(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
26 October 2017 (26.10.2017)

(10) International Publication Number
WO 2017/182924 A1

(51) International Patent Classification:
B60H 1/00 (2006.01)

(21) International Application Number:
PCT/IB2017/052155

(22) International Filing Date:
13 April 2017 (13.04.2017)

(25) Filing Language: Polish

(26) Publication Language: English

(30) Priority Data:
PL416882 18 April 2016 (18.04.2016) PL

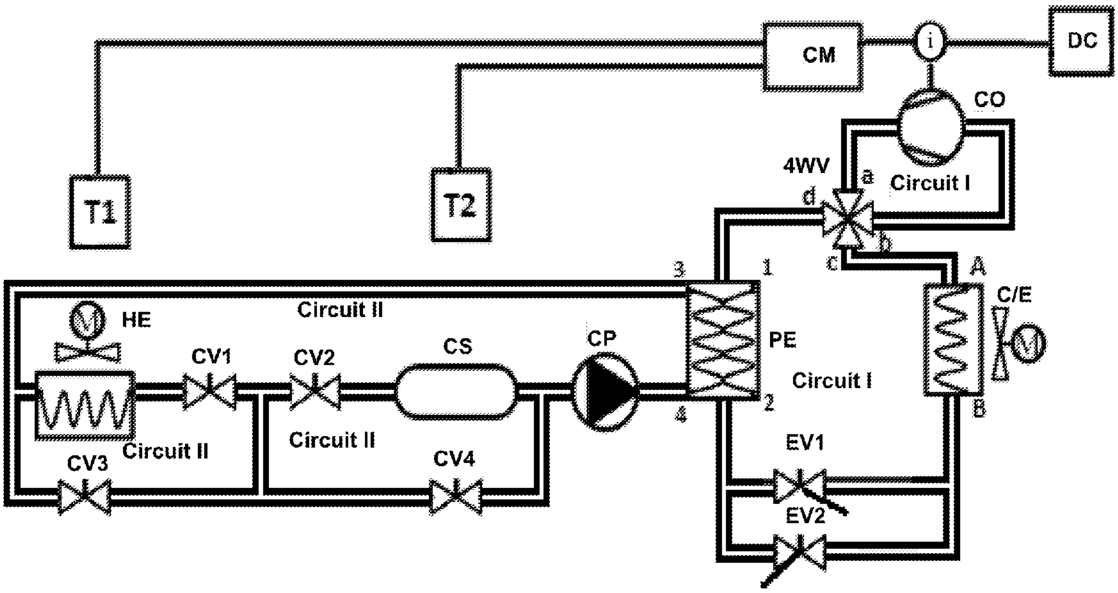
(71) Applicant: **POLITECHNIKA LUBELSKA** [PL/PL]; Nadbystrzycka 38D, 20-618 Lublin (PL).

(72) Inventors: **ZIELINSKI, Dariusz**; Nowogrod 63, 21-010 Leczna (PL). **JARZYNA, Wojciech**; Biskupinska 102, 20-830 Lublin (PL). **KOLANO, Krzysztof**; Paganiniego 4/213, 20-854 Lublin (PL).

(74) Agent: **TAGOWSKA, Magdalena**; Patpol Kancelaria Patentowa Sp. z o.o., Nowoursynowska 162J, 02-776 Warszawa (PL).

(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.

(54) Title: A METHOD AND SYSTEM FOR STORING HEAT OR COLD IN VEHICLES WITH ELECTRIC PROPULSION



(57) Abstract: The invention provides a system, in which the temperature measurement modules (T1 and T2) are connected to the inverter (i) via the control module (CM), and the direct current buses (DC) are connected to the inverter (i). On the other hand, the inverter (i) is connected to the compressor (CO), which is connected via two lines to the connector (a) and (b) of the four-way valve (4WV). Also, the four-way valve (4WV) is connected to the connector (c) with the condenser-evaporator (C/E), which is connected in parallel to two expansion valves (EV1 and EV2). On the other hand, the expansion valves are connected in an inverse-parallel configuration to each other. Also, the expansion valves (EV1 and EV2) are connected to the connector (2) of the plate exchanger (PE), wherein the plate exchanger (PE) is connected via the connector (1) to the connector (d) of the four-way valve (4WV). On the other hand, the connector (3) of the plate exchanger (PE) is connected to the heat exchanger (HE) and to the controlled valve (CV3). Also, the heat exchanger (HE) is connected via the controlled valve (CV1) and the controlled valve (CV2) to the heat and cold storage unit (CS), which is connected to the circulation pump (CP). On the other hand, the circulation pump (CP) is connected to the connector (4) of the plate exchanger (PE). And the controlled valve (CV3) is connected between the controlled valve (CV1) and the controlled

WO 2017/182924 A1

[Continued on next page]

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

Published:

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

valve (CV2), whereas the controlled valve (CV3) is connected via the controlled valve (CV4) in-between the heat and cold storage unit (CS) and the circulation pump (CP).

A method and system for storing heat or cold in vehicles with electric propulsion

FIELD OF THE INVENTION

The object of the invention is a method and system for storing heat or cold in vehicles with electric propulsion.

STATE OF THE ART

Cold accumulators using fluids freezing in low temperatures are widely used in refrigeration technology to compensate for extreme heat loads and save the consumption of electric energy by a refrigerating device described by the authors Recknagel H. Sprenger E. Hönmann W. Schramek E.R. Ogrzewanie i klimatyzacja, Poradnik, Gdańsk, 1994, p. 1814.

Small commercial refrigerator trucks with a thermally insulated chamber and thermoelectric refrigeration unit are known and described by the author - S.Filin, Jutrzejszy dzień termoelektryczności, Technika Chłodnicza i Klimatyzacyjna, no. 11, 2004, and Холодильный бизнес, no. 7. 2002, pp. 13-14. Their shortcoming is low refrigeration capacity, which is usually limited by the capabilities of the electric power supply - an alternator driven by an internal combustion engine, which is in turn related to limited space for installing a higher power alternator in a car.

