(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 426 344 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
07.03.2012 Bulletin 2012/10

(21) Application number: **10175608.8**

(22) Date of filing: **07.09.2010**

(51) Int Cl.:
F02M 31/14 *(2006.01)* ***F02M 31/20*** *(2006.01)*
F02M 63/00 *(2006.01)* ***F02M 53/00*** *(2006.01)*
F02M 53/04 *(2006.01)*

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO SE SI SK SM TR
Designated Extension States:
BA ME RS

(71) Applicant: **Caterpillar Motoren GmbH & Co. KG**
24159 Kiel (DE)

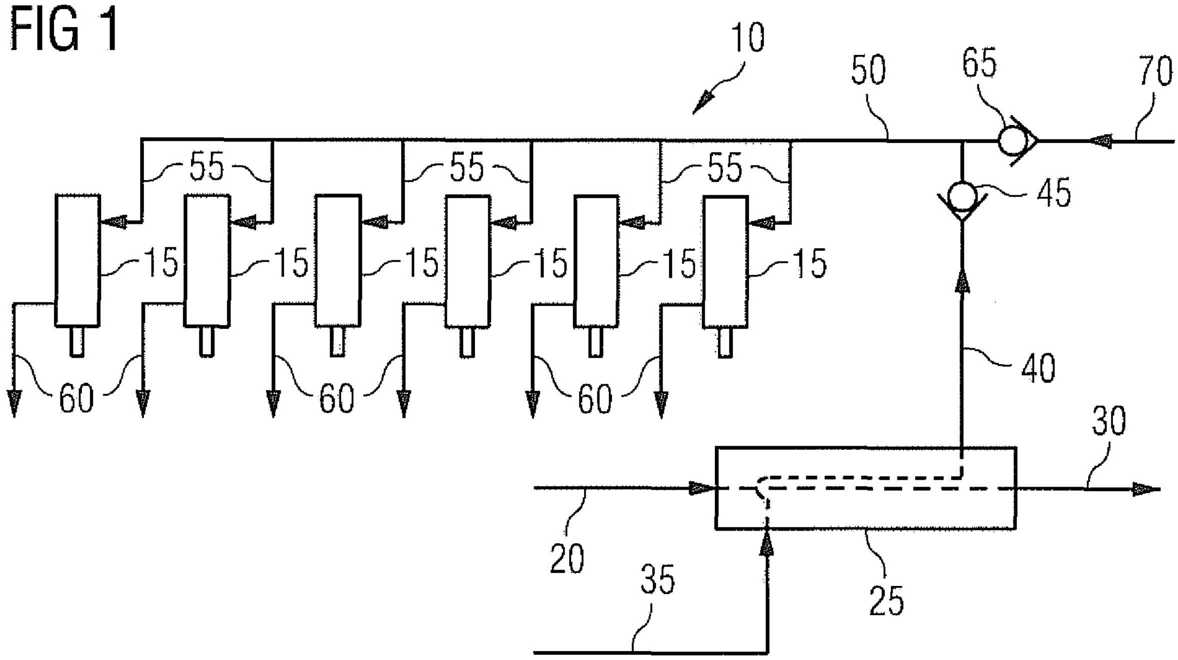
(72) Inventors:
- **Abraham, Volker**
  24159 Kiel (DE)
- **Jacobs, Holger**
  24937 Flensburg (DE)

(74) Representative: **Kramer - Barske - Schmidtchen**
Landsberger Strasse 300
80687 München (DE)

(54) Heating system for an internal combustion engine

(57) The present disclosure refers to a device and method for operating an internal combustion engine. The internal combustion engine may be configured to be operated in an operation mode in which fuel of a specific type injected into at least one combustion chamber, and in a standby mode in which no fuel is burned in the at least one combustion chamber. The method may comprise the steps of circulating heated fuel during the standby mode of the internal combustion engine and circulating lube oil (35,40,50,60,70) during the standby mode of the internal combustion engine. Thermal energy may be transferred in a heat exchanger (25) from said circulating heated fuel (20,30) to said circulating lube oil (35,40,50,60,70), such that said lube oil is heated thereby during the standby mode of the internal combustion engine. Said circulating heated lube oil may be supplied to the at least one injector (15) for heating purposes during the standby mode of the internal combustion engine.

FIG 1



EP 2 426 344 A1

Description

Technical Field

[0001] The present disclosure generally refers to internal combustion engines configured to bum fuel of a specific type, e.g. heavy fuel oil. More specifically, the present disclosure refers to internal combustion engines configured to operate in an operating mode in which said fuel is burned, and a standby mode in which no fuel is burned, wherein switching from the standby mode into the operation mode may be performed without burning any other fuel than said fuel, for example heavy fuel oil.

[0002] Furthermore, the present disclosure refers to a heating system to be used at or together with an internal combustion engine of the type mentioned herein, and, in addition, to a method for operating an internal combustion engine of the type mentioned herein.

Background

[0003] Internal combustion engines, e.g. common rail engines and, in particular, medium-speed common rail engines, may be configured to operate with a specific type of fuel having a relatively high viscosity. The types of fuel include, for example, diesel oil (DO), marine diesel oil (MDO), and particularly heavy fuel oil (HFO), as exemplary shown in Fig. 4. When supplied to the engine for combustion, the viscosity of these fuels may vary from 2.5 cSt to 16 cSt.

[0004] Generally, the term "internal combustion engine" refers to internal combustion engines which may be used as main or auxiliary engines of ships/vessels such as cruiser liners, cargo ships, container ships, and tankers, or in power plants for production of heat and/or electricity. In particular, these engines, which are also known as "middle" and "large" internal combustion engines, may be configured to bum at least one fuel selected from the group consisting of diesel, marine diesel oil (MDO), and heavy fuel oil (HFO).

