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(54) **TRANSPORT VEHICLE WITH AN AIR CONDITIONING SYSTEM USING AN ABSORPTION REFRIGERATOR**

(57) This transport vehicle (2) comprises: an air-conditioning system (12) for conditioning the air inside the transport vehicle, said air-conditioning system having an absorption refrigeration machine (32) for cooling the air inside the transport vehicle; an internal combustion engine (4), said internal combustion engine being equipped with a fuel injection system (6) and an exhaust line (8). The absorption refrigeration machine (32) is thermally connected to the exhaust line in order to use the heat of hot exhaust gases for said cooling; and a heat measuring

device (10) for measuring the amount of heat in the exhaust gases. The vehicle comprises an engine fuel post-injection controller (13) for controlling the post-injection of fuel into said engine (4), said engine fuel post-injection controller being adapted to: receive a heat signal from said heat measuring device (10); if the heat signal is below a predetermined threshold, control said fuel injection system (6) to post-inject an additional amount of fuel into the internal combustion engine (4).

Application to railway vehicles.

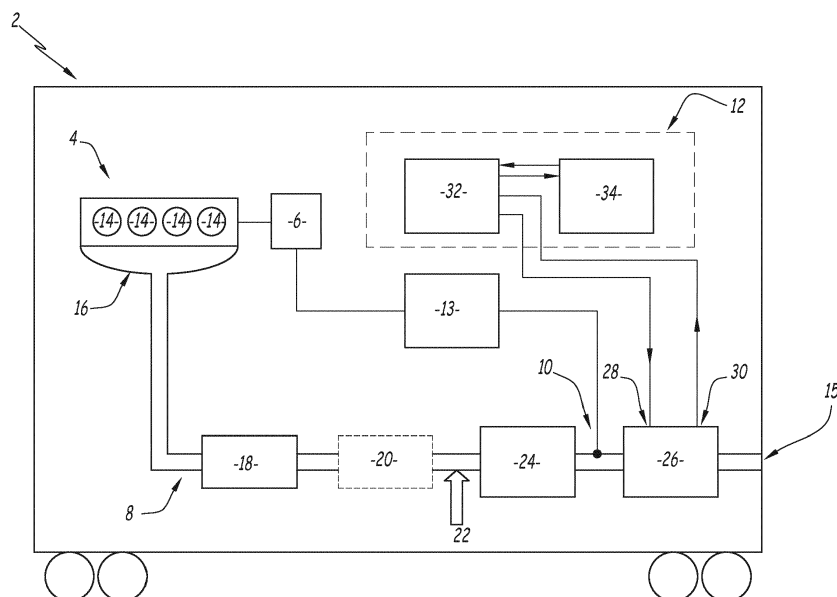


Fig.1

Description

[0001] The present invention relates to a transport vehicle, in particular a railway vehicle for passenger transport, comprising:

an air-conditioning system for conditioning the air inside the transport vehicle, said air-conditioning system having an absorption refrigeration machine for cooling the air inside the transport vehicle;
 an internal combustion engine for propelling the transport vehicle, said internal combustion engine being equipped with a fuel injection system;
 an exhaust line connected to the internal combustion engine for discharging hot exhaust gases from the internal combustion engine;
 wherein the absorption refrigeration machine is thermally connected to said exhaust line in order to use the heat of said hot exhaust gases for said cooling;
 and
 a heat measuring device for measuring the amount of heat in the exhaust gases.

[0002] Such a transport vehicle is known from US 2006/0021332 A1. This document discloses a motor vehicle having, as shown in Fig. 2, a diesel engine 1 equipped with an exhaust system 2. The exhaust system 2 is fitted with an exhaust heat exchanger 16, which allows extracting heat from the hot exhaust gases. The extracted heat can be provided to an absorption refrigeration machine 26. The absorption refrigeration machine 26 uses the extracted heat to generate cold, which is used to cool the interior 20 of the motor vehicle via an air-conditioning heat exchanger 27.

[0003] When the exhaust gas from the diesel engine 1 does not contain enough heat for said cooling operation, a pre-oxidation unit 5 located in the exhaust line 3 of the exhaust system 2 is used to inject fuel into the exhaust line 3. This fuel burns in the exhaust line 3 so that enough heat is available for the cooling operation.