There are known freezer trucks with a chamber cooled by the means of eutectic plates, filled with a liquid with a low freezing point, described by authors - S. Kwaśniowski, J. Grajnert, Dynamika wymiany ciepła w nadwoziu samochodu lodowni, Chłodnictwo no. 7, 1998, pp. 29-30. The plates are frozen during night by connecting a refrigeration system to an external refrigeration unit. Their shortcoming is the necessity to use an external unit and the losses of the agent into the atmosphere during connection and disconnection.

In known thermoelectric refrigeration units with an ice-water type accumulator - Sergiy Filin, Termoelektryczne urządzenia chłodnicze, Gdańsk, 2002, fig. 9.11c and 9.15, accumulation is used in order to stabilise the temperature of hot module welds. The low working efficiency of the accumulators both in the charging and the discharging mode is associated with the necessity to overcome heat resistances created by a thick ice layer, since freezing the layer takes place at one side of the accumulator, while ice melting - at the other side. Considering the lack of the supply of refrigerating capacity in most thermoelectric units, the accumulation of cold on the cold side of the unit is usually not used.

There are also known such technical solutions as: Thermoelectric refrigeration units with an ice-water type accumulator described in patent document PL 209274 B1. Technical solutions of this type are proposed by a heat exchanger in the form of a finned plate on the hot side and radiators with fans on the cold side. The cold accumulator has been realised as a finned plate with hollowed fins. Hermetically sealed internal spaces of the fins are filled with water. From the side of the base, the accumulator is thermally insulated by a layer of insulation. The spatial shape of the accumulator fins reflects the shape of radiator channels. Due to the ability to rotate around the shaft axis, the accumulator may be set on two working positions: Ł - charging, and R - discharging. Cooling the interior of the chamber may take place by the means of: only the unit itself, by the means of only the inserts or jointly by the unit and the inserts. Before use, the cold storage unit must be frozen during stoppage, while night rate is in effect. An additional disadvantage is the problem of freezing the radiators, which sometimes makes it impossible to switch from the charging mode to the discharge of the storage tank.

There are known technical solutions from patents SU 1096465, SU 1195152 and SU 1196627, combined compressor-thermoelectric refrigeration systems with an interstage cold accumulator, in which melting ice is used. Their drawback is the necessity to transfer the stream of heat from the thermoelectric modules towards the evaporator wall through a layer of ice creating considerable thermal resistance. As a result, the effectiveness of the cold accumulator is decreased and the use of electric energy necessary for the supercooling of ice increases.

From patent SU 1196627 there is a known refrigeration system with an interstage cold accumulator, which comprises a thermoelectric module of the low temperature stage, installed on the wall of the accumulator container, filled with water. Water is refrigerated by the means of the evaporator of the refrigerating device - high temperature stage placed inside the container. Ice is created on the evaporator and fills the space between the evaporator and the wall on which the thermoelectric module is located. The freezing of ice proceeds from the bottom, and its melting - from the top, as a result of which the ice layer is always placed in the way of the heat stream between the low and high temperature stages. Another drawback of this solution is the heating of water in the near-wall layer above 0℃ with an increased heat load. Equalising the temperature of water and melting ice is possible only when using a stirrer. However, such a solution results in complexity of construction, an increase in the volume and mass of the accumulator, which is unacceptable in the case of mobile systems.

There is also known a technical solution of a thermoelectric refrigerator car presented in patent description PL 209274. It comprises a thermally insulated refrigeration chamber, a thermoelectric unit placed in its cover, powered from the electrical network of the vehicle and the so-called inserts, i.e. cold storage tanks having the form of flat containers, filled with fluid freezing at a low temperature, inserted into the chamber. Cooling the interior of the chamber may take place by the means of the unit only, by the means of the inserts only or jointly. The inserts must be frozen before use in a home freezer or by the means of another freezing device.

The purpose of the invention is to provide improvement of the passenger's heating comfort in vehicles with electric propulsion by using the system for storing heat or cold. The solution is intended to extend the total range of vehicles with electric propulsion and gain financial profits by the recovery of energy during braking and maintaining a set speed when driving downhill. Another purpose is to limit the operating costs by replacing expensive and faulty unreliable chemical sources with a cheap and simple solution in the form of a heat and cold storage unit. The invention can partially replace electrochemical accumulators, which can result in extending the designed operating time. The invention is based on completely biodegradable components, which can have an advantageous impact on the natural environment.

DISCLOSURE OF THE INVENTION

According to the invention, the essence of the system for storing heat or cold in vehicles with electric propulsion, having: temperature measurement modules, a control module, a heat exchanger, a condenser-evaporator, a plate exchanger, a compressor, a circulation pump, controlled valves, expansion valves, a four-way valve, is that the first and second temperature measurement modules are connected to the inverter via a control module. There are direct current buses connected to the inverter. On the other hand, the inverter is connected to the compressor, which is connected via two lines to the first and second connector of the four-way valve. The four-way valve is connected to the third connector with the condenser-evaporator, which is connected in parallel to the two expansion valves. The expansion valves are connected in an inverse-parallel configuration to each other. Also, the expansion valves are connected to the second connector of the plate exchanger. The plate exchanger is connected via the first connector to the fourth connector of the four-way valve. The third connector of the plate exchanger is connected to the heat exchanger and to the third controlled valve, while the heat exchanger is connected via the first and second controlled valves to the heat and cold storage unit. Also, the heat and cold storage unit is connected to the circulation pump, while the circulation pump is connected to the fourth connector of the plate exchanger. Also, the third controlled valve is connected between the first and second controlled valves and the third controlled valve is connected via the fourth controlled valve in-between the heat and cold storage unit and the circulation pump.

