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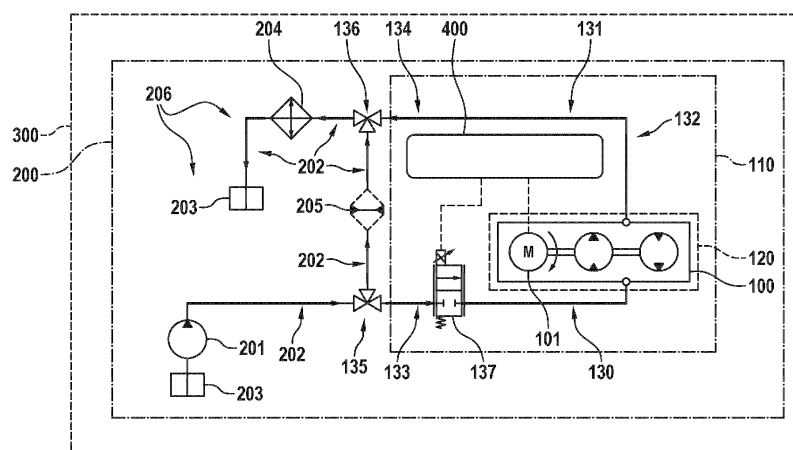
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(54) **METHOD FOR OPERATING AN AIR COMPRESSOR**

(57) A method for operating an air compressor in an air pressure supply system of a vehicle electrically driven by traction batteries, the compressor having a cooling system in which a coolant is conducted by coolant lines and/or by ducts or cavities belonging to a compressor housing into that compressor sections, which are subject to increased temperature load due to the operation of the compressor, said coolant being discharged via further

coolant lines after absorption of at least part of the heat generated there and discharging the absorbed heat into regions outside the compressor, whereby the cooling system of the compressor is connected to at least one cooling system of the electrically driven vehicle and the coolant present therein is used for cooling the compressor too.

Fig. 1



Description

Background of the Invention

[0001] The present invention relates to a method for operating an air compressor in an air pressure supply system of a vehicle electrically driven by traction batteries, the compressor having a cooling system in which a coolant is conducted by coolant lines and/or by ducts or cavities belonging to a compressor housing into that compressor sections, which are subject to increased temperature load due to the operation of the compressor, said coolant being discharged via further coolant lines after absorption of at least part of the heat generated there and discharging the absorbed heat into regions outside the compressor.

[0002] Depending on the load, working machines such as compressors generate considerable heat. To prevent overheating, the compressor must either be switched off after a specified operating time, or the process heat must be dissipated into the environment via a cooling system provided for the compressor.

[0003] A specified operating time, also known as duty cycle, is specified when a device, without overheating, can only provide the rated power temporarily. This is usually the case if the dissipated heat cannot be dissipated quickly enough, and damage or premature failure would therefore be expected in the long term.

[0004] Duty cycle is defined as the maximum permissible operating interval of a piece of equipment, after which a rest phase must take place in order not to damage or destroy the equipment. However, a given duty cycle may result in limited availability of such a working machine, e.g., a compressor, which is undesirable.

[0005] On the other hand, it is possible to provide cooling systems for compressors, which dissipate the process heat with the help of a coolant. However, such cooling systems are relatively complex in terms of design and are also expensive. In this respect, DE 40 26 684 discloses a device for saving energy in a piston compressor for generating compressed air in motor vehicles. Here it is mentioned that the cylinder head can be equipped with cooling channels in which water, or another cooling liquid flows to cool the piston compressor.

[0006] Cooling systems in vehicles or for individual devices present in vehicles are also known. DE 10 2018 121 227 A1 discloses a modular commercial vehicle which has, among other things, a cooling system for active cooling of high-voltage energy storage devices. Without detailed presentation, it is also disclosed there that the cooling system should be able to cool further electrical components and for this purpose is to have a cooling interface via which the further components can be connected.

[0007] EP 2 151 344 A1 discloses a hybrid vehicle with a hybrid vehicle drive system comprising an electric motor that can be operated as a generator and a gas engine being operated as an internal combustion engine. The

electric motor is also intended to be able to drive auxiliary units and is liquid-cooled, whereby the cooling circuits of the electric motor and the cooling circuit of the gas engine can be connected.