[0004] In this way, cooling of the vehicle interior 20 with the absorption refrigeration machine 26 is made possible even when the diesel engine 1 is idling or running with a low load.

[0005] However, this known solution requires a complicated pre-oxidation unit 5 in the exhaust line 3.

[0006] Accordingly, it is an object of the present invention to provide a transport vehicle with an internal combustion engine wherein the cooling of the vehicle's interior via an absorption refrigeration machine using the heat of the engine's exhaust gas is guaranteed in a simple way even when the engine is idling or running with a low load.

According to the invention, this object is achieved with the above-defined transport vehicle, which is characterised by

[0007] an engine fuel post-injection controller for controlling the post-injection of fuel into said engine, said

engine fuel post-injection controller being adapted to:

- receive a heat signal from said heat measuring device;
- 5 - if the heat signal is below a predetermined threshold, which indicates that the heat from the exhaust gases is insufficient for the cooling needs of the absorption refrigeration machine, control said fuel injection system to post-inject an additional amount of fuel into the internal combustion engine, i.e. at the end of its combustion phase, thus increasing the heat from the exhaust gases above said predetermined threshold.

[0008] Thanks to the inventive fuel post-injection in the internal combustion engine, the heat of the exhaust gases can be increased when it would otherwise be insufficient for cooling the transport vehicle's inside. By using the engine's already present fuel injection system for keeping the heat of the exhaust gases sufficiently high, one can do without the additional fuel injection device in the exhaust line taught by US 2006/0021332, thus reducing complexity and saving costs. According to preferred embodiments, the inventive transport vehicle may include one, several or all of the following features, in all technically feasible combinations:

- the engine fuel post-injection controller is adapted to:
 - receive a cooling mode signal from the air-conditioning system indicating that the same is in a cooling mode;
 - if the heat signal is below a predetermined threshold, which indicates that the heat from the exhaust gases is insufficient for the cooling needs of the absorption refrigeration machine, and if concurrently there is a cooling mode signal from the air-conditioning system, control said fuel injection system to post-inject the additional amount of fuel into the internal combustion engine, i.e. at the end of its combustion phase, thus increasing the heat from the exhaust gases above said predetermined threshold;
- the engine fuel post-injection controller is adapted to control said fuel injection system to perform two subsequent post-injections;
- the engine fuel post-injection controller is adapted to control said fuel injection system to start the post injection of the first fuel post-injection at the end of a first time interval which is defined by a crank angle sweep of the internal combustion engine comprised between 1° to 5°;
- the time interval between said two subsequent post-injections is a period in which the crank angle of the internal combustion engine covers an angle comprised between 90° to 180°;
- the heat measuring device is a temperature sensor located in the exhaust line;

- the predetermined threshold is 252 °C;
- the absorption refrigeration machine is installed on the roof or below the car body of the transport vehicle;
- the internal combustion engine is a diesel motor; and
- the transport vehicle is a railway vehicle in the form of a diesel multiple unit for regional passenger transport.

[0009] Exemplary embodiments of the invention will now be described in detail with reference to the drawings, wherein:

Figure 1 is a schematic drawing of a transport vehicle according to the invention; and

Figure 2 is a diagram of the fuel injections injected into the internal combustion engine of the transport vehicle according to the invention.

[0010] With reference to figure 1, there is shown a schematic diagram of a transport vehicle 2. The transport vehicle comprises an internal combustion engine 4, a fuel injection system 6, an exhaust line 8 connected to the internal combustion engine, a heat measuring device 10 arranged in the exhaust line 8, an air-conditioning system 12 and a post-injection controller 13. Whenever the term "downstream" or "upstream" is used in this description, it refers to a flow direction of a gas stream. "Downstream" defines a direction that is the same as the flow direction of the gas stream. "Upstream" defines a direction opposite to the flow direction of the gas stream.

[0011] The transport vehicle 2 is preferably a railway vehicle in the form of a diesel multiple unit for regional passenger transport. Alternatively, the transport vehicle is a bus or a truck.

[0012] The internal combustion engine 4 is preferentially a diesel motor adapted for propelling the transport vehicle 2. The diesel motor is equipped with a fuel injection system 6 for controllably injecting fuel into the diesel motor. The diesel motor 4 has one or more combustion chambers 14 for burning the injected fuel during a combustion phase shown in figure 2. While the diagram of figure 2 shows in the axis of abscissae the time in [ms], it is clear that for a given speed of revolution, the axis of abscissae also corresponds to the sweep angle of the crankshaft of the combustion engine 4. The crank angle and the time correspond therefore one to another for a given revolution speed.

