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An agency of Industry Canada

CA 2890872 C 2017/06/27

(11)(21) **2 890 872**

(12) **BREVET CANADIEN**
CANADIAN PATENT

(13) **C**

(22) **Date de dépôt/Filing Date:** 2015/05/11
(41) **Mise à la disp. pub./Open to Public Insp.:** 2015/11/12
(45) **Date de délivrance/Issue Date:** 2017/06/27
(30) **Priorité/Priority:** 2014/05/12 (ATA50331/2014)

(51) **Cl.Int./Int.Cl.** ***F25B 45/00*** (2006.01), ***B60H 1/32*** (2006.01), ***F25B 43/00*** (2006.01)
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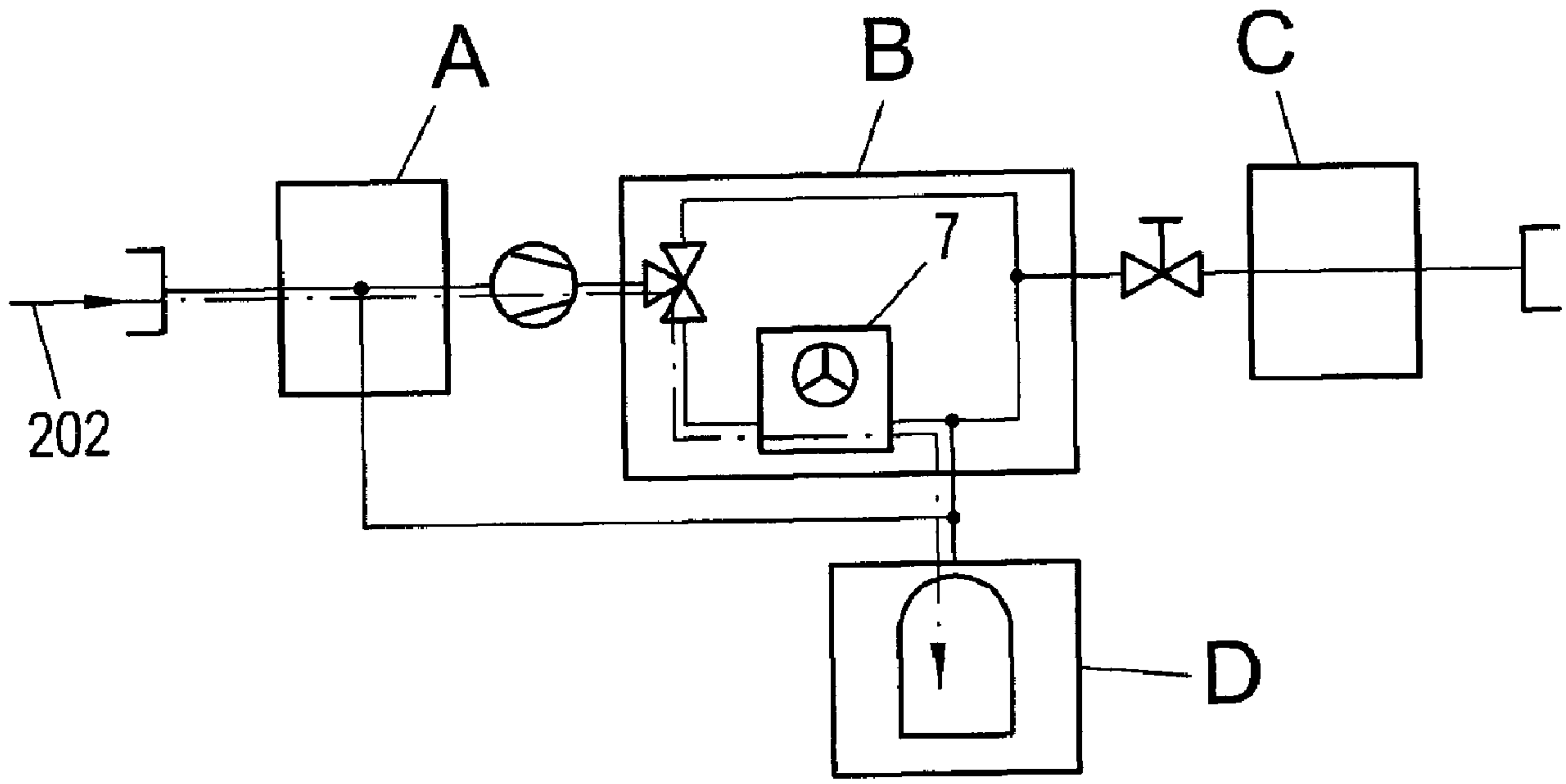
(54) **Titre : DISPOSITIF ET METHODE DE MAINTIEN D'UN APPAREIL DE CONDITIONNEMENT DE L'AIR**
(54) **Title: DEVICE AND METHOD FOR MAINTAINING AN AIR CONDITIONER**