[0008] Regarding the design of or methods for operating compressors, however, no satisfactory solution is available in the prior art which, on the one hand, avoids shutting down compressors due to overheating and, on the other hand, dispenses with costly separate cooling systems for only the compressor.

Summary of the invention

[0009] Against this background it is a first object of the present invention to provide a method for operating an air compressor in an air pressure supply system of a vehicle electrically driven by traction batteries. This object is solved by the features of the main claim. Further embodiments are disclosed in the sub-claims.

[0010] It is a further object of the present invention to design an air compressor cooling system of an air pressure supply system of a vehicle electrically driven by traction or drive batteries. The object to design such an air compressor cooling system is solved by the features of claim 6, while further embodiments are disclosed in the claims dependent on claim 6.

[0011] The first object of the invention is achieved through a method to operate said air compressor in such a way that the cooling system of the compressor is connected to at least one cooling system of the electrically driven vehicle and the coolant present therein is used for cooling the compressor. Thus, it is achieved that cooling of the compressor is carried out by means of cooling liquids circulating in cooling systems already present and provided with all the necessary devices for heat dissipation. Either no duty cycle needs to be specified at all or a duty cycle may be specified, which is much longer and provides sufficient and extended availability of the compressor.

[0012] This is particularly the case in a further embodiment of the invention, wherein the cooling system of the compressor is connected to a cooling system of the traction batteries and wherein the latter's coolant is used in the cooling system of the compressor. Since the cooling system of the traction batteries is usually designed in such a way that the temperature of the batteries does not exceed a maximum temperature of 40° C, for example, this cooling system is also ideally suited for cooling the compressor of a compressed air system in the vehicle.

[0013] In a further development of the invention the coolant is provided for cooling a reciprocating piston compressor, and the coolant is guided close to the cylinder head of the reciprocating compressor. This achieves targeted cooling of the areas of a reciprocating compressor most exposed to thermal stress. The operating time of the compressor is thus significantly extended.

[0014] This is particularly evident in a further develop-

ment of the invention in which the coolant is used to cool a compressor for supplying compressed air to a vehicle air suspension system.

[0015] But also, in another embodiment of the invention, which is based on that the coolant is used to cool a compressor for supplying compressed air to a cleaning system for vehicle, in particular a compressed air cleaning system for sensors, it is important to reduce thermal stress of the compressor and to extend availability.

[0016] The above-mentioned further object of the invention is achieved through an air compressor cooling system of an air pressure supply system of a vehicle electrically driven by traction or drive batteries, in which a coolant is conducted in first coolant lines and/or in ducts or cavities belonging to a compressor housing into that compressor sections, which are subject to increased temperature load due to the operation of the compressor, said coolant being dischargeable via second coolant lines after at least some of the compressor's heat has been absorbed, said heat thereby being dissipated into regions outside the compressor, whereby the cooling system of the compressor is connected via said first and second coolant lines to a cooling system of the traction or drive batteries, and coolant lines, ducts or cavities are provided in which the coolant of the cooling system of the traction or drive batteries is conducted to those sections of the compressor which are subject to increased temperature stress due to the operation of the compressor.

[0017] This is particularly apparent in interaction with another embodiment of the invention, wherein the air compressor is a reciprocating piston compressor, said coolant lines and/or ducts or cavities running close to the cylinder head of the piston compressor, thereby being arranged in such a way that the heat of the cylinder head can be dissipated by the coolant. A cylinder head with cooling lines/cooling ducts suitable for this purpose can be designed and manufactured without difficulty and is well suited for air compressors designed to supply compressed air to a vehicle air suspension system.

[0018] Another embodiment is based on that the coolant lines of the compressor cooling system form a cooling circuit with an inlet and a return, the inlet and return each being connected to the cooling system of the traction or drive batteries via branches, preferably 3-way valves, the inlet having at least one solenoid valve, which can be actuated via a control device, for opening and closing the inlet, preferably a switchable 2/2-way valve. This allows the cooling system for the compressor to be connected in parallel with the traction or drive batteries cooling system without the need for complex equipment.