The essence of the method according to the invention for storing heat or cold in vehicles with electric propulsion using heat exchange agents (further also described as agent or agents) is that a set temperature value is established in the air-conditioned zone of the vehicle and this value is measured by the means of the first temperature measurement module and at the same time, this information is transmitted to the control module. Simultaneously, the temperature inside the heat and cold storage unit is measured by the means of the second temperature measurement module and this information is transmitted to the control module. Furthermore, voltage on the direct current buses is measured and the measured signal is transmitted to the control module, which controls the rotating speed of the compressor and the degree of opening of the first and second expansion valves. The rotational speed of the compressor is changed by the means of the inverter and the agent in the first circuit is compressed. When the temperature in the air-conditioned zone of the vehicle is lower than the set value and the system works in the heating mode, the agent in the first circuit compresses by the means of the compressor, and the four-way valve is repositioned by the means of the control module, so that the compressed vapours of the agent of the first circuit are directed into the connector of the first plate exchanger. In this exchanger the agent of the first circuit condenses, due to which the heat is released, after which the condensed agent of the first circuit flows out via the second connector and is directed to the first expansion valve. In this valve the agent of the first circuit decompresses and is directed into the second connector of the condenser-evaporator, in which the agent of the first circuit vaporises and the heat from the surroundings is received. Subsequently, the resulting vapours of the agent of the first circuit are directed via the second and third connector of the four-way valve into the compressor. In turn, by the means of the agent in the second circuit, the heat which was generated in the first circuit is received and the agent is pumped via the circulation pump into the fourth connector of the plate exchanger, while the agent of the second circuit is heated in the plate exchanger and is directed into the heat exchanger and the third controlled valve. In the case when the system works in the heating mode and the temperature measured in the air-conditioned space of the vehicle by the means of the first temperature measurement module is lower than 5℃ compared to the set temperature and the temperature measured in the heat and cold storage unit by the means of the second temperature measurement module is positive in the Celsius scale, then the third and fourth controlled valves close and the first and second controlled valves open. In this configuration, the agent of the second circuit is pumped by the means of the circulation pump from the heat exchanger through the heat and cold storage unit into the fourth connector of the plate exchanger. In the case when the system works in the heating mode and the temperature measured in the air-conditioned space of the vehicle by the means of the first temperature measurement module is lower than 3℃ compared to the set temperature and the temperature measured in the heat and cold storage unit by the means of the second temperature measurement module is negative and not lower than -5℃, then the third and fourth controlled valves close and the first and second controlled valves open. The agent of the second circuit is pumped by the means of the circulation pump from the heat exchanger through the heat and cold storage unit into the fourth connector of the plate exchanger. In the case when the system works in the heating mode and the temperature measured in the air-conditioned space of the vehicle by the means of the first temperature measurement module is lower than 10℃ compared to the set temperature and the temperature measured in the heat and cold storage unit by the means of the second temperature measurement module is negative in the Celsius scale, then the second and third controlled valves close and the first and fourth controlled valves open. Then the agent of the second circuit is pumped by the means of the circulation pump from the heat exchanger via the controlled valve into the fourth connector of the plate exchanger. In the case when the system works in the heating mode and the temperature measured in the air-conditioned space of the vehicle by the means of the first temperature measurement module is close to the set temperature by ±3℃ and the voltage measured on the direct current buses is higher than the rated voltage determined by the producer of the vehicle, then the first and fourth controlled valves close and the second and third controlled valves open. Then the agent of the second circuit is pumped by the means of the circulation pump via the third and fourth controlled valves into the fourth connector of the plate exchanger. In the case when the system works in the heating mode and the temperature measured in the air-conditioned space of the vehicle by the means of the first temperature measurement module is close to the set temperature by ±3℃ and the voltage measured on the direct current buses is close to the rated voltage, with a tolerance determined by the producer of the vehicle, the compressor and the circulation pump are disabled. When the temperature in the air-conditioned zone of the vehicle is higher than the set value and the system works in the refrigeration mode, the agent in the first circuit is compressed by the means of the compressor. On the other hand, the four-way valve is repositioned by the means of the control module so that the compressed agent of the first circuit is directed into the condenser-evaporator, in which the heat is received and the agent of the first circuit is condensed, and afterwards the condensed agent of the first circuit flows out through the second connector of the condenser-evaporator and is directed into the expansion valve in which expansion takes place. The decompressed agent of the first circuit is directed into the second connector of the plate exchanger, in which the process of evaporating and receiving heat from the plate exchanger takes place. The heat is received from the agent of the second circuit in the process of evaporation, which agent of the second circuit is pumped in by the circulation pump to the fourth connector of the plate exchanger. Subsequently, the refrigerated agent of the second circuit flows out through the third connector of the plate exchanger and is directed into the first connector of the heat exchanger and the third controlled valve. In the case when the system works in the refrigeration mode and the temperature measured in the air-conditioned space of the vehicle by the means of the first temperature measurement module is higher than 5℃ compared to the setting, and the temperature measured in the heat and cold storage unit by the means of the second temperature measurement module is negative in the Celsius scale, then the third and fourth controlled valves close and the first and second controlled valves open. The agent of the second circuit is pumped by the means of the circulation pump from the heat exchanger through the heat and cold storage unit into the fourth connector of the plate exchanger. In the case when the system works in the refrigeration mode and the temperature measured in the air-conditioned space of the vehicle by the means of the first temperature measurement module is higher than 3℃ compared to the set temperature and the temperature measured in the heat and cold storage unit by the means of the second temperature measurement module is positive in the Celsius scale and not higher than 5℃, then the third and fourth controlled valves close, and the first and second controlled valves open. The agent of the second circuit is pumped by the means of the circulation pump from the heat exchanger through the heat and cold storage unit into the fourth connector of the plate exchanger. In the case when the system works in the refrigeration mode and the temperature measured in the air-conditioned space of the vehicle by the means of the first temperature measurement module is higher than 10℃ and the temperature measured in the heat and cold storage unit by the means of the second temperature measurement module is positive in the Celsius scale, the second and third controlled valves close and the first and fourth controlled valves open, and the agent of the second circuit is pumped by the means of the circulation pump from the heat exchanger via the fourth controlled valve into the connector of the plate exchanger. In the case when the system works in the refrigeration mode and the temperature measured in the air-conditioned space of the vehicle by the means of the first temperature measurement module is close to the set temperature by ±3℃ and the voltage measured on the direct current buses is higher than the rated voltage determined by the producer of the vehicle, then the first and fourth controlled valves close and the second and third controlled valves open. The agent of the second circuit is pumped by the means of the circulation pump through the heat and cold storage unit into the fourth connector of the plate exchanger. In the case when the system works in the refrigeration mode and the temperature measured in the air-conditioned space of the vehicle by the means of the first temperature measurement module is close to the set temperature by ±3℃ and the voltage measured on the direct current buses is close to the rated voltage determined by the producer of the vehicle, the compressor and the circulation pump are disabled.