[0005] Heavy fuel oil may contain "asphaltenes". Asphaltenes may be defined as molecular substances that are found in crude oil, along with resins, aromatic hydrocarbon, and alcane (i.e, saturated hydrocarbons). Asphaltenes may consist primarily of carbon, hydrogen, nitrogen, oxygen, and sulfur, as well as great amounts of vanadium and nickel. Heavy oils may contain a much higher proportion of asphaltenes than of medium API graphic oil or light crude oils. Fuel Standard ISO 8217, for example, describes various parameters of "heavy fuel oil", also referred to as "marine distillate fuels" or "marine residual fuels".

[0006] The fuel injectors used may become soiled by the fuel injected, particularly if a type of fuel with a high viscosity, particularly HFO, is injected. The problems may even get worse when the internal combustion engine is put in a standby mode as defined above.

[0007] JP 2005146964 A discloses an arrangement including a pump, which supplies liquefied gas fuel from a feed pipe to an injection pipe connected to a fuel injection nozzle of a diesel engine. A cooling-medium path cools the injection pipe.

[0008] US 7,383,794 shows an injection nozzle having channels connected to lubricant oil or motor oil lines, through which lubricant oil or motor oil can flow. These channels are arranged in the region of the nozzle needle. Channels connected to lubricant oil or motor oil lines, through which lubricant oil or motor oil can flow, are also arranged in the region of the control valve and/or an electromagnet actuating the control valve. The valve needle cooperating with the valve seat has a branch line which allows lubricating oil, such as motor oil, to flow.

[0009] JP 2007303404A discloses a large sized two-cycle multi cylinder engine of cross head delivery type for use as a main engine in a power station. The engine has a valve that connects a medium-pressure pipe to an injection pipe via a control valve for fuel circulation. A control valve, which connects an injection pipe to a common rail during start of fuel injection, controls the flow of heavy fuel oil from the common rail to an injection valve. A fuel valve has an intake connected to the control valve, and an output opening connected to a low pressure pipe. The injection pipe is connected to a medium-pressure pipe during fuel injection. A valve connects the pipe to the pipe via the control valve for fuel circulation, when the engine is not operating.

[0010] KR 2008/068500 A shows a fuel filter unit for a fuel reduction system. The filter unit has a fuel injection port that is connected to a two-way valve via a link tube, said fuel injection port being provided to introduce fuel into a heating device. The valve selectively supplies fuel to be injected to the filters through the fuel injection port. The fuel injection port is connected to the valve through a link tube.

[0011] CN 201351555 Y discloses an oil injector cooling unit for diesel engines, having an automatic temperature regulator connected to a feeding hole of a cooler, and a pressure oil pump coupled to a power driving device. The oil pump is driven by a power driving device. The cooling unit has a cooler, i.e. a tube bundle, that is connected to an oil feeding pipe to form two connecting points as a front parallel connection pivot (a) and a back parallel connection pivot (b). The automatic temperature regulator is provided in the front parallel connection pivot and connected to a feeding hole of the cooler. A pressure oil pump is provided in the back parallel connection pivot and connected to the oil feeding pipe. The pressure oil pump is connected to a power driving device, and is driven by the power driving device.

[0012] In internal combustion engines of the type mentioned herein, the possible negative effects of fuels, particularly fuels having a relatively high viscosity, shall be addressed. The present disclosure is directed, at least in part, to improving or overcoming one or more aspects of prior systems.

Summary of the Disclosure

[0013] According to a first aspect of the present disclosure, a heating system for an internal combustion engine is provided. The internal combustion engine may be configured to be operated in an operation mode and a standby mode. During the operation mode, a fuel of a specific type, e.g. heavy fuel oil of the type mentioned herein, is injected into an associated combustion chamber via at least one injector. During the standby mode, the internal combustion engine may do not bum any fuel. Switching from the standby mode into the operation mode may be performed without burning any other fuel than said fuel injected during the operation mode. The heating system may comprise a lube oil supply system and a fuel supply system. The lube oil supply system may be configured to circulate lubricating oil, also known as "lube oil", through the at least one injector in order to heat the at least one injector. The fuel supply system may be configured to circulate said fuel heated during the standby mode for maintaining a predetermined temperature of ate least a part of the internal combustion engine. During the operation mode, the fuel supply system may be configured to supply said fuel to the at least one injector for injecting the same into the combustion chamber. A heat exchanger may be provided. The heat exchanger may be connected to the lube oil supply system and the fuel supply system, such that thermal energy from the fuel circulating in the fuel supply system is transferred to the lube oil circulating in the lube oil supply system. This thermal energy transfer may particularly be used for heating lube oil at a predetermined temperature, and, subsequently, for heating the at least one fuel injector during the standby mode by means of the heated lube oil.

[0014] According to a second aspect of the present disclosure, an internal combustion engine is provided, the internal combustion engine being configured to be operated in an operating mode in which a specific fuel is burned, and a standby mode in which no fuel is burned. Switching from the standby mode into the operation mode may be performed by exclusively burning the specific fuel. The internal combustion engine may comprise at least one injector configured to inject the specific fuel in an associated combustion chamber during the operation mode. The at least one fuel injector may be configured such that lube oil for heating the at least one fuel injector can be circulated therein. In addition, the internal combustion engine may comprise a heating system of the type mentioned herein.