[0019] In a further development of the invention the air compressor is provided with at least one temperature sensor in areas of increased temperature load and the solenoid valve can be switched by the control device as a function of the signals from the temperature sensors. This provides an easy way to adjust the cooling capacity to the current demand.

[0020] The same applies to another embodiment of the invention, which is based on that the solenoid valve can be switched by the control device as a function of a pre-defined compressor running time.

[0021] In another embodiment of the invention the cooling circuit of the compressor cooling system is arranged in parallel to a cooling circuit of the traction or drive battery cooling system and the inlet of the compressor cooling system's cooling circuit is located at a line section of the drive battery cooling system's cooling circuit before the coolant of the latter enters other elements or devices in which heat is dissipated or released by the coolant. This makes the capacity of the coolant to absorb heat equally available to the connected cooling circuits/cooling systems. Other elements or devices in this context primarily include the vehicle's battery system to be cooled, i.e. where the heat from the batteries is dissipated by the coolant, but also devices for heat release, such as auxiliary or parking heaters, or cabin heaters.

[0022] To achieve a best possible efficiency a further development of the invention is foreseen, wherein a cooler is provided in which the absorbed heat is extracted from the coolant after passing through one or more of the cooling systems.

[0023] The invention also relates to a reciprocating piston compressor to supply compressed air in a vehicle air suspension, where the compressor is equipped with the cooling system according to the invention and to a vehicle air suspension system provided with such a compressor.

Description of the preferred embodiment

[0024] In the figures, the same or similar elements and features may be referenced with the same reference signs. For clarification of the invention, it is advantageous to view the figures in synopsis.

[0025] To this end, Fig. 1 shows, only as a rough sketch, partly as a black box sketch and using technical symbols, an air compressor 100 which has an air compressor cooling system 110 and which is a part of an air pressure supply system 120 for an air suspension system in a vehicle 300, neither of which is shown in more detail here. The vehicle 300 is electrically driven by traction or drive batteries, the batteries also are not depicted here in details. The air compressor 100 is designed here as a reciprocating piston compressor, the upper part of which is shown in Fig. 2. The air compressor 100 is driven by an electric motor 101.

[0026] In the compressor cooling system 110 a coolant is conducted in first coolant lines 130 and in ducts 141 or cavities 142 belonging to a compressor housing 140, as can be seen better in Fig. 2.

[0027] Said first coolant lines 130, ducts 141 and cavities 142 conduct the coolant into that compressor sections, which are subject to increased temperature load due to the operation of the air compressor 100. The coolant is discharged from said compressor sections via said ducts 141 and/or second coolant lines 131 after at least

some of the compressor's heat has been absorbed by the coolant. The absorbed heat is then discharged / dissipated within devices outside the air compressor 100, e.g., in the cooler 204.

[0028] Fig. 2 clearly shows, that in the cooling system 110 of the reciprocating piston compressor 100, said ducts 141 or cavities 142 are running close to or inside a cylinder head 143 of the piston compressor 100, thereby being arranged in such a way that the heat of the cylinder head 143 can be dissipated by the coolant. The cylinder head 143 is that section of the compressor 100 which is subject to increased temperature stress due to high compression of air through the reciprocating piston 144.

[0029] The combination of Figs. 1 and 2 shows that the compressor cooling system 110 is connected to another cooling system 200 in the vehicle 300, in this case and in accordance with the invention to the cooling system 200 of the traction or drive batteries.

[0030] With this design said first and second coolant lines 130, 131, ducts 141 or cavities 142 are provided to conduct the coolant of the cooling system 200 of the traction or drive batteries to those sections of the compressor 100 which are subject to increased temperature stress i.e. to the cylinder head 143.

[0031] Coolant lines 130 and 131 form a cooling circuit 132 with an inlet 133 and a return 134, the inlet 133 and return 134 each being connected to the cooling system 200 of the traction or drive batteries via branches 135, 136, designed as 3-way valves 135, 136, the inlet 133 having a solenoid valve 137 which can be actuated via a control device 400, for opening and closing the inlet 133. The solenoid valve 137 is a switchable 2/2-way valve. The solenoid valve may be integrated in the compressor housing but can just as well be designed as a separate solenoid valve 137 in the compressor cooling system 110, as it is here.