(57) **Abrégé/Abstract:**
A device for maintaining an air conditioner, in particular, for air conditioners using CO_2 or R744 as a coolant. The device has a low-pressure side region (A), which is connectable to a service port on the low-pressure side of the air conditioner via a low- pressure side coupler (1), and a high-pressure side region (C), which is connectable to a service port on the high-pressure side of the air conditioner via a high-pressure side coupler (1'). A compressor (4) is provided between the low-pressure side region (A) and the high-pressure side region (C) and between the compressor (4) and the high-pressure side region (C) an over-pressure region (B) is provided, which is connected to the high-pressure side region (C) via a throttle device (5).

Abstract

A device for maintaining an air conditioner, in particular, for air conditioners using CO_2 or R744 as a coolant. The device has a low-pressure side region (A), which is connectable to a service port on the low-pressure side of the air conditioner via a low-pressure side coupler (1), and a high-pressure side region (C), which is connectable to a service port on the high-pressure side of the air conditioner via a high-pressure side coupler (1'). A compressor (4) is provided between the low-pressure side region (A) and the high-pressure side region (C) and between the compressor (4) and the high-pressure side region (C) an over-pressure region (B) is provided, which is connected to the high-pressure side region (C) via a throttle device (5).

Device and method for maintaining an air conditioner

The present invention relates to a device for maintaining an air conditioner, in particular, for air conditioners using CO_2 or R744 as a coolant, and the device has a low-pressure side region, which is connectable to a service port on the low-pressure side of the air conditioner via a low-pressure side coupler, and a high-pressure side region, which is connectable to a service port on the high-pressure side of the air conditioner via a high-pressure side coupler, and a compressor is provided between the low-pressure side region and the high-pressure side region. Furthermore, the present invention relates to a method for operating a service device for air conditioners.

Independent of the used coolant, an air conditioning service has the task to empty, evacuate, and then to refill the air conditioner again with the right amount of coolant and oil. Modern service devices, for example, those used for air conditioners in motor vehicles, conventionally have two service ports, one being connected to the high-pressure side of the air conditioner and the other to the low-pressure side. In this way, a circuit is formed that conventionally leads from the low-pressure side connector via an oil separator, an evaporator, a compressor and a condenser to the high-pressure side connector. Furthermore, empty and fill devices for suctioning the mixture of coolant and compressor oil out of the coolant circuit and refilling the air conditioner with coolant and compressor oil are provided in the service device. For this purpose, the circuit mixture is suctioned out in a first phase via a separation stage, for example an oil separator or a filter. Subsequently, the circuit system is emptied almost completely of residual content by a vaccum pump and, then, new coolant and new oil are added from a storage container to the system.

Systems and methods for maintaining air conditioners are, for example, known from the publications WO 2011/088831 A1, DE 202008003123 U1, or DE 102009054436 A1.

When emptying the air conditioning circuit, one problem is that the coolant, when relaxing rapidly in the wet steam region, may solidify below a pressure threshold. For CO_2 or R744 as a coolant, the threshold for CO_2 to solidify to dry ice in the wet steam region is at a pressure of 5.18 bar. In order to prevent CO_2 from freezing, a relaxation to approximately 18 bar, therefore, may be carried out in a first step and, then, one waits until the CO_2 in the vehicle is completely evaporated before the suctioning may be continued.