[0015] According to another aspect of the present disclosure, a method for operating an internal combustion engine is provided. The method may comprise the step of circulating heated fuel during a standby mode of the internal combustion engine. During the standby mode, no fuel may be burned in the combustion chamber. In addition, during the standby mode of the internal combustion chamber, lube oil may be circulated. Furthermore, a thermal energy transfer from the circulated heated fuel to the circulating lube oil, thereby heating the lube oil, may be performed during the standby mode of the internal combustion engine. During the standby mode of the internal combustion engine, the circulating heated lube oil may be supplied to the at least one fuel injector which is configured to inject the fuel into an associated combustion chamber.

[0016] Other features and aspects of this disclosure will be apparent from the following description and the accompanying drawings.

Brief Description of the Drawings

[0017] Fig. 1 shows a schematic diagram of an exemplary embodiment of a heating system for an internal combustion engine according to the present disclosure,

[0018] Fig. 2 shows another schematic view of an exemplary embodiment of a part of an internal combustion engine and a heating system according to the present disclosure,

[0019] Fig. 3 shows an exemplary embodiment of a fuel injector which may be used in an internal combustion engine according to the present disclosure, and

[0020] Fig. 4 shows an exemplary diagram of an engine operation over a wide range of fuel viscosities.

Detailed description

[0021] Referring to Fig. 1, an internal combustion engine (only partly shown) may include one or more injectors 15. Each injector 15 may be associated with a combustion chamber of the internal combustion engine. In other words: Each combustion chamber of the internal combustion engine may be equipped with one or more injectors 15. The injectors 15 may be configured to inject fuel into the associated combustion chamber. An injector 15 may have a structure as shown in Fig. 3 and will be discussed later in more detail. Each injector 15 may be connected to a branch line 55, which in turn may be connected to a common supply line 50 for heated lube oil. Furthermore, each injector 15 may be connected to a lube oil drain line 60.

[0022] The common supply line 50 for heated lube oil may be connected to a primary lube oil supply line 70 and/or a secondary lube oil supply line 40. A check valve 45 or any other control means known in the art for controlling the supply of lube oil from the secondary lube oil supply line 40 into the common supply line 50 for lube oil may be provided. Another check valve 65 may be interconnected between the primary lube oil supply line 70 and the common supply line 50 for lube oil.

[0023] A heat exchanger 25 may be provided in the arrangement shown in Fig. 1, e.g. providing a heating system 10 for an internal combustion engine. The heat exchanger 25 may be coupled to a lube oil inlet 35 for cool lube oil and a fuel inlet 20 for heated fuel of a specific type, e.g. heavy fuel oil (HFO). The heat exchanger 25 may be also connected to a fuel outlet 30 and the secondary lube oil supply line 40. The heat exchanger 25 may be designed such that lube oil flowing via the lube oil inlet 35 into the heat exchanger 25 and the fuel flowing in the fuel inlet 20 into the heat exchanger, are guided within the heat exchanger 25 in a manner that at least part of the thermal energy of one of the fluids entering via the inlets 20 or 35 is exchanged between the fluids. That transfer of thermal energy may result in that fuel entering the heat exchanger 25 via the HFO inlet 20 leaves the heat exchanger 25 via outlet 30 with a temperature lower than the fuel's entering temperature, and lube oil entering the heat exchanger 25 via the lube oil inlet 35 leaves the heat exchanger 25 via the outlet or secondary lube oil supply line 40 with a temperature higher than the temperature of the lube oil at the entrance of the heat exchanger 25.

[0024] The heat exchanger 25 may be of any type known in the art, in particular of the type including tube bundle heat exchangers, shell and tube heat exchangers, plate heat exchangers, plate fin heat exchangers etc.

[0025] Another schematic diagram of a part of an internal combustion engine equipped with a heating system 10 as outlined above, is shown in Fig. 2. It shall be noted that reference signs used in Fig. 2 that are identical with reference signs used in Fig. 1 may refer to the same components or elements. Accordingly, as far as elements or components in Fig. 2 are labeled with reference signs already mentioned with respect to Fig. 1, it is referred to the corresponding explanations.

[0026] The arrangement shown in Fig. 2 shows a an oil pan or reservoir 215 for lube oil 220. The reservoir 215 may include a pre-lubricating pump 240 for lube oil 220. The pre-lubricating pump 240 may be connected to the heat exchanger 25 via the lube oil inlet 35. In this exemplary embodiment of the present disclosure, a pipe coil 210 for lube oil may be housed in the heat exchanger 25. The pipe coil 210 for lube oil 220 may be connected to the lube oil inlet 35 at a first side and may be connected to the secondary lube oil supply line 40 at a second end of the pipe coil 210. The pipe coil 210 may be provided within a chamber 235 defined within the heat exchanger 25.

[0027] The heat exchanger 25 itself may be arranged within a housing 24 of a fuel filter 23. However, the heat exchanger 25 may be also arranged at another location of the heating system 10. The arrangement within or as part of the fuel filter 23 may provide the benefit of reducing the size of the system.

[0028] As shown in Fig. 2, the lube oil drain lines 60 of each injector 15 may extend to the reservoir 215, whereby lube oil leaving an injector body 151 (see Fig. 3) of an injector 15 is guided back to the reservoir 215.

[0029] The heat exchanger 25 as shown in Fig. 2 may be equipped with the fuel inlet 20 and the fuel outlet 30. The fuel outlet 30 may be connected to a common rail 300 from which fuel branch lines 310 are extending to each injector 15.

[0030] A lube oil pump 250, e.g. mechanically driven by the internal combustion engine during the operation mode, may be provided and connected at an inlet side with the reservoir 215 via a line 255, and at an outlet side of the pump 250 with the primary lube oil supply line 70.

[0031] A control unit 260 may be connected to the pump 240 and the the pump 270 for controlling the flow rate of the respective fluid, namely the lube oil and the fuel, flowing in the heat exchanger 25 via the lines 20 and 35 respectively.