[0032] The solenoid valve 137 is switched by the control device 400 or by signal from control device as a function of a predefined running time of compressor 100.

[0033] Fig. 1 also shows the basic equipment of the cooling system 200 for the traction or drive batteries. Starting with a pump 201, which delivers the coolant/cooling liquid, in this case water, via various cooling lines 202 into elements or devices 205 of the traction drive battery cooling system 200, the cooling system 200 has a reservoir 203, a cooler 204 for heat dissipation and is connected to the branches 135, 136 of the compressor cooling system 110. Various system elements or devices 205, in which heat is dissipated or released by the coolant of cooling system 200, also form a part of the traction drive battery cooling system 200. Such elements or devices 205 are shown here merely symbolically. These various elements or devices 205 primarily include the vehicle's battery system to be cooled, i.e., where the batteries heat is dissipated by the coolant, but may also include devices for heat release, such as auxiliary heaters or cabin heaters.

[0034] Looking at Fig. 1 and 2, it is clear that when the solenoid valve 137 is closed, the coolant cannot circulate through the compressor cooling system 110, but only through the remaining part of the cooling system of the traction batteries 200. If the solenoid valve 137 is opened by a signal of the controller device 400 the coolant enters the compressor cooling system 110 via inlet 133 and through coolant lines 130 and is guided through the ducts 141 and cavities 142 to the compressor housing 140 and the cylinder head 143. The Coolant flowing through the compressor housing 140 and through the cylinder head 143 reduces the temperature of the compressor 100 which leads to improved operation time.

[0035] The cooling circuit 132 belonging to the compressor cooling system 110 thereby is arranged in parallel to a cooling circuit 206 belonging to the traction or drive battery cooling system 200. The inlet 133 of the cooling circuit 132 is located at a line section of the cooling circuit 206 before the coolant of the latter enters said other devices 205 in which heat is dissipated or released by the coolant.

[0036] After passing the compressor cooling system 110 the coolant is directed via cooling lines 131 to return 134, where it is fed via the 3-way valve 136 into the so-called "hot side" of the drive battery cooling system 200. The heat absorbed by the coolant from both the compressor cooling system 110 and the from the drive battery cooling system 200 is then dissipated via the cooler 204.

Reference sign list (part of the specification)

[0037]

100	air compressor, reciprocating air compressor,
110	compressor cooling system
120	air pressure supply system for an air suspension system
130	first coolant lines
131	second coolant lines
132	cooling circuit of the compressor cooling system
133	inlet of cooling circuit
134	return of cooling circuit
135, 136	branches, 3-way valves
137	solenoid valve, proportional solenoid valve
140	compressor housing
141	ducts belonging to a compressor housing
142	cavities belonging to a compressor housing
143	cylinder head
144	piston
200	cooling system of the traction or drive batteries
201	water punmp
202	cooling line
203	reservoir
204	cooler

- 205 various system elements
 206 cooling circuit of the drive battery cooling system
- 300 vehicle, electrically driven by traction or drive batteries
- 400 control device , control unit

Claims

1. A method for operating an air compressor (100) in an air pressure supply system (120) of a vehicle (300) electrically driven by traction or drive batteries, the compressor having a cooling system (110) in which a coolant is conducted by first coolant lines (130) and/or by ducts (141) or cavities (142) belonging to a compressor housing (140) into that compressor sections, which are subject to increased temperature load due to the operation of the compressor, said coolant being discharged via second coolant lines (131) after absorption of at least part of the heat generated there and discharging the absorbed heat into regions outside the compressor (100), **characterized in that** the cooling system (110) of the compressor (100) is connected to at least one cooling system (200) of the electrically driven vehicle (300) and the coolant present therein is used for cooling the compressor (100).
2. The method according to claim 1, wherein the cooling system (110) of the compressor (100) is connected to a cooling system (200) of the traction or drive batteries and wherein the latter's coolant is used in the cooling system (110) of the compressor (100).
3. The method according to claim 1 or 2, wherein the coolant is provided for cooling a reciprocating piston compressor (100), and the coolant is guided close to the cylinder head (143) of the reciprocating compressor.
4. The method according to one of the claims 1 to 3, wherein the coolant is used to cool a compressor (100) for supplying compressed air to a vehicle air suspension system (120).
5. The method according to one of the claims 1 to 3, in which the coolant is used to cool a compressor for supplying compressed air to a cleaning system for vehicle, in particular a compressed air cleaning system for sensors.
6. An air compressor cooling system (110) of an air pressure supply system (120) in a vehicle (300), the vehicle (300) being electrically driven by traction or drive batteries, whereby in said cooling system (110) a coolant is conducted in first coolant lines (130)