[0013] The diesel motor 4 has an exhaust manifold 16 for ejecting the burned fuel, or hot exhaust gases, from the combustion chambers 14. The fuel injection system 6 is equipped with fuel injectors (not shown), for example piezo-elements (not shown) adapted to swing in order to inject fuel into the combustion chambers 14 of the diesel motor 4.

[0014] The fuel injectors are adapted to bend about a distance D in order to inject fuel into the combustion chambers 14. The amount of fuel injected into the combustion chambers 14 depends on the distance D and the

opening time. The greater the distance D and the opening time, the greater the amount of fuel injected into the combustion chambers 14 (see figure 2).

[0015] The fuel injection system 6 is configured to inject zero, one or more pre-injections PI of fuel, one main-injection MI of fuel, and at least a first post-injection LI1 of fuel into the combustion chambers 14.

[0016] The pre-injection PI allows reducing the ignition delay of the main combustion inside the combustion chambers 14. This results in lower noise emissions. The actual used number of PI pre-injections depends on the engine operation. The main-injection MI is adapted for providing sufficient energy to the diesel motor 4 in order to propel the transport vehicle 2. There are two types of post-injections commonly used. On the one hand, there are one or more first post-injections LI1, which take place immediately after the main injection. These are mainly used to oxidize soot particles from the main combustion process. Also, this type of post-injection influences formation of nitrogen oxide and the exhaust gas temperature. The number and type of LI1 first post-injections depends on the engine operation. Operation without LI1 is also carried out. On the other hand, a late post-injection LI2 can take place. This introduces unburned hydrocarbons into the exhaust tract, which do not burn in the combustion chamber 14 but in a catalytic converter 18 arranged downstream of the exhaust manifold 16 in order to raise the exhaust gas temperature very effectively. This allows the particle filter to be cleaned.

[0017] The number and type of late post-injections LI2 depends on engine operation, even operation without LI2 is temporarily possible, e.g. when the particulate filter is discharged.

[0018] The exhaust line 8 is connected to the combustion chambers 14 via the exhaust manifold 16 of the diesel motor 4.

[0019] The exhaust line 8 is adapted to discharge the hot exhaust gases from the diesel motor 4 via an exhaust 15. The exhaust line 8 is also adapted to clean the hot exhaust gases and to eject them out of the transport vehicle 2. The exhaust line 8 is also adapted to extract heat from the hot exhaust gases. The exhaust line 8 can comprise the catalytic converter 18 arranged downstream of the exhaust manifold 16. The catalytic converter 18 is adapted to transform products of imperfect combustion (like hydrocarbons and carbon monoxide) into non-toxic compounds.

[0020] The exhaust line 8 can comprise a particulate filter 20 arranged downstream of the catalytic converter 18, adapted for cleaning the hot exhaust gases. The particulate filter 20 might be integrated into the catalytic converter 18 to save available space. The exhaust line 8 can comprise an urea injector 22 arranged downstream of the catalytic converter 18, adapted for injecting urea into the exhaust line 8. The urea injector 22 allows to dose urea into the exhaust gas. The urea converts to ammonia. The ammonia is used to reduce the nitrogen oxides in a selective catalytic reductor 24 arranged downstream of

the urea injector 22.

[0021] The exhaust line 8 can comprise the selective catalytic reductor 24 arranged downstream of the urea injector 22. The selective catalytic reductor 24 allows to deoxidize nitrogen oxides in the exhaust. Instead of an urea injector 22 and a selective catalytic reductor 24 a storage system for nitrogen oxides can be used.

[0022] The exhaust line 8 comprises the heat measuring device 10 arranged in the exhaust line 8, for example arranged downstream of the selective catalytic reductor 24. The heat measuring device 10 can be in contact with the hot exhaust gases or the heat is calculated in the heat measuring device 10 based on available sensor data.

[0023] The heat measuring device 10 is adapted for determining the amount of heat in the hot exhaust gases.

[0024] The heat measuring device 10 is for example a temperature sensor adapted for measuring the temperature and a flow meter adapted for measuring the flow rate of the hot exhaust gases. Alternatively, the heat measuring device 10 can be a computational model in which the temperature and the flow rate are calculated based on available sensor data. The exhaust line 8 comprises a first heat exchanger 26 arranged downstream of the heat measuring device 10. The first heat exchanger 26 is in contact with the hot exhaust gases.

[0025] The first heat exchanger 26 has an input 28 allowing a heat-transporting medium to access the first heat exchanger 26, and an output 30 allowing the heat-transporting medium to exit the first heat exchanger 26.

[0026] The first heat exchanger 26 is adapted to bring the heat-transporting medium in indirect contact with the hot exhaust gases. The heat-transporting medium is for example a liquid, in particular water, ammonia, brine or a combination thereof.

[0027] The air-conditioning system 12 comprises an absorption refrigeration machine 32 and a second heat exchanger 34. The air-conditioning system 12 is adapted for conditioning air inside the transport vehicle 2, for example the air-stream of a ventilation system of a passenger compartment. The air-conditioning system 12 has at least one cooling mode in which the air-conditioning system 12 is cooling the air inside the transport vehicle 2, and a non-cooling mode in which the air-conditioning system 12 is not cooling the air inside the transport vehicle 2. The air-conditioning system 12 is electrically connected to the post-injection controller 13. The post-injection controller 13 will be described later.

[0028] The air-conditioning system 12 can emit a cooling mode signal to the post-injection controller 13 indicating a mode of cooling or can emit a non-cooling mode signal indicating a mode of not cooling. The absorption refrigeration machine 32 is thermally connected to the exhaust line 8, in particular to the first heat exchanger 26 arranged in the exhaust line 8, and to the second heat exchanger 34 adapted for cooling for example the air inside the transport vehicle 2. The absorption refrigeration machine 32 is adapted to use heat from the hot ex-

haust gases for cooling the air inside the transport vehicle 2.

[0029] In particular, the absorption refrigeration machine 32 is thermally connected to the input 28 and output 30 of the first heat exchanger 26 in order to extract heat from the first heat exchanger 26.

[0030] The absorption refrigeration machine 32 is thermally connected to the second heat exchanger 34 in order to extract heat from the second heat exchanger 34.

[0031] The second heat exchanger 34 is adapted to receive an air-stream of the ventilation system of a passenger compartment. The air-stream is preferably a hot air-stream which is cooled via the second heat exchanger 34. This cooled air-stream is adapted for cooling a passenger compartment of the transport vehicle 2.

[0032] The absorption refrigeration machine 32 is for example installed on a roof of the transport vehicle 2 or below the car body shell. This allows reducing occupied space inside the transport vehicle 2.

[0033] The post-injection controller 13 is electrically connected to the heat measuring device 10 in order to receive a heat signal. The heat signal indicates the temperature of the hot exhaust gases.

[0034] The post-injection controller 13 is advantageously electrically connected to the air-conditioning system 12 in order to receive the cooling mode signal indicating a cooling mode of the air-conditioning system 12.

[0035] The post-injection controller 13 is adapted for controlling the fuel injection system 6 in order to inject fuel into the diesel motor 4.

[0036] The post-injection controller 13 is adapted for controlling a post-injection of fuel into the diesel motor 4.

[0037] The post-injection controller 13 is adapted for evaluating the heat signal and advantageously the cooling mode signal in order to control the fuel injection system 6.

[0038] The post-injection controller 13 is adapted for starting a post-injection via the fuel injection system 6 if the heat signal is lower than a predetermined threshold and advantageously if the cooling mode signal indicates that the air-conditioning system 12 is in a cooling mode.

[0039] The predetermined threshold indicates a minimum temperature of the hot exhaust gases in order to sufficiently supply heat to the absorption refrigeration machine 32 via the first heat exchanger 26.

[0040] The predetermined threshold is comprised between 120°C and 280°C, in particular the threshold is about 252 °C.

[0041] The post-injection comprises at least one first fuel post-injection LI1 at the end of the combustion phase of the diesel motor 4 (see figure 2).

[0042] The post-injection of the first fuel post-injection LI1 starts at the end of a first time interval TI1 defined by a crank angle sweep of the internal combustion engine 4 comprised between 1° and 5° crank angle sweep at the end of the main fuel injection MI. In other words, the engine fuel post-injection controller 13 is adapted to control said fuel injection system 6 to start the post injection

of the first fuel post-injection LI1 at the end of a first time interval TI1 which is defined by a crank angle coverage or sweep of the internal combustion engine 4 comprised between 1° and 5°.

[0043] The operation of the air-conditioning system and the post-injection controller 13 is described now.

[0044] The post-injection controller 13 receives a heat signal from the heat measuring device 10.

[0045] Then, the post-injection controller 13 analyses the received heat signal and compares the received heat signal with the predetermined threshold.

[0046] If the received heat signal is smaller than the predetermined threshold, and advantageously if concurrently the post-injection controller 13 receives a cooling mode signal from the air-conditioning system 12, the post-injection controller 13 post-injects the first post-injection LI1 into the diesel motor 4.

[0047] The first post-injection LI1 is done for each combustion phase if the received heat signal is smaller than the predetermined threshold, and advantageously if concurrently the post-injection controller 13 receives a cooling mode signal.

[0048] The first post-injection LI1 is initiated at the end of the first time interval TI1 after the end of the main injection MI. Thanks to the inventive post-injection of the fuel, it becomes possible to use an absorption refrigeration machine for cooling the interior of a railway vehicle. So far, train air-conditioning systems have always used compressors for cooling to guarantee cooling in all operating states of the train. However, these compressors consume electricity. By replacing the compressor with an absorption refrigerator, the waste heat of the diesel motor, which is generated in any case, is used for cooling. Hence, it's no longer necessary to generate extra energy for the air-conditioning. The inventive air-conditioning solution thus reduces the energy consumption of the railway vehicle.

[0049] In an alternative embodiment, the post injection may comprise two separate subsequent post-injections, wherein the first post-injection LI1 and a subsequent late post-injection LI2 are temporally separated by a second time interval TI2.

[0050] The second time interval TI2 is comprised between 90° to 180° crank angle. That is, the time interval TI2 between said two subsequent post-injections LI1 and LI2, or between the peaks of these post-injections, is a period in which the crank angle of the internal combustion engine 4 covers or sweeps an angle comprised between 90° to 180°.

[0051] Two separate subsequent post-injections allow increasing the exhaust gas temperature faster than with only one post-injection. In an alternative embodiment, the heat measuring device 10 is arranged in the heat exchanger 26.

[0052] It should be noted that the invention is not limited to the above embodiments.

Claims

1. A transport vehicle (2), in particular a railway vehicle for passenger transport, comprising:

an air-conditioning system (12) for conditioning the air inside the transport vehicle, said air-conditioning system having an absorption refrigeration machine (32) for cooling the air inside the transport vehicle;
an internal combustion engine (4) for propelling the transport vehicle, said internal combustion engine being equipped with a fuel injection system (6);
an exhaust line (8) connected to the internal combustion engine for discharging hot exhaust gases from the internal combustion engine;
wherein the absorption refrigeration machine (32) is thermally connected to said exhaust line in order to use the heat of said hot exhaust gases for said cooling; and
a heat measuring device (10) for measuring the amount of heat in the exhaust gases;

characterised by an engine fuel post-injection controller (13) for controlling the post-injection of fuel into said engine (4), said engine fuel post-injection controller being adapted to:

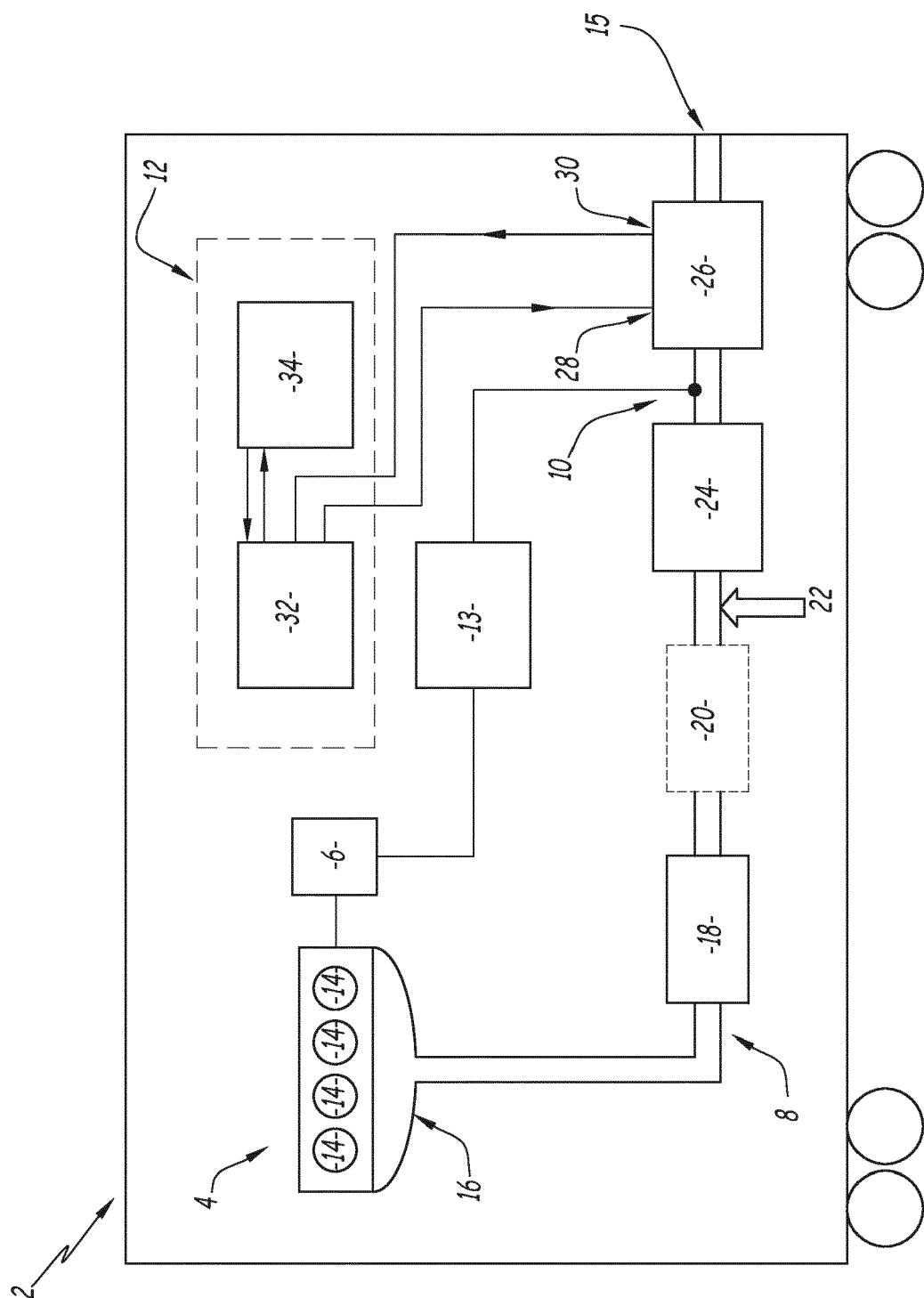
- receive a heat signal from said heat measuring device (10);
- if the heat signal is below a predetermined threshold, which indicates that the heat from the exhaust gases is insufficient for the cooling needs of the absorption refrigeration machine (32), control said fuel injection system (6) to post-inject an additional amount of fuel into the internal combustion engine (4), i.e. at the end of a combustion phase, thus increasing the heat from the exhaust gases above said predetermined threshold.

2. The transport vehicle of claim 1, wherein the engine fuel post-injection controller (13) is adapted to:

- receive a cooling mode signal from the air-conditioning system (12) indicating that the same is in a cooling mode;
- if the heat signal is below a predetermined threshold, which indicates that the heat from the exhaust gases is insufficient for the cooling needs of the absorption refrigeration machine (32), and if concurrently there is a cooling mode signal received from the air-conditioning system (12), control said fuel injection system (6) to post-inject the additional amount of fuel into the internal combustion engine (4), i.e. at the end of its combustion phase, thus increasing the heat

from the exhaust gases above said predetermined threshold.

3. The transport vehicle of claim 1 or 2, wherein the engine fuel post-injection controller (13) is adapted to control said fuel injection system (6) to perform two subsequent post-injections (LI1, LI2). 5
4. The transport vehicle of claim 3, wherein the engine fuel post-injection controller (13) is adapted to control said fuel injection system (6) to start the post injection of the first fuel post-injection (LI1) at the end of a first time interval (TI1) which is defined by a crank angle sweep of the internal combustion engine (4) comprised between 1° and 5°. 10 15
5. The transport vehicle of claim 3 or 4, wherein the time interval (TI2) between said two subsequent post-injections (LI1, LI2) is a period in which the crank angle of the internal combustion engine (4) covers an angle comprised between 90° to 180°. 20
6. The transport vehicle of any one of the previous claims, wherein the heat measuring device (10) is a temperature sensor located in the exhaust line (8). 25
7. The transport vehicle of any one of the previous claims, wherein the predetermined threshold is 252 °C. 30
8. The transport vehicle of any one of the previous claims, wherein the absorption refrigeration machine (32) is installed on the roof or below the car body of the transport vehicle (2). 35
9. The transport vehicle of any one of the previous claims, wherein the internal combustion engine (4) is a diesel motor.
10. The transport vehicle of any one of the previous claims, wherein the transport vehicle (2) is a railway vehicle in the form of a diesel multiple unit for regional passenger transport. 40 45 50 55



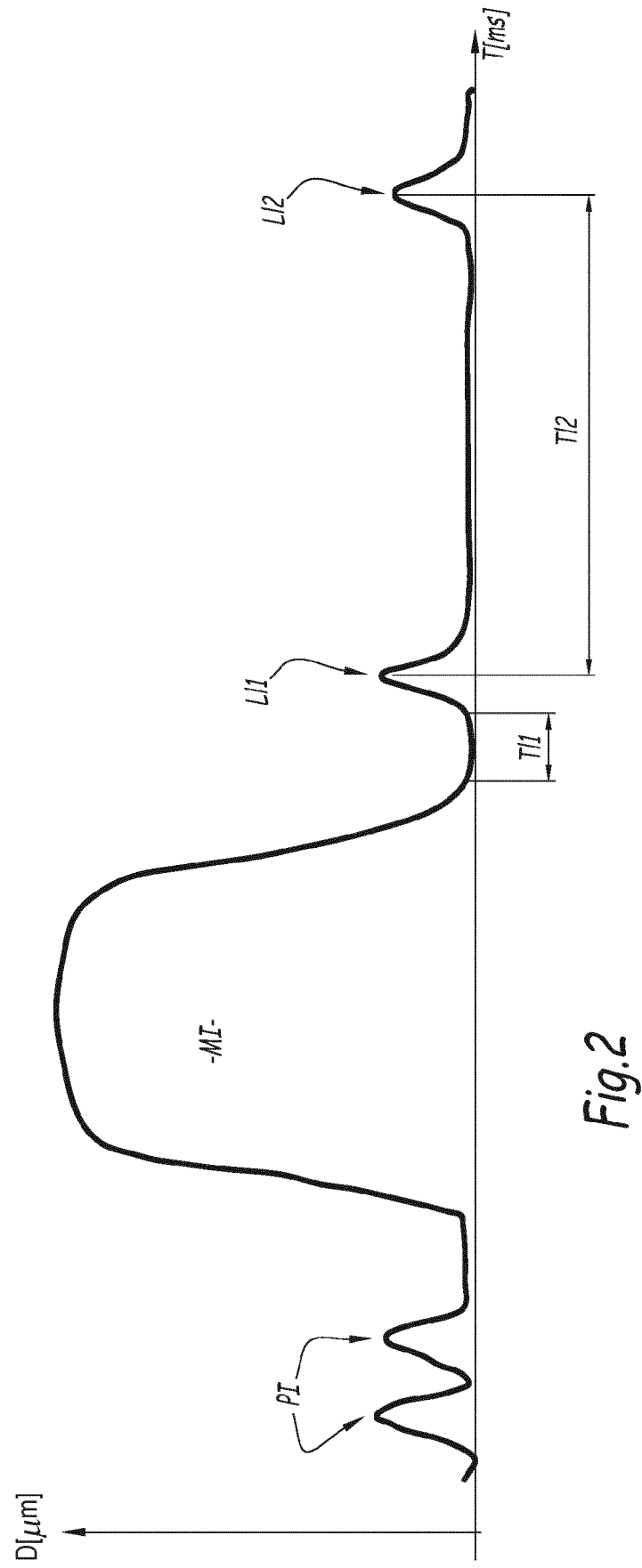


Fig.2



EUROPEAN SEARCH REPORT

Application Number
EP 18 30 5900

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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			TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 18 January 2019	Examiner Awad, Philippe
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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