A preferred effect of the invention is that using the method and system for storing heat or cold in vehicles with electric propulsion extends the life of electrochemical accumulators which are used in electric vehicles. In traditional solutions with electric propulsion the energy is lost in braking resistors. The system according to the invention receives the braking energy, converts the received energy into a stream of heat or cold and stores the converted energy in a heat or cold storage tank. Subsequently, the accumulated energy is used in the process of air-conditioning the interior of the cabin of the vehicle, which thus translates into extending the range of electric vehicles and decreases the operating costs. Furthermore, via proper management of the system it is possible to limit current surges during start-ups of air conditioning, which advantageously affects the stabilisation of voltage in the traction system. The additional possibility of charging the storage tank during the night rate positively affects the load of the electric power system. Replacing the electrochemical sources of electric energy with the proposed technical solution will extend the operating time of the source from 10 to 30 years, which will exceed the predicted operating time of an electric vehicle. On the other hand, minimising the number of chemical accumulators will affect the increase in the operational safety of electric vehicles.

The invention has been presented as an example of an embodiment on a schematic drawing.

The system for storing heat or cold in vehicles with electric propulsion having: temperature measurement modules T1 and T2 - PT100 sensors, a control module CM - PLC Simens S7200 controller, a heat exchanger HE - plate, soldered, with a capacity of 20kW, a condenser-evaporator C/E with a capacity of 20kW, a plate exchanger PE soldered, with a capacity of 20kW, a compressor CO of spiral type, with an electric power of 8kW, a circulation pump CP with an electric power of 100W, controlled valves CV1-CV4, expansion valves EV1 and EV2, controlled electronically, and a four-way valve 4WV. The temperature measurement module T1 and the temperature measurement module T2 are connected to the inverter i via the control module CM and the direct current buses DC are connected to the inverter i. On the other hand, the inverter i is connected to the compressor CO, which is connected via two lines to the connectors a and b of the four-way valve 4WV. The four-way valve 4WV is connected to the connector c with the condenser-evaporator C/E, which is connected in parallel to the first expansion valve EV1 and the second expansion valve EV2. The first and second expansion valves EV1 and EV2 are connected in an inverse-parallel configuration to each other, them being connected to the connector 2 of the plate exchanger PE, which is connected via the connector 1 to the connector d of the four-way valve 4WV. The connector 3 of the plate exchanger PE is connected to the heat exchanger HE and to the third controlled valve CV3. The heat exchanger HE is connected via the first controlled valve CV1 and the second controlled valve CV2 to the heat and cold storage unit CS, which is connected to the circulation pump CP. The circulation pump CP is connected to the connector 4 of the plate exchanger PE. The third controlled valve CV3 is connected between the first controlled valve CV1 and the second controlled valve CV2 and the third controlled valve CV3 is connected via the fourth controlled valve CV4 in-between the heat and cold storage unit CS and the circulation pump CP.

The system for storing heat or cold in a trolleybus, in an exemplary embodiment, consists of the temperature measurement module T1 PT100 and the temperature measurement module T2 PT100 connected to a three-phase inverter i with a power of 12kW via the control module CM of the controller CS and the direct current buses DC are connected to the inverter i. The inverter i is connected to a spiral compressor CO with a power of 8kW, which is connected via two lines in the form of copper pipes to the connectors a and b of the four-way valve 4WV. The four-way valve 4WV is connected via the connector c in the form of copper pipes to the condenser-evaporator C/E, which is connected in parallel to the first expansion valve EV1 and the second expansion valve EV2. The expansion valves are controlled electronically by the means of a PLC controller. The expansion valves EV1 and EV2 are connected inverse-parallel to each other. The first and second expansion valves EV1 and EV2 are connected to the connector 2 of a laminated copper plate exchanger PE. The plate exchanger PE is connected via the connector 1 to the connector d of the four-way valve 4WV, and the connector 3 of the plate exchanger PE is connected to the heat exchanger HE installed in the passenger's cabin, having an assembly for the forced circulation of air, and to the third controlled valve CV3 with an electromagnetic coil. The heat exchanger HE is connected via the first controlled valve CV1 and the second controlled valve CV2, having electromagnetic coils, to the heat and cold storage unit CS. The heat and cold storage unit has been constructed in the form of a thermally insulated container, inside which there are 170 elements accumulating the energy of heat or cold in the form of cylindrical vessels with a volume of 1 l made of polyethylene with an elevated density, filled with water. The vessels were filed with water to a level of 90% and stacked. The heat and cold storage unit CS is connected to the circulation pump CP with a power of 100 W. The circulation pump CP is connected via hydraulic piping to the connector 4 of the plate exchanger PE. The third controlled valve CV3 is connected between the first controlled valve CV1 and the second controlled valve CV2. The third controlled valve CV3 is connected via the fourth controlled valve CV4 in-between the heat and cold storage unit CS and the circulation pump CP.

