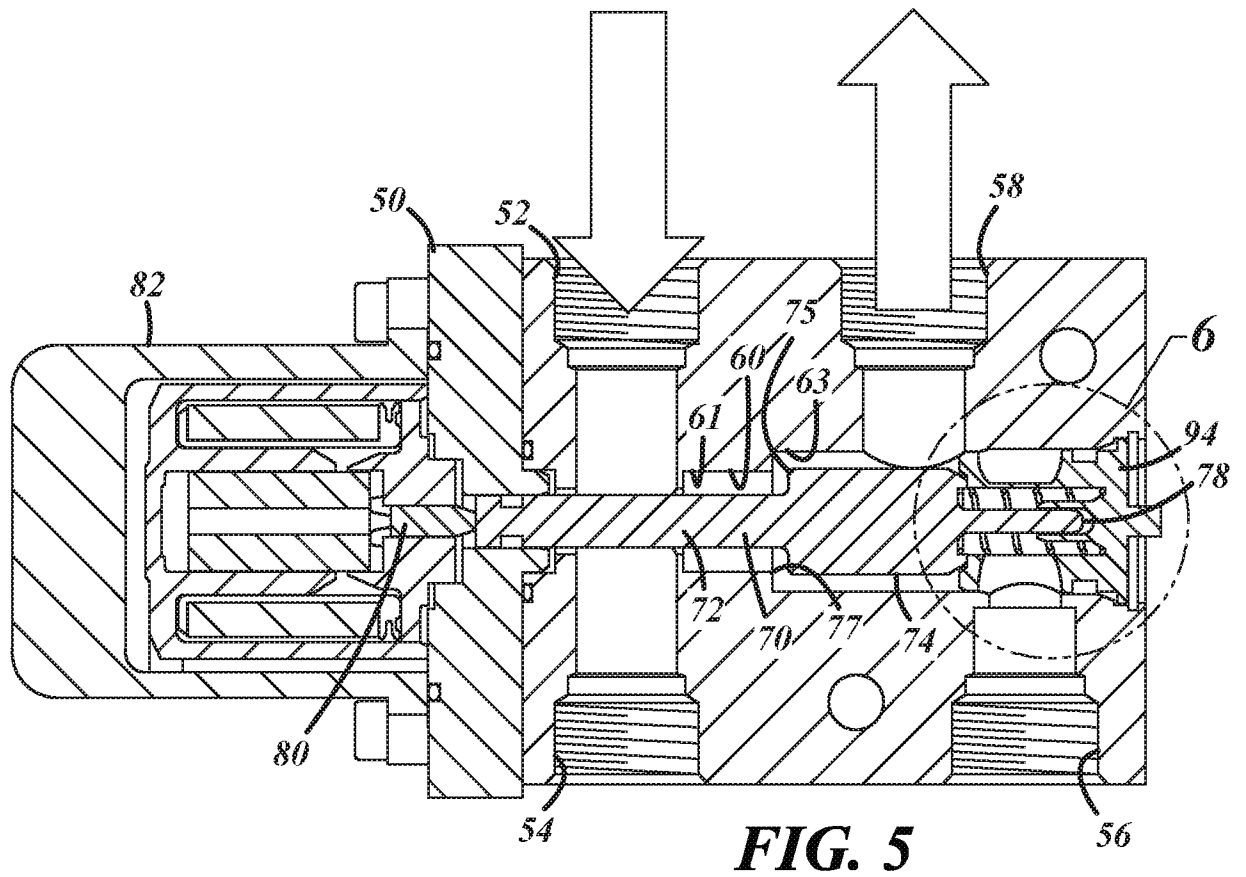
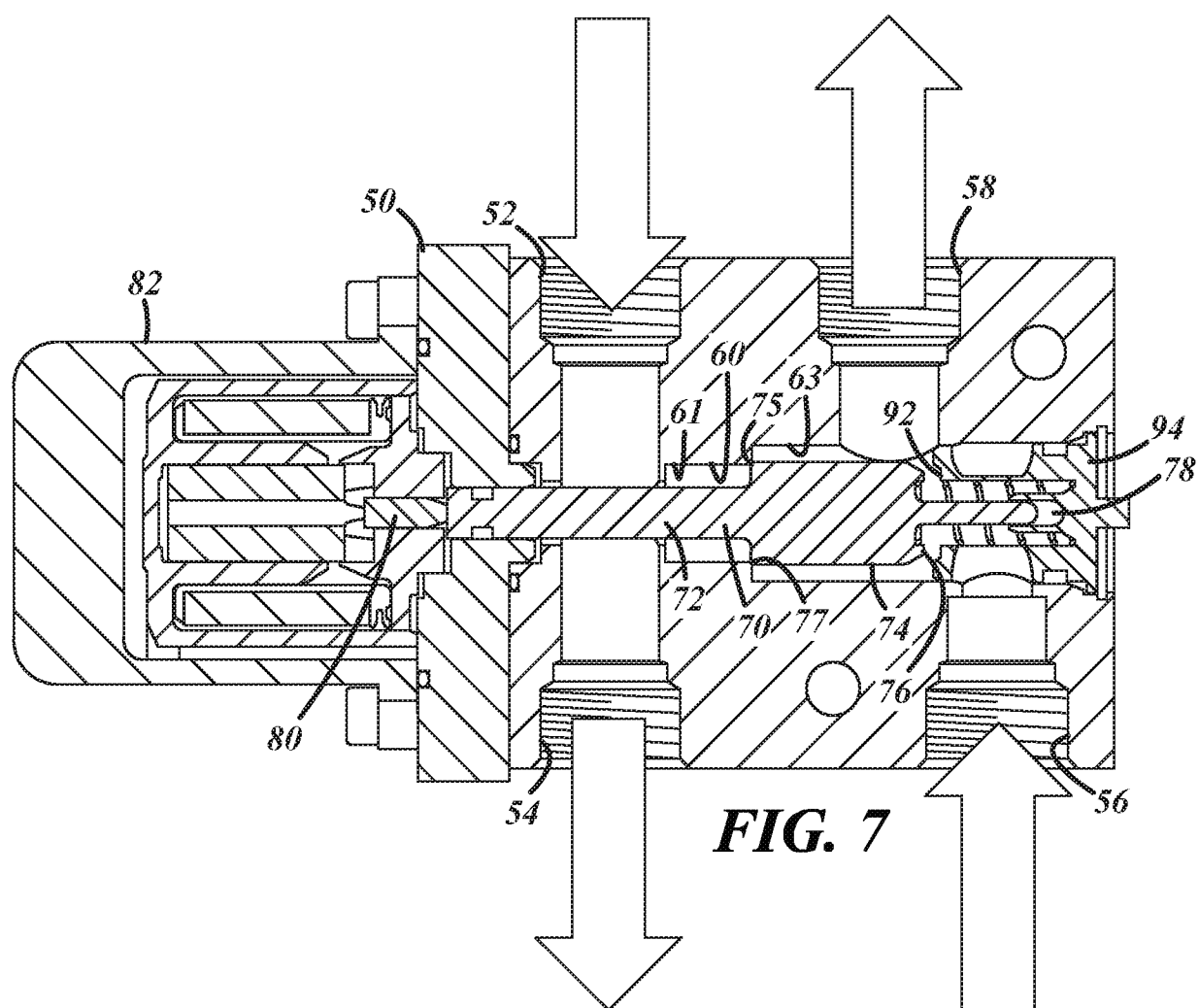