[0032] The pump 270 and the line 20, 30 may form a part of a fuel supply system 7. A lube oil supply system 6 may be formed by pumps 240 and/or 250 and associated lines, e.g. 35, 40, 50.

[0033] Fig. 3 shows a longitudinal cross section of an exemplary embodiment of a fuel injector 15 as may be used in the systems shown in Fig. 1 or 2 and as described herein.

[0034] The shown injector body 151 may be provided with lube oil channels 152, 153 and 154. The exemplary design of the channels 152, 153, 154 may be such that at least part of the injector 15 can be cooled or heated via the lube oil 220 flowing in direction 155. Here, the channels 152 and 154 are straight, but in other exemplary embodiments these channels may be designed or shaped differently, e.g. like a coil, or the channels 152, 153, 154 may meander. The channel 153 is shown as a ring channel surrounding a movable injector needle 157, but can also have any other design appropriate for providing a thermal heat transfer from the lube oil flowing within channel 153 to parts of the injector 15 in the vicinity of channel 153. The same applies to channels 152, 154.

[0035] In this exemplary embodiment of a fuel injector 15, two or more nozzle holes 158 are provided through which fuel can be injected into an associated combustion chamber (not shown). The point of time and the amount of fuel injected via the nozzle holes 158 may be controlled by the movable needle 157.

[0036] An entrance opening of channel 152 at the upper side of the injector body 151 may be connected to an associated branch line 55. An outlet opening of channel 156 at the upper side of the injector body 151 may be connected to an associated drain line 60.

[0037] Fig. 4 shows a diagram where kinematic viscosities and the viscosities of different types of fuel are plotted at different temperatures. In particular, the different kinematic viscosities and the different viscosities of various kinds of heavy fuel oil are plotted at different temperatures in comparison to marine gas oil and marine diesel oil. Furthermore, the limit for pre-heating and the limit of pumpability are also plotted for different temperatures.

[0038] It is obvious that marine diesel oil need not be pre-heated to more than 50°C. The viscosities of the different types of heavy fuel oil (IF 700), however, are much higher than that of MDO, even at temperatures of 150°C or more. Hence, if an internal combustion engine is supplied with heavy fuel oil and bums heavy fuel oil, for example one of the types of heavy fuel oils mentioned herein, the heavy fuel oil has to be pre-heated, because otherwise its viscosity would be too high and the HFO could not flow within the fuel supply lines and its components, particularly within the injectors. This problem may particularly arise in a standby mode when the internal combustion engine does not bum any fuel. Accordingly, it might be known that heavy fuel oil is pre-heated and circulated in the supply lines during the standby mode.

[0039] However, during standby mode, particularly heavy fuel oil remaining in an injector may be stagnant and cool down to a temperature of e.g. about 60°C. As shown in Fig. 4, at this temperature, the viscosity of heavy fuel oil is very high and it could be difficult to re-start the internal combustion engine.

[0040] According to the present disclosure, the principle concept may include using lube oil heated by circulating fuel, e.g. heavy fuel oil, which itself is heated, to keep the injector warm, even in a standby mode.

Industrial Applicability

[0041] In the following, the basic operation of a fuel injection system 10 including a heating system 10 is described.

[0042] In an operation mode of the internal combustion engine, fuel, e.g. heavy fuel oil of the type mentioned, for example, in Fig. 4, is supplied via common rail 300 and branch lines 310 to each injector 15. Via the fuel injectors 15, an appropriate amount of fuel may be injected into the associated combustion chamber at a controlled point of time. Here, a common rail 300 is used to provide sufficient pressure to the fuel to be injected via the injectors 15. However, other technologies than common rail technology can also be used, for example an arrangement including separate high-pressure pumps connected to injectors.

[0043] During the operation mode of the internal combustion engine, lube oil 220 may be supplied via the primary lube oil supply line 70 and the common supply line 50 and branch lines 55 to each injector 15. In this case, the lube oil 220 may flow in the direction as indicated by reference sign 155 in the injector body 151 within channels 152, 153 and 154, and leave the injector body 151 via the respective drain line 60.

[0044] In the operation mode, the lube oil 220 may cool each injector 15 and the lube oil 220 may have a temperature lower than the temperature of each injector 15 supplied with fuel at a high pressure, e.g. 1500 bar to 2000 bar or even more. Accordingly, the temperatures of the injectors 15 may rise during the operation mode and may have to be lowered by the lube oil 220 circulating therein.

[0045] If the internal combustion engine is switched to a standby mode in which less or no fuel is burned in the injectors 15, the fuel, particularly heavy fuel oil, may be circulated to keep the whole engine at a temperature level appropriate to avoid any undesired solidification of fuel in the system. Accordingly, particularly a heating device (not shown) may be provided for heating the circulating fuel during standby mode.

[0046] By the way, in case the internal combustion engine is running in the operation mode, check valve 65 may open due to the high pressure of the lube oil 220 supplied by the pump 250, and check valve 45 may close due to the lower pressure of the lube oil within line 40, so that no lube oil in the secondary lube oil supply line 40 can enter the common supply line 50. In addition, the pump 240 may be switched off during the operation mode.

[0047] During the standby mode, the system according to the present disclosure may operate as follows.

[0048] The pump 240 may pump lube oil 220 from the reservoir 215 into the heat exchanger 25. At the same time, heated fuel circulating in the fuel supply system 7 may be directed into heat exchanger 25 and may leave the heat exchanger via outlet 30. The heated fuel may be circulated back to the inlet 20 as indicated by the broken line in Fig. 2. As the lube oil 220 flows within the pipe coil 210 arranged within the heat exchanger 25 and, at the same time, the heated fuel circulates in the heat exchanger 25 within the chamber 235, the temperature of the lube oil within the pipe coil 210 may be increased. The temperature increase may be controlled by a control unit, which may be connected to pump 240 and the fuel supply pump 270.