The storage of heat in a trolleybus proceeded in such a method that: the set temperature value of 20˚C was established in the air-conditioned zone of the vehicle and this value was measured by the means of the first temperature measurement module T1 in the form of a PT100 type sensor. At the same time, the temperature inside the heat and cold storage unit CS in the form of a thermally insulated container, inside which there are 170 containers with a volume of 1 l made of polyethylene with an elevated density, filled with water to a level of 90% and stacked, was measured by the means of the second module T2 in the form of a PT100 sensor. The measured temperature values were transmitted to the control module CM in the form of a PLC controller. At the same time, the voltage on the direct current buses DC was measured by the means of an LV-25P measurement transducer and the measured signal was transmitted to the control module CM, which controls the rotating speed of the compressor CO with an electric power of 8 kW and the degree of opening of the expansion valves EV1 and EV2, controlled electronically by the means of stepper motors. The rotating speed of the compressor CO was adjusted by the means of the inverter i with an electric power of 12kW. The agent in circuit I, which is the refrigerating agent R507, was compressed by the means of the compressor CO. When the temperature in the air-conditioned zone of the vehicle dropped below the set value of 20˚C during work in the heating mode, the agent in circuit I was compressed by the means of the compressor CO and by the means of the control module CM the four-way valve 4WV was repositioned, so that the compressed vapours of the agent of circuit I were directed into the plate exchanger PE, in which the agent of circuit I condensed, due to which the heat was released. Subsequently, the condensed agent of circuit I was directed into the expansion valve EV1. In the expansion valve EV1, the agent decompressed and the decompressed agent of circuit I was directed into the condenser-evaporator C/E, in which it was evaporated and the heat was received from the surroundings. Subsequently, the gas vapours were directed via the four-way valve 4WV into the compressor CO. By the means of the agent in circuit II in the form of polypropylene glycol with a concentration of 37%, the heat which was obtained in circuit I was received, and the agent was pumped via the circulation pump CP with a power of 100W to the plate exchanger PE. The agent of circuit II was heated in the plate exchanger PE and it was directed into the heat exchanger HE and into the controlled valve CV3. In the case when the system worked in the heating mode and the temperature measured in the air-conditioned space of the vehicle by the means of the temperature measurement module T1 was lower by 5℃ than the set temperature of 20℃ and the temperature measured in the heat and cold storage unit CS by the means of the temperature measurement module T2 was positive in the Celsius scale, then the controlled valves CV3 and CV4 were closed and the controlled valves CV1 and CV2 were opened, through which the agent of circuit II was pumped from the heat exchanger HE through the heat and cold storage unit CS into the plate exchanger PE by the means of the circulation pump CP. Such an operating method resulted in simultaneous heating of the air-conditioned space and charging the heat and cold storage unit CS, which was built from the insulating chamber in which there are 170 cylindrical containers made of high density polyethylene with a volume of 1 litre. The containers were filed with water to a level of 90% and stacked.

In the second variant of carrying out the embodiment of heating, the agent in circuit II was an alcoholic solution with an ethyl alcohol content of 96%. In this variant the heat and cold storage unit CS is constructed of a thermally insulated container filled with elements accumulating the energy of heat or cold in the form of spherically shaped vessels made of copper, filled with animal fat in a volume of 90%.

In the third variant of carrying out the embodiment of heating, the agent in circuit II was a solution of water and salt with a 10% NaCl content. In this variant the heat and cold storage unit CS is constructed of a thermally insulated container filled with elements accumulating the energy of heat or cold in the form of spherically shaped vessels made of aluminium, filled with water.

The storage of cold in a trolleybus proceeded in such a method that: when in the air-conditioned zone of the vehicle the temperature exceeded the set value of 20℃ and the system worked in the refrigeration mode, then by the means of the compressor CO the agent in circuit I was compressed, and by the means of the control module CM the four-way valve 4WV was repositioned so that the compressed agent of circuit I was directed into the condenser-evaporator C/E, in which the heat was received and the agent of circuit I condensed. The condensed agent of circuit I was directed into the expansion valve EV2, in which expansion took place. Subsequently, the decompressed agent of circuit I was directed into the plate exchanger PE, in which evaporation and receiving heat from the plate exchanger PE took place. The heat was received from the agent of circuit II, which agent of circuit II was pumped by the circulation pump CP into the plate exchanger PE and subsequently the refrigerated agent of circuit II flowed out from the plate exchanger PE and was directed into the heat exchanger HE and the third controlled valve CV3. During work in the refrigeration mode when the temperature measured in the air-conditioned space of the vehicle by the means of the first temperature measurement module T1 increased by 5℃ compared to the set temperature of 20℃, and the temperature measured in heat and cold storage unit CS by the means of the second temperature measurement module T2 was below zero Celsius, the controlled valves CV3 and CV4 were closed and the first and second controlled valves CV1 and CV2 were opened and by the means of the circulation pump CP the agent of circuit II was pumped from the heat exchanger HE through the heat and cold storage unit CS into the plate exchanger PE. Such an operating method resulted in the simultaneous refrigeration of the air-conditioned space of the vehicle by the air-conditioning system and the storage of cold in the heat and cold storage unit CS.

In the second variant of carrying out the embodiment of refrigerating, the agent in circuit II was an alcoholic solution with an ethyl alcohol content of 96%. In this variant the heat and cold storage unit CS is constructed of a thermally insulated container filled with elements accumulating the energy of heat or cold in the form of spherically shaped vessels made of copper, filled with animal fat in a volume of 90%.

In the third variant of carrying out the embodiment of refrigerating, the agent in circuit II was a solution of water and salt with a 10% NaCl content. In this variant the heat and cold storage unit CS is constructed of a thermally insulated container filled with elements accumulating the energy of heat or cold in the form of spherically shaped vessels made of aluminium, filled with water.

List of references:

HE:	heat exchanger,
C/E:	condenser-evaporator (external heat exchanger),
CS:	heat and cold storage unit,
PE:	plate exchanger,
CO:	compressor,
CP:	circulation pump,
i:	inverter,
DC:	direct current buses,
CM:	control module,
T1:	first temperature measurement module,
T2:	second temperature measurement module,
EV1:	first expansion valve,
EV2:	second expansion valve,
CV1:	first controlled valve,
CV2:	second controlled valve,
CV3:	third controlled valve,
CV4:	fourth controlled valve,
4WV:	four-way valve,
1:	first connector of the plate exchanger,
2:	second connector of the plate exchanger,
3:	third connector of the plate exchanger,
4:	fourth connector of the plate exchanger,
I:	first circuit,
II:	second circuit,
A:	first connector of the condenser-evaporator,
B:	second connector of the condenser-evaporator,
a:	first connector of the four-way valve,

b: second connector of the four-way valve,

c: third connector of the four-way valve,

d: fourth connector of the four-way valve.