The present invention is based on the idea to create a device and a method by which the problems of the related art mentioned above may be alleviated. In particular, an object of the present invention is to shorten the time required to empty the air conditioner.

According to the present invention, this and further objectives are achieved by a device mentioned at the outset that provides, between the compressor and the high-pressure side region, an over-pressure region, which is connected to the high-pressure side region via a throttling device. On the gas side of the phase diagram, the achievable over-pressure enables a more effective procedural utilization of the region outside of the wet steam curve of the coolant. Within the context of this present invention, any device that is able to execute the pressure-controlling function of a throttle is referred to as a throttle device. These include, for example, an expansion valve, a fixed throttle, an orifice having a bypass or an orifice not having a bypass, etc.

According to an aspect of the present invention, there is provided a device for maintaining an air conditioner, the device comprising: a low-pressure side region, which is connectable to a service port on a low-pressure side of the air conditioner via a low-pressure side coupler; and a high-pressure side region, which is connectable to a service port on a high-pressure side of the air conditioner via a high-pressure side coupler,

wherein a compressor is provided between the low-pressure side region and the high-pressure side region, and

wherein between the compressor and the high-pressure side region, an over-pressure region is provided, which is connected to the high-pressure side region via a throttle device.

According to an aspect of the present invention, there is provided a method of operating a service device for an air conditioner, wherein the service device for establishing a circuit is, via a low-pressure side coupler and a high-pressure side coupler, connected to a low-pressure side or a high-pressure side of the air conditioner, and wherein the method comprises transferring a coolant in the air conditioner from a phase state II within a wet steam curve via a circuit process to a phase state II^E outside of the wet steam curve, wherein a specific enthalpy in phase state II^E has a value which isenthalp lays completely outside of the dry ice region.

A vacuum pump, which may evacuate the fluid system of the unit or individual regions thereof, may be connected in an advantageous manner to the low-pressure side region.

In an advantageous embodiment of the present invention, a circuit fluid connection may, starting from the low-pressure side coupler, be released by valves to the high-pressure side coupler via the low-pressure side region, the compressor, the region of over-pressure, the throttle device, and the high-pressure side region. This circuit fluid connection enables to condition the coolant located in the system very rapidly in a circuit process and in such a manner that a formation of dry ice is prevented during draining.

In a further advantageous embodiment, a storage container, which is connectable to the over-pressure region and/or the low-pressure side region via valves, may be provided in a storage region. For this purpose, the storage container may be used for storing the out-pumped coolant and also for providing the coolant to be in-pumped.

Furthermore, an out-pumping fluid connection may, starting from the low-pressure side coupler, be released by valves to the storage container via the low-pressure side region, the compressor, and the over-pressure region. In this way, coolant suctioned out of the air conditioner may be processed and stored for reuse in the storage container.

In a further advantageous embodiment an in-pumping fluid connection may, starting from the storage container, be released by valves to the high-pressure side coupler via the the compressor, the over-pressure region. and the high-pressure side region. In doing so, the coolant may, using the compressor, be pumped from the storage container into the air conditioner via the high-pressure side connection. Preferably, the coolant in the over-pressure region may be cooled by a gas cooler in this instance and the amount pumped in may be measured using a flow rate meter.

According to an advantageous embodiment, drain valves may, according to the present invention, be connected at the low-pressure side region and/or at the high-pressure side region. This enables to drain coolant, for example, CO_2, into the environment.

In an advantageous embodiment, a new oil container may be connected to the fluid system via a new oil valve. This enables to refill new oil into the air conditioner in a simple manner. Within the context of the present description, *fluid system* refers to all conduits and components of the device in its entirety and, if applicable, to the air conditioner connected thereto, in which the fluid may be situated as coolant or through which the coolant may flow.