FIG. 4





INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/017176**A. CLASSIFICATION OF SUBJECT MATTER****F16H 57/04(2010.01)i, B60K 11/00(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)

F16H 57/04; F28D 15/00; B60H 1/00; F01P 1/06; F16H 59/72; B60K 11/00

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: transmission oil, engine coolant, heat exchanger, solenoid, bypass, and temperature

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6427640 B1 (HICKEY et al.) 06 August 2002	1-4, 9, 10
A	See column 2, line 56 - column 4, line 55 and figure 1.	5-8, 11, 12
Y	US 2011-0284309 A1 (GOODEN et al.) 24 November 2011	1-4, 9, 10
	See paragraphs [0034]-[0038] and figures 2-4.	
Y	US 2007-0295475 A1 (SAMIE et al.) 27 December 2007	4
	See paragraphs [0013]-[0022] and figure 1.	
A	US 2009-0101312 A1 (GOODEN et al.) 23 April 2009	1-12
	See paragraphs [0015]-[0022] and figure.	
A	KR 10-2002-0052288 A (HYUNDAI MOTOR COMPANY) 04 July 2002	1-12
	See pages 2-3 and figure 2.	



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

18 May 2017 (18.05.2017)

Date of mailing of the international search report

18 May 2017 (18.05.2017)

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

KIM, Jin Ho

Telephone No. +82-42-481-8699



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2017/017176

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6427640 B1	06/08/2002	None	
US 2011-0284309 A1	24/11/2011	US 8205709 B2	26/06/2012
US 2007-0295475 A1	27/12/2007	EP 1873421 A1	02/01/2008
		EP 1873421 B1	20/01/2010
		JP 2008-008489 A	17/01/2008
		US 8042609 B2	25/10/2011
US 2009-0101312 A1	23/04/2009	CN 101417608 A	29/04/2009
		DE 102008037467 A1	28/05/2009
		DE 102008037467 B4	27/11/2014
		GB 2455170 A	03/06/2009
KR 10-2002-0052288 A	04/07/2002	KR 10-0387823 B1	18/06/2003