Patent claims

1. A system for storing heat or cold in vehicles with electric propulsion having: temperature measurement modules (T1 and T2), a control module (CM) and a heat exchanger (HE), a condenser-evaporator (C/E), a plate exchanger (PE), a compressor (CO), a circulation pump (CP), controlled valves (CV1-CV4), expansion valves (EV1 and EV2) and a four-way valve (4WV), constituting the elements of two circuits of a heat exchange agent separated by a heat exchanger, **characterised in that** the temperature measurement module (T1) and the temperature measurement module (T2) are connected to the inverter (i) via the control module (CM) and the direct current buses (DC) are connected to the inverter (i), while the inverter (i) is connected to the circuit I of the agent comprising the compressor (CO), which is connected by two lines to the connector (a) and (b) of the four-way valve (4WV), while the four-way valve (4WV) is connected via the connector (c) to the condenser-evaporator (C/E), which is connected in parallel to the first expansion valve (EV1) and the second expansion valve (EV2), which are connected inverse-parallel to each other, while the first and second expansion valves (EV1, EV2) are connected to the connector (2) of the plate exchanger (PE), which is connected via the connector (1) to the connector (d) of the four-way valve (4WV),

wherein the plate exchanger (PE) is incorporated into circuit II of the system comprising the heat exchanger (HE) and the third controlled valve (CV3) connected to it, which are connected to the plate exchanger (PE) via the connector (3), while the heat exchanger (HE) is connected via the first controlled valve (CV1) and the second controlled valve (CV2) to the heat and cold storage unit (CS), which is connected to the circulation pump (CP), while the circulation pump (CP) is connected to the connector (4) of the plate exchanger (PE), while the third controlled valve (CV3) is connected between the first controlled valve (CV1) and the second controlled valve (CV2), and the third controlled valve (CV3) is connected via the fourth controlled valve (CV4) in-between the heat and cold storage unit (CS) and the circulation pump (CP).

2. The system according to claim 1, characterised in that the agent in circuit II is an alcoholic solution.

3. The system according to claim 1, characterised in that the agent in circuit II is a solution of water and salt.

4. The system according to any of claims 1 - 3, characterised in that the heat and cold storage unit (CS) has a form of a thermally insulated container comprising elements accumulating the energy of heat or cold in a cylindrical shape.

5. The system according to any of claims 1 - 3, characterised in that the heat and cold storage unit (CS) has a form of a thermally insulated container comprising elements accumulating the energy of heat or cold in a spherical shape.

6. The system according to claim 4 or 5, characterised in that the elements accumulating the energy of heat or cold are filled with water.

7. The system according to claim 4 or 5, characterised in that the elements accumulating the energy of heat or cold are filled with fat.

8. A method for storing heat or cold in vehicles with electric propulsion in a system defined in any of claims 1 - 7, characterised in that the set value of temperature is determined in the air-conditioned zone of the vehicle and said value is measured by the means of the first temperature measurement module (T1) and simultaneously this information is transmitted to the control module (CM), at the same time the temperature inside the heat and cold storage unit (CS) is measured by the means of the second module (T2) and this information is transmitted to the control module (CM), voltage is measured on the direct current buses (DC) and the measured signal is transmitted to the control module (CM), which controls the rotating speed of the compressor (CO) and the level of opening of the first and second expansion valves (EV1, EV2), wherein by the means of the inverter (i) the rotating speed of the compressor (CO) is changed and the agent in circuit (I) is compressed, when the temperature in the air-conditioned zone of the vehicle is lower than the set value and the system works in the heating mode, by the means of the compressor (CO) the agent in circuit (I) is compressed and by the means of the control module (CM) the four-way valve (4WV) is repositioned, so that the compressed vapours of the agent in circuit (I) are directed to the connector (1) of the plate exchanger (PE), where the agent of circuit (I) is condensed, due to which the heat is released, after which the condensed agent of circuit (I) flows out through the connector (2) and is directed into the first expansion valve (EV1), in which it is decompressed, and the decompressed agent of circuit (I) is directed to the connector (B) of the condenser-evaporator (C/E), in which the agent is vaporised and the heat is received from the surroundings, subsequently gas vapours are directed from the