Preferably, an oil separator and/or evaporator and/or filter dryer may be provided in the low-pressure side region and a fluid separator and/or a gas cooler and/or a flow rate meter may be provided in the over-pressure region. These features enable an advantageous conditioning of the coolant. In particular, old oil and pollutants may be removed from the coolant. The flow rate meter enables an accurate measurement of the amount of coolant.

An advantageous embodiment of the device according to the present invention may provide that, in the region of over-pressure between the compressor and the gas cooler, a switch valve is provided, which is able to reroute the circuit fluid connection to a bypass circumventing the gas cooler. Therefore, one single compressor may be used for the circulation step (via the bypass) and also for pumping the coolant in and out (respectively via the gas cooler).

The method according to the present invention for operating a service device for air conditioners, in particular, for air conditioners using CO_2 or R744 as coolant, is characterized by the fact that the service device for forming a circuit via a low-pressure side coupler and a high-pressure side coupler is connected to the low-pressure side or the high-pressure side of the air conditioner, respectively, and the method features the step of transferring the coolant in the air conditioner from a phase state II within the wet steam curve via a circuit process to a phase state II^E outside of the wet steam curve, and the specific enthalpy in phase state II_E has a value which isenthalp lays completely outside of the dry ice region. Proceeding from phase stage II^E, the coolant may be drained without forming dry ice.

Within the context of the present invention, *circuit process* refers to a process step in which the coolant is left circulating in the circuit. With regard to the phase change, this process is not closed looped because the aimed-at endpoint of the state change (phase state II^E) does not correspond with the initial state (phase state II). For example, a basic circulation unit having a gas pump and a heat supply, for example, a heat exchanger, could carry out the circuit process because this would suffice to increase the enthalpy of the coolant. Particularly advantageous, however, is utilizing the device according to the present invention herein described for maintaining an air conditioner.

In an advantageous manner, the circuit process starting from phase state II may include the following state changes: isobaric heating of the coolant to outside of the wet steam curve; isentropic compression to an over-pressure above the pressure of the initial phase state II and, preferably, above the critical pressure of the coolant; isenthalpic expansion; and mixing with the coolant in the air conditioner. This illustrates a basic circuit process, which may be realized using an evaporator, a compressor, and a throttle device.

Before the step of the circuit process, the method according to the present invention may have the following steps: evacuating a sealed-off region of the service device that connects at the low-pressure side of the air conditioner and that is separated from said low pressure side by a closed valve; and opening of a fluid connection between the evacuated region of the service device and the fluid system of the air conditioner. In this way, the circuit process may be started from a convenient phase state II resulting after a first expansion of the coolant.

In an advantageous manner, the method may, after the circuit process, feature the step of pumping the coolant out of the air conditioner into a storage container. The coolant may, according to the respective circumstances and the legal requirements, either be completely drained from the air conditioner or stored for recycling.

In a preferred embodiment, old oil may be separated during the method and the amount of the old oil separated from the air conditioner may be determined. This way, the amount of new oil for refilling the air conditioner may be determined.

A further advantageous embodiment of the method may feature the step of evacuating the system after draining and, if applicable, out-pumping the coolant with a vacuum pump. The evacuation of the unit enables to test for leaks. Simultaneously, water is, if applicable, evaporated in the unit and removed from the circuit.

After removing the coolant and before refilling the air conditioner, new oil may be brought into the evacuated fluid system in an advantageous manner, and the amount of new oil may be determined on the basis of the amount of separated old oil. In this way, a simple and accurate dosage of the amount of new oil via a basic valve is possible. As the new oil is suctioned in by the vacuum, a pump is not required. During the subsequent filling the oil is carried by the coolant and, in this manner, reaches the air conditioner.

In the following, the present invention is described in detail on the basis of an exemplary embodiment in reference to the appended drawings, which, in an exemplary manner, schematically and non-restrictively show advantageous embodiments of the present invention, and

Figure 1 shows a circuit diagram of a servie device;

Figures 2A-2C show in a schematic illustration