[0049] As an alternative, the pumping rotation speed of the pump 240 and/or of the pump 270 may be adjusted, such that a desired temperature of the lube oil 220 leaving the heat exchanger 25 may be reached.

[0050] Another alternative may include controlling mechanically the flow rate of heated lube oil 220 entering each injector 15. According to another exemplary embodiment of the present disclosure the flow rate of heated lube oil 220 entering the common supply line 50 may mechanically controlled, e.g. via an aperture plate. The aperture plate may be adjustable, such that the aperture diameter may be adjustable.

[0051] The heated lube oil may leave the heat exchanger 25 via the secondary lube oil supply line 40 and may flow through the respective injector body 151 via the channels 152, 153, 154. The lube oil leaving each injector 15 may flow back to the reservoir 215 via drain lines 60. Accordingly, the temperatures of injectors 15 may be kept above a predetermined temperature level, such that a solidification of fuel or residues etc. in the proposed system, and particularly in the injectors 15, may be avoided or at least may be reduced.

[0052] Although the preferred embodiments of this disclosure have been described herein, improvements and modifications may be incorporated without departing from the scope of the following claims.

Claims

1. A heating system (10) for an internal combustion en-

gine, wherein the internal combustion engine is configured to be operated in an operation mode in which fuel of a specific type is injected via at least one injector (15) in an associated combustion chamber, and a standby mode in which the internal combustion engine is not burning any fuel, the switching from the standby mode into the operation mode being performed by burning exclusively said fuel,
the heating system (10) comprising:

a lube oil supply system (6) configured to circulate lube oil (220) through the at least one injector (15) for cooling or heating the at least one injector (15);
a fuel supply system (7) configured to circulate said fuel and to supply it to the at least one injector (15) for injection into the associated combustion chamber; and
a heat exchanger (25) configured to be connected to the lube oil supply system (6) and the fuel supply system (5), such that thermal energy from said fuel circulating in the fuel supply system (7) is transferred to the lube oil (220) circulating in the lube oil supply system (6).

2. The heating system of claim 1, further comprising a control unit (260) configured to control the lube oil supply system (6) and the fuel supply system (7), such that during the standby mode the lube oil (220) circulating in the lube oil supply system (6) is heated to an appropriate temperature.

3. The heating systemof claim 2, wherein the lube oil supply system (6) includes a lube oil pump (240) and the fuel supply system (7) includes a fuel pump (270), the lube oil pump (240) and the fuel pump (270) being controlled by the control unit (260), such that appropriate amounts of lube oil (220) and fuel are circulating in the respective fluid supply system (6, 7).

4. The heating system of any one of the preceding claims, further comprising a fuel filter (23) including a filter housing (24), the filter housing (24) being configured to house the heat exchanger (25).

5. The heating system of any one of the preceding claims,
wherein the at least one injector (15) includes an injector body (151) with at least one lube oil channel (152, 153, 154) fluidly connected to the lube oil supply system (6), the injector body (151) being cooled by the lube oil (220) circulating in the at least one lube oil channel (152, 153, 154) during the operation mode, and being heated by heated lube oil (220) circulating in the at least one lube oil channel (152, 153, 154) during the standby mode.

6. An internal combustion engine configured to be operated in an operating mode in which fuel of a specific type is burned and a standby mode in which no fuel is burned, the switching from the standby mode into the operation mode being performed by burning exclusively said fuel, the internal combustion engine comprising:

at least one injector (15) configured to inject the heavy fuel oil in an associated combustion chamber during the operation mode, the at least one injector (15) being configured such that lube oil (220) can be circulated therein for cooling and heating the at least one injector (15); and
a heating system (5) according to one of the claims 1-5.

7. The internal combustion engine of clam 6, further comprising a common rail (300) to which the at least one injector (15) is connected.

8. A method for operating an internal combustion engine, the internal combustion engine being configured to be operated in an operation mode in which fuel of a specific type injected into at least one combustion chamber, and in a standby mode in which no fuel is burned in the at least one combustion chamber;
the method comprising the steps of:

circulating heated fuel during the standby mode of the internal combustion engine;
circulating lube oil (220) during the standby mode of the internal combustion engine;
performing a thermal energy transfer from said circulating heated fuel to said circulating lube oil, thereby heating the lube oil (220) during the standby mode of the internal combustion engine; and
supplying said circulating heated lube oil (220) to the at least one injector (15) during the standby mode of the internal combustion engine.

9. The method of claim 8, further comprising the steps of:

switching from the standby mode to the operation mode, and
supplying exclusively said fuel to the at least one injector (15) during the switching to the operation mode.

10. The method of claim 8 or 9, further comprising the steps of:

operating the internal combustion engine in the operation mode;
switching from the operation mode to the standby mode.

11. The method of any one of claims 8-10, further comprising the steps of:

circulating lube oil (220) during the operation mode such that the at least one injector (15) is cooled.

12. The method of any of claims 8-11, wherein the step of performing a thermal energy transfer from said fuel to said lube oil (220) is executed upstream of the least one injector (15).

13. The method of any one of claims 8-12 , wherein the step of performing a thermal energy transfer from said fuel to said lube oil (220) is executed within the housing (24) of the fuel filter (23).

14. The method of any one of claims 8-13, wherein the step of performing a thermal energy transfer from said fuel to said lube oil (220) is executed within a heat exchanger (25).