- and/or in ducts (141) or cavities (142) belonging to a compressor housing (140) of a compressor (100) into that compressor sections, which are subject to increased temperature load due to the operation of the compressor (100), said coolant being dischargeable via said ducts (141) and/or second coolant lines (131) after at least some of the compressor's heat has been absorbed, said heat thereby being dissipated within devices (204) outside the air compressor (100), **characterized in that** the compressor cooling system (110) is connected via said first and second coolant lines (130, 131) to a cooling system (200) of the traction or drive batteries, and said first and second coolant lines (130, 131), ducts or cavities (141, 142) are provided to conduct the coolant of the cooling system (200) of the traction or drive batteries to those sections of the compressor (100) which are subject to increased temperature stress due to the operation of the compressor (100).
7. An air compressor cooling system (110) according to claim 6, in which the air compressor (100) is a reciprocating piston compressor, said coolant lines (130, 131) and/or ducts (141) or cavities (142) running close to a cylinder head (143) of the piston compressor (100), thereby being arranged in such a way that the heat of the cylinder head (143) can be dissipated by the coolant.
 8. An air compressor cooling system (110) according to claim 6 or 7, in which the air compressor (100) is designed to supply compressed air to a vehicle air suspension system (120).
 9. An air compressor cooling system (110) according to one of claims 6 to 8, in which the first and second coolant lines (130, 131) form a cooling circuit (132) with an inlet (133) and a return (134), the inlet and return (133, 134) each being connected to a cooling circuit (206) of the traction or drive battery cooling system (200) via branches (135, 136), preferably 3-way valves, the inlet (133) having at least one solenoid valve (137), which can be actuated via a control device (400), for opening and closing the inlet (133), preferably a switchable 2/2-way valve (137).
 10. An air compressor cooling system (110) according to claim 9, in which the air compressor (100) is provided with at least one temperature sensor in areas of increased temperature load and the solenoid valve (137) can be switched by the control device (400) as a function of the signals from the temperature sensors.
 11. An air compressor cooling system (110) according to claim 9 or 10, in which the solenoid valve (137) can be switched by the control device (400) as a function of a predefined compressor running time.

12. An air compressor cooling system (110) according to claim 6 to 11, in which the cooling circuit (132) of the compressor cooling system (110) is arranged in parallel to the cooling circuit (206) of the traction or drive battery cooling system (200) and the inlet (133) of the cooling circuit (132) is located at a line section of the cooling circuit (206) before the coolant of the latter enters other elements or devices (205) in which heat is dissipated or released by the coolant.
13. An air compressor cooling system (110) according to one of claims 6 to 12, wherein a cooler (204) is provided as a heat dissipating device in which the absorbed heat is extracted from the coolant (204) after passing through one or more of the cooling systems (110, 200).
14. Reciprocating piston compressor (100) to supply compressed air in a vehicle air suspension (120), the compressor having a cooling system (110) according to one of the claims 6 to 13.
15. Vehicle air suspension system with a compressor (100) according to claim 14.