connector (A) via the connectors (c) and (b) of the four-way valve (4WV) into the compressor (CO), while by the means of the agent in circuit (II), the heat which has been obtained in circuit (I) is received and pumped via the circulation pump (CP) into the connector (4) of the plate exchanger (PE), while the agent of circuit (II) is heated in the plate exchanger (PE) and directed to the heat exchanger (HE) and to the third controlled valve (CV3), in the case when the system works in the heating mode and the temperature measured in the air-conditioned space of the vehicle by the means of the first temperature measurement module (T1) is lower than 5℃ compared to the set temperature, and the temperature measured in the heat and cold storage unit (CS) by the means of the second temperature measurement module (T2) is positive in the Celsius scale, then the third and fourth controlled valves (CV3 and CV4) close and the first and second controlled valves (CV1 and CV2) open, and the agent of circuit (II) is pumped by the means of the circulation pump (CP)into the heat exchanger (HE) through the heat and cold storage unit (CS) into the connector (4) of the plate exchanger (PE), in the case when the system works in the heating mode and the temperature measured in the air-conditioned space of the vehicle by the means of the first temperature measurement module (T1) is lower than 3℃ compared to the set temperature, and the temperature measured in the heat and cold storage unit (CS) by the means of the second temperature measurement module (T2) is negative and not lower than -5℃, then the third and fourth controlled valves (CV3 and CV4) close and the first and second controlled valves (CV1 and CV2) open, and the agent of circuit (II) is pumped by the means of the circulation pump (CP) from the heat exchanger (HE) through the heat and cold storage unit (CS) into the connector (4) of the plate exchanger (PE), in the case when the system works in the heating mode and the temperature measured in the air-conditioned zone of the vehicle by the means of the first temperature measurement module (T1) is lower than 10℃ compared to the set temperature and the temperature measured in the heat and cold storage unit (CS) by the means of the second temperature measurement module (T2) is negative in the Celsius scale, then the second and third controlled valves (CV2 and CV3) close and the first and fourth controlled valves (CV1 and CV4) open, and the agent of circuit (II) is pumped by the means of the circulation pump (CP) from the heat exchanger (HE) through the controlled valve (CV4) into the connector (4) of the plate exchanger (PE), in the case when the system works in the heating mode and the temperature measured in the air-conditioned zone of the vehicle by the means of the first temperature measurement module (T1) is close to the set temperature by ±3℃ and the voltage measured on the direct current bus (DC) is higher than the rated voltage determined by the producer of the vehicle, then the first and fourth controlled valves (CV1 and CV4) close and the second and third controlled valves (CV2 and CV3) open, and the agent of circuit (II) is pumped by the means of the circulation pump (CP) through the heat and cold storage unit (CS) into the connector (4) of the plate exchanger (PE), in the case when the system works in the heating mode and the temperature measured in the air-conditioned zone of the vehicle by the means of the first temperature measurement module (T1) is close to the set temperature by ±3℃ and the voltage measured on the direct current bus (DC) is close to the rated voltage determined by the producer of the vehicle, the compressor (CO) and the circulation pump (CP) are disabled, wherein when the temperature in the air-conditioned zone of the vehicle is higher than the set value and the system works in the refrigeration mode, by the means of the compressor (CO) the agent in circuit (I) is compressed, and by the means of the control module (CM) the four-way valve (4WV) is repositioned, so that the compressed agent of circuit (I) is directed into the condenser-evaporator (C/E), in which the heat is received and the agent of circuit (I) is condensed, after which the condensed agent of circuit (I) flows out through the connector (B) and is directed to the second expansion valve (EV2), in which decompression takes place, also, the decompressed agent of circuit (I) is directed into the connector (2) of the plate exchanger (PE), in which the process of evaporation and receiving heat from the plate exchanger (PE) takes place, and the heat is received from the agent of circuit (II), said agent of circuit (II) is pumped by the circulation pump (CP) into the connector (4) of the plate exchanger (PE), subsequently, the refrigerated agent of circuit (II) flows out through the connector (3) of the plate exchanger (PE) and is directed to the connector (1) of the heat exchanger (HE) and the third controlled valve (CV3); in the case when the system works in the refrigeration mode and the temperature measured in the air-conditioned zone of the vehicle by the means of the first temperature measurement module (T1) is higher than 5℃ compared to the set temperature and the temperature measured in the heat and cold storage unit (CS) by the means of the second temperature measurement module (T2) is negative in the Celsius scale, then the third and fourth controlled valves (CV3 and CV4) close and the first and second controlled valves (CV1 and CV2) open, and the agent of circuit (II) is pumped by the means of the circulation pump (CP) from the heat exchanger (HE) through the heat and cold storage unit (CS) into the connector (4) of the plate exchanger (PE), in the case when the system works in the refrigeration mode and the temperature measured in the air-conditioned zone of the vehicle by the means of the first temperature measurement module (T1) is higher than 3℃ compared to the set temperature and the temperature measured in the heat and cold storage unit (CS) by the means of the second temperature measurement module (T2) is positive and not higher than 5℃, then the third and fourth controlled valves (CV3 and CV4) close and the first and second controlled valves (CV1 and CV2) open, and the agent of circuit (II) is pumped by the means of the circulation pump (CP) from the heat exchanger (HE) through the heat and cold storage unit (CS) into the connector (4) of the plate exchanger (PE), in the case when the system works in the refrigeration mode and the temperature measured in the air-conditioned zone of the vehicle by the means of the first temperature measurement module (T1) is higher than 10℃ and the temperature measured in the heat and cold storage unit by the means of the second temperature measurement module (T2) is positive in the Celsius scale, the second and third controlled valves (CV2 and CV3) close and the first and fourth controlled valves (CV1 and CV4) open, and the agent of circuit (II) is pumped by the means of the circulation pump (CP) from the heat exchanger (HE) via the fourth controlled valve (CV4) into the connector of the plate exchanger (PE), in the case when the system works in the refrigeration mode and the temperature measured in the air-conditioned zone of the vehicle by the means of the first temperature measurement module (T1) is close to the set temperature by ±3℃ and the voltage measured on the direct current bus (DC) is higher than the rated voltage determined by the producer of the vehicle, the first and fourth controlled valves (CV1 and CV4) close and the second and third controlled valves (CV2 and CV3) open, and the agent of circuit (II) is pumped by the means of the circulation pump (CP) through the heat and cold storage unit (CS) into the connector (4) of the plate exchanger (PE), in the case when the system works in the refrigeration mode and the temperature measured in the air-conditioned zone of the vehicle by the means of the first temperature measurement module (T1) is close to the set temperature by ±3℃ and the voltage measured on the direct current bus

(DC) is close to the rated voltage determined by the producer of the vehicle, the compressor (CO) and the circulation pump (CP) are disabled.