15. The method of any one of claims 8-14, wherein said fuel is heavy fuel oil.

FIG 1

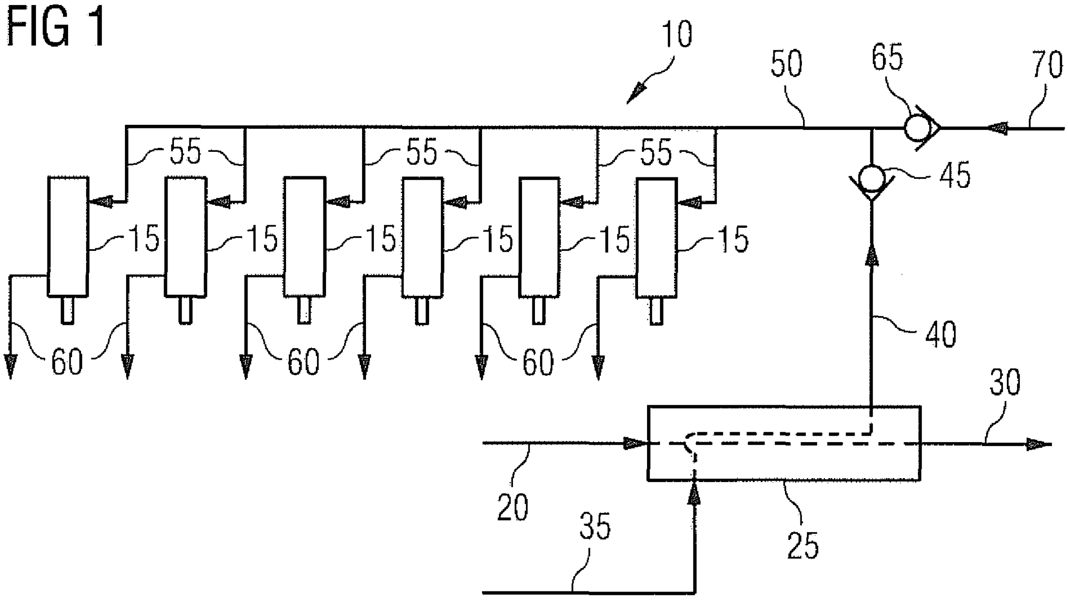

10
50
65
70
55
55
55
45
15
15
15
15
15
15
60
60
60
40
30
20
35
25

FIG 2

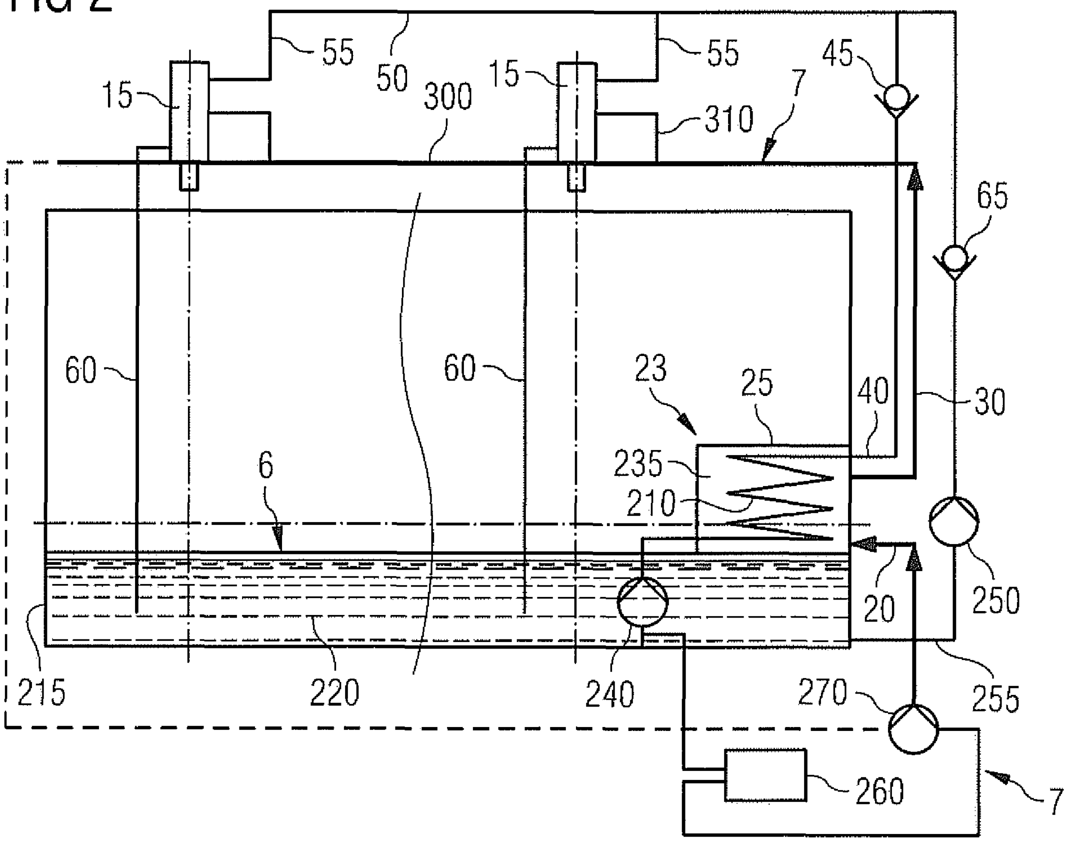

55
50
55
45
15
300
15
310
7
65
60
60
23
25
40
30
6
235
210
20
250
215
220
240
270
255
260
7