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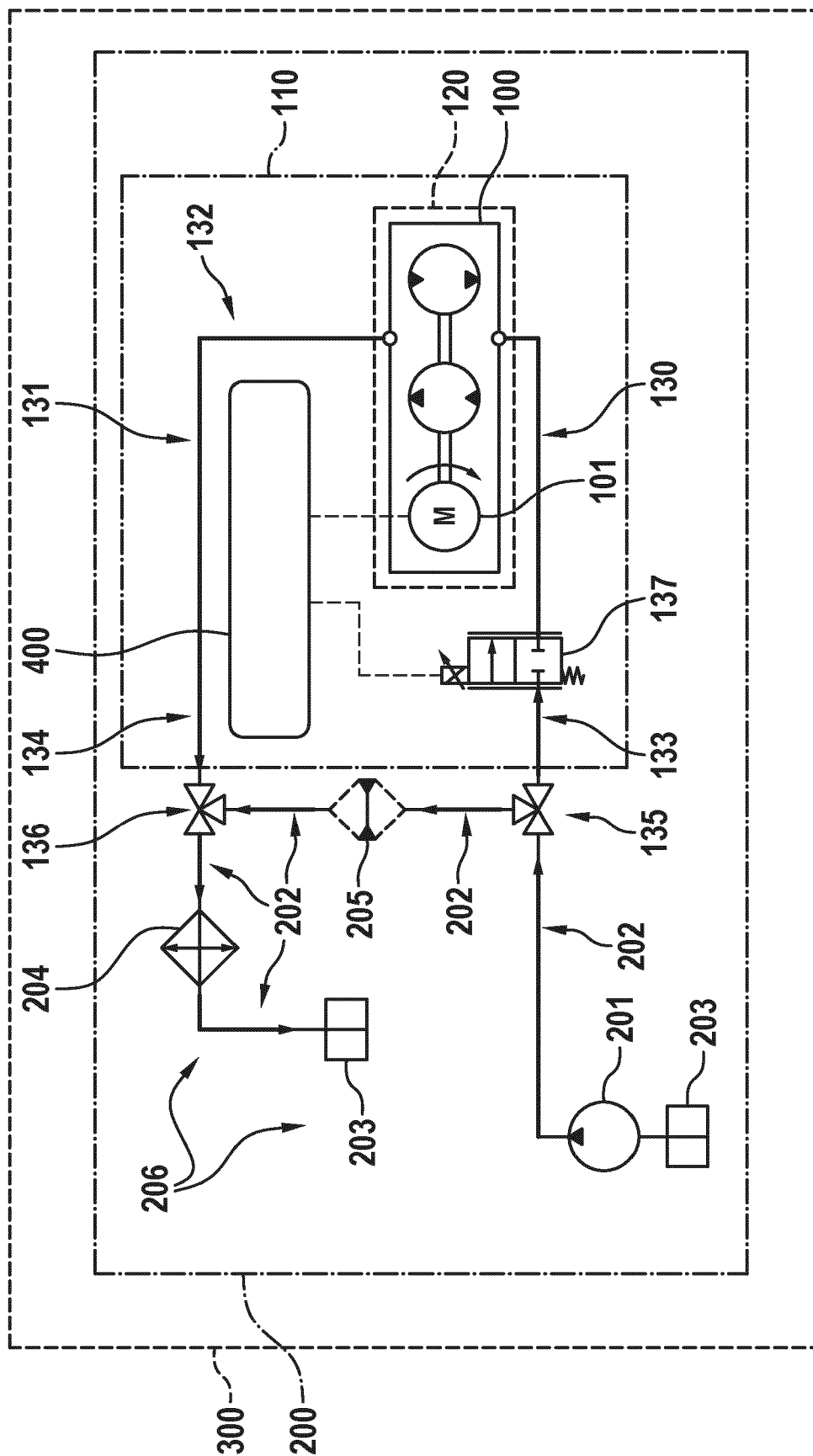
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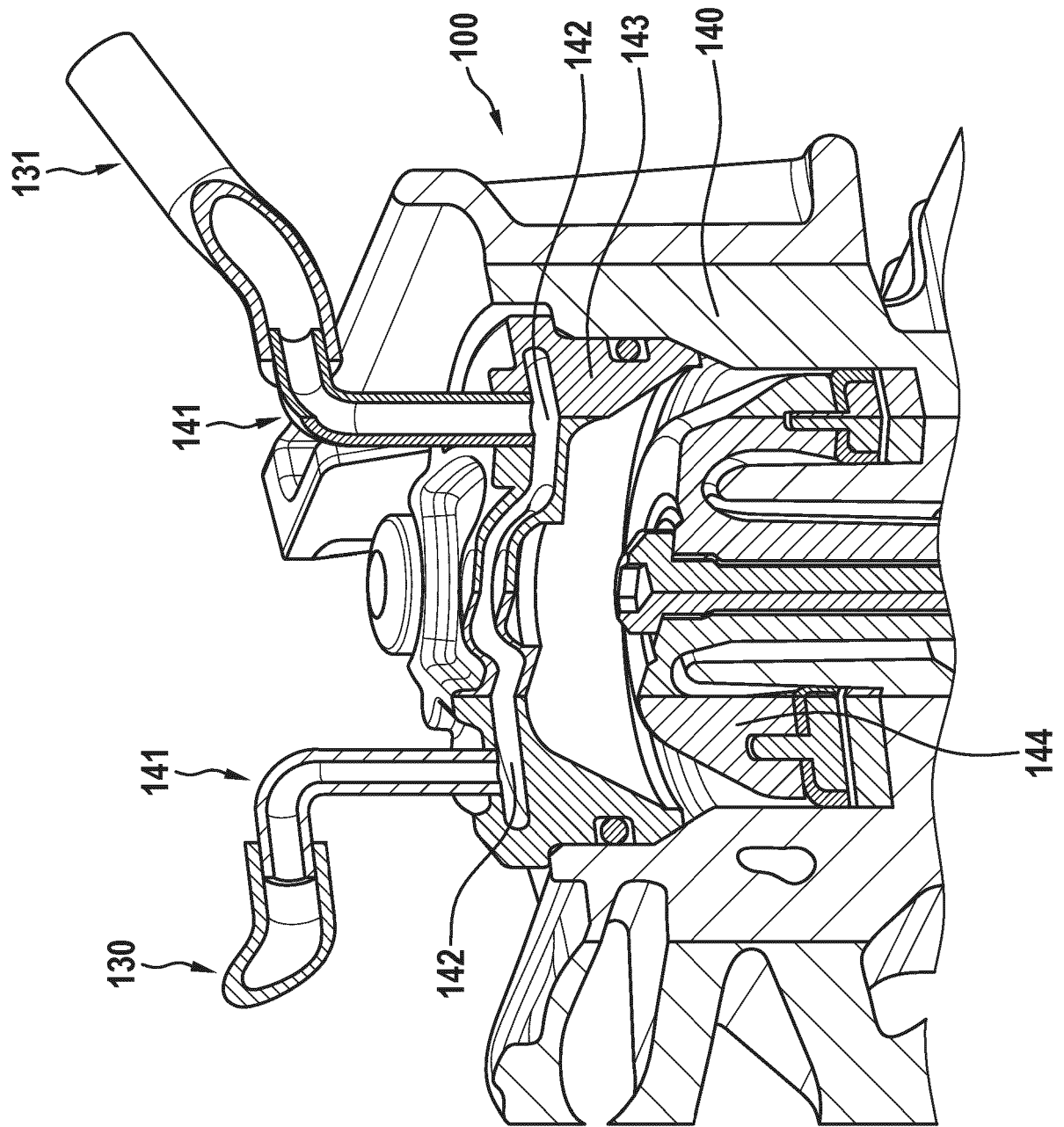
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Fig. 2





EUROPEAN SEARCH REPORT

Application Number

EP 23 16 8681

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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Y	* paragraphs [0008], [0021] - [0037]; figures 1-5 *	3, 7	B60H1/00
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A	US 2017/008407 A1 (PORRAS ANGEL FERNANDO [US] ET AL) 12 January 2017 (2017-01-12) * paragraphs [0014] - [0041]; figures 1-5 *	1-15	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			B60T B60H F04B

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Place of search

Munich

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20 September 2023

Examiner

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CATEGORY OF CITED DOCUMENTS

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 23 16 8681

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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REFERENCES CITED IN THE DESCRIPTION

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