9. The method according to claim 8, characterised in that the agent in circuit II is an alcoholic solution.

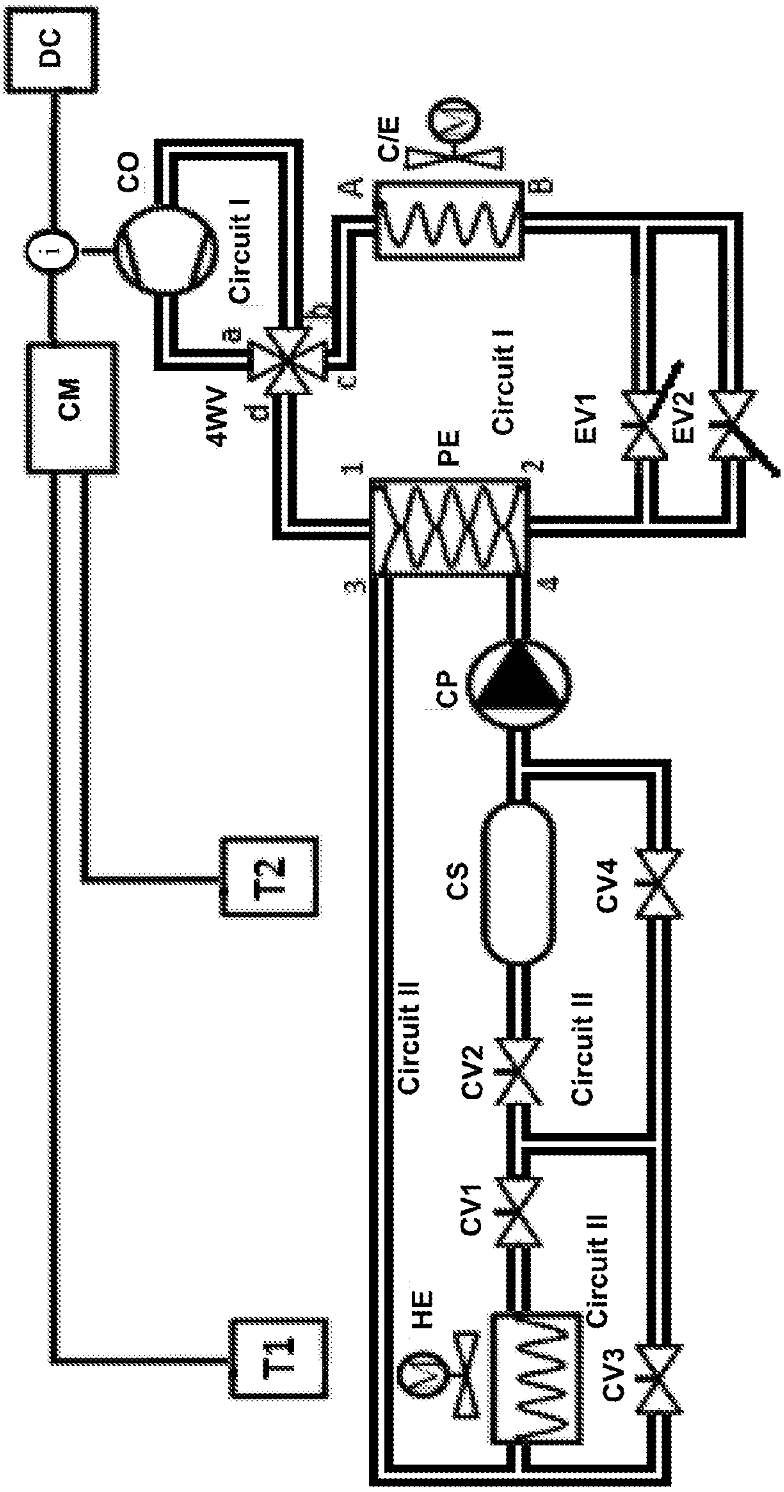
10. The method according to claim 8, characterised in that the agent in circuit II is a solution of water and salt.

11. The method according to any of claims 8 - 10, characterised in that the heat and cold storage unit (CS) has a form of a thermally insulated container comprising elements accumulating the energy of heat or cold in a cylindrical shape.

12. The method according to any of claims 8 - 10, characterised in that the heat and cold storage unit (CS) has a form of a thermally insulated container comprising elements accumulating the energy of heat or cold in a spherical shape.

13. The method according to claim 11 or 12, characterised in that the elements accumulating the energy of heat or cold are filled with water.

14. The method according to claim 11 or 12, characterised in that the elements accumulating the energy of heat or cold are filled with fat.


DC
i
CO
Circuit I
C/E
A
B
a
b
c
d
4WV
CM
PE
1
2
3
4
Circuit I
EV1
EV2
CP
CS
CV4
Circuit II
CV2
Circuit II
CV1
Circuit II
HE
CV3
T1
T2

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2017/052155

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60H1/00
ADD.

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)
B60H F28D H01M B60L F25B

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	FR 2 814 399 A1 (SANDEN CORP [JP]) 29 March 2002 (2002-03-29) page 3, lines 1-20; page 13, lines 1-19; page 17, lines 13-19; figure 1 -----	1-14
Y	EP 0 640 503 A1 (SEIKO EPSON CORP [JP]) 1 March 1995 (1995-03-01) column 6, lines 9-16; column 8, lines 5-47; column 16, lines 25-29; claims 2-7; figures 1-2 -----	1-14
Y	EP 2 253 495 A2 (TOYOTA JIDOSHOKKI KK [JP]) 24 November 2010 (2010-11-24) paragraphs [0013], [0022] - [0023], [0056] - [0075]; figures 14-17 -----	1-14
	-/--	

[X] Further documents are listed in the continuation of Box C.

[X] 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	Date of mailing of the international search report
31 July 2017	08/08/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Kristensen, Julien

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2017/052155

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	US 6 701 731 B2 (DENSO CORP [JP]) 9 March 2004 (2004-03-09) column 7, line 25 - line 67; claims 41-48; figures 2, 3a,3b,3c,8	4-7 11-14
A	US 2013/146000 A1 (CHOI YONG HYUN [KR] ET AL) 13 June 2013 (2013-06-13) column 4 - column 6; claims 1-3; figures 1-4	1,8
A	EP 2 191 990 A2 (SCANIA CV ABP [SE]) 2 June 2010 (2010-06-02) paragraphs [0020] - [0028]; figures 3-6	1,8

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2017/052155

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
FR 2814399	A1	29-03-2002	DE	10146477	A1	27-02-2003
			FR	2814399	A1	29-03-2002
EP 0640503	A1	01-03-1995	DE	69413481	D1	29-10-1998
			DE	69413481	T2	11-03-1999
			EP	0640503	A1	01-03-1995
			JP	3353299	B2	03-12-2002
			US	5507153	A	16-04-1996
			WO	9421481	A1	29-09-1994
EP 2253495	A2	24-11-2010	EP	2253495	A2	24-11-2010
			JP	2011001048	A	06-01-2011
			US	2010293966	A1	25-11-2010
US 6701731	B2	09-03-2004	DE	10308542	A1	11-09-2003
			FR	2836421	A1	29-08-2003
			KR	20030071568	A	03-09-2003
			US	2003159455	A1	28-08-2003
US 2013146000	A1	13-06-2013	CN	103161606	A	19-06-2013
			DE	102012105632	A1	13-06-2013
			JP	6043512	B2	14-12-2016
			JP	2013121817	A	20-06-2013
			KR	20130065435	A	19-06-2013
			US	2013146000	A1	13-06-2013
EP 2191990	A2	02-06-2010	AT	522381	T	15-09-2011
			CN	101746241	A	23-06-2010
			EP	2191990	A2	02-06-2010
			JP	2010126155	A	10-06-2010
			SE	0850104	A1	28-05-2010