FIG 3

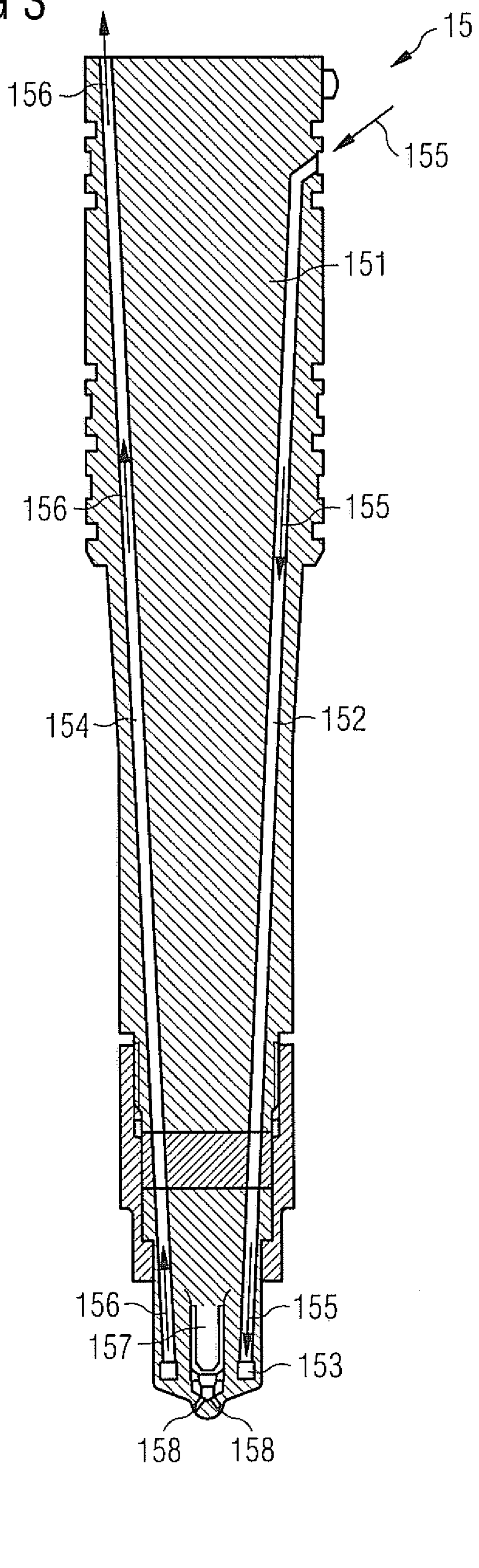
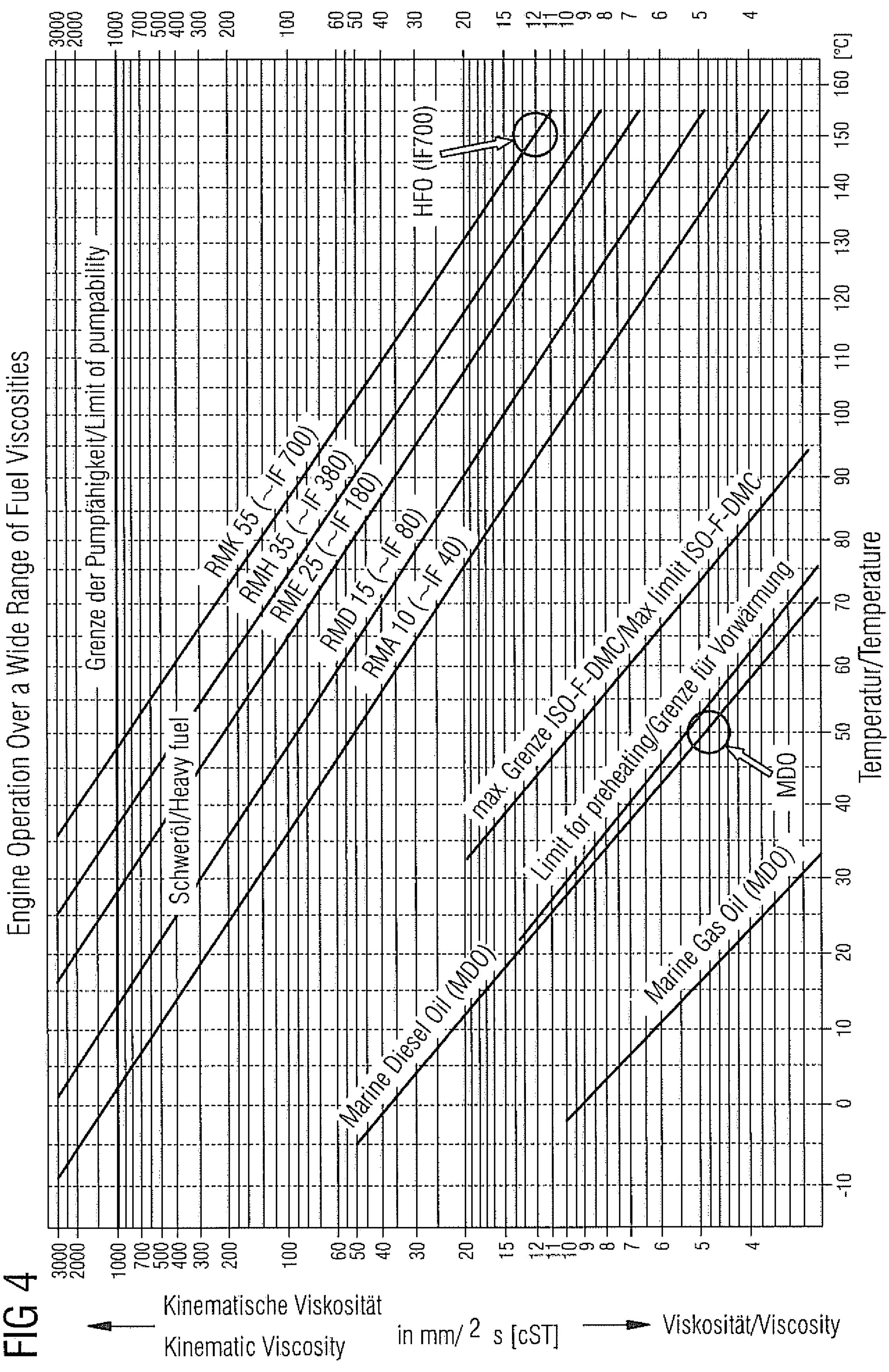


FIG 4


Engine Operation Over a Wide Range of Fuel Viscosities
Grenze der Pumpfähigkeit/Limit of pumpability
Schweröl/Heavy fuel
RMK 55 (~IF 700)
RMH 35 (~IF 380)
RME 25 (~IF 180)
RMD 15 (~IF 80)
RMA 10 (~IF 40)
HFO (IF700)
max. Grenze ISO-F-DMC/Max limit ISO-F-DMC
Limit for preheating/Grenze für Vorwärmung
MDO
Marine Diesel Oil (MDO)
Marine Gas Oil (MDO)
3000 2000 1000 700 500 400 300 200 100 60 50 40 30 20 15 12 11 10 9 8 7 6 5 4
-10 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 [°C]
Temperatur/Temperature
Kinematische Viskosität
Kinematic Viscosity
in mm/ 2 s [cST]
Viskosität/Viscosity

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 10 17 5608

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 4 432 329 A (REDELE JEAN E A [FR]) 21 February 1984 (1984-02-21) * claims 1,6; figure 1 *	1-5 6,7	INV. F02M31/14 F02M31/20 F02M63/00 F02M53/00 F02M53/04
X A	US 3 945 353 A (DREISIN ALEXANDER) 23 March 1976 (1976-03-23) * column 3, line 16 - column 4, line 58; figures 1,2 *	1-5 6,7	
A	GB 1 121 013 A (MASCHF AUGSBURG NUERNBERG AG) 24 July 1968 (1968-07-24) * page 2, line 25 - line 108 *	8-15	
A	EP 0 304 742 A1 (WEBER SRL [IT]) 1 March 1989 (1989-03-01) * column 2, line 26 - column 3, line 54; figure 1 *	8-15	
A	US 3 354 872 A (LOUIS GRATZMULLER JEAN) 28 November 1967 (1967-11-28) * column 2, line 8 - column 3, line 5; figure 1 *	8-15	TECHNICAL FIELDS SEARCHED (IPC) F02M
A	WO 2006/021014 A1 (BOSCH GMBH ROBERT [DE]; HLOUSEK JAROSLAV [AT]; GUGGENBICHLER FRANZ [AT) 2 March 2006 (2006-03-02) * page 7, line 5 - line 23; figure 4 *	8-15	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	6 April 2011	Kolland, Ulrich

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document

4

EPO FORM 1503 03.82 (P04C01)

Europäisches Patentamt
European Patent Office
Office européen des brevets

Application Number
EP 10 17 5608

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

Europäisches Patentamt
European Patent Office
Office européen des brevets

LACK OF UNITY OF INVENTION SHEET B

Application Number
EP 10 17 5608

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-7

A heating system comprising a lube oil supply system circulating lube oil through an injector also for cooling it;
a fuel supply system supplying the fuel to an at least one injector; and
a heat exchanger connected to the lube oil supply system and the fuel supply system.

---

2. claims: 8-15

A method for operating an internal combustion engine operating in a standby mode in which no fuel is burned in the at least one combustion chamber;
the method comprising the steps of:
circulating heated fuel and circulating lube oil during the standby mode, heating the lube oil by the fuel.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 10 17 5608

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

06-04-2011

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
US 4432329	A	21-02-1984	CA	1188942	A1	18-06-1985
			DE	3270595	D1	22-05-1986
			EP	0069639	A1	12-01-1983
			FR	2509380	A1	14-01-1983
			JP	58015753	A	29-01-1983
			PL	237303	A1	14-03-1983
			RO	84871	A1	17-08-1984
US 3945353	A	23-03-1976	CA	1037803	A1	05-09-1978
GB 1121013	A	24-07-1968	CH	432934	A	31-03-1967
			DK	112282	B	25-11-1968
			NL	6607091	A	11-01-1967
EP 0304742	A1	01-03-1989	BR	8804305	A	21-03-1989
			DE	3865593	D1	28-11-1991
			ES	2026234	T3	16-04-1992
			IT	1217257	B	22-03-1990
			JP	1121562	A	15-05-1989
			JP	2726276	B2	11-03-1998
			US	4872438	A	10-10-1989
US 3354872	A	28-11-1967	AT	278443	B	26-01-1970
			BE	667226	A	16-11-1965
			CH	434873	A	30-04-1967
			DE	1476207	A1	03-02-1972
			DK	116036	B	01-12-1969
			FR	1411759	A	24-09-1965
			GB	1080273	A	23-08-1967
			NL	6509487	A	24-01-1966
			SE	305981	B	11-11-1968
WO 2006021014	A1	02-03-2006	AT	452287	T	15-01-2010
			AT	500773	A1	15-03-2006
			CN	101006268	A	25-07-2007
			EP	1781931	A1	09-05-2007
			JP	2008510914	T	10-04-2008
			KR	20070046904	A	03-05-2007
			US	2008017169	A1	24-01-2008

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2005146964 A **[0007]**
- US 7383794 B **[0008]**
- JP 2007303404 A **[0009]**
- KR 2008068500 A **[0010]**
- CN 201351555 Y **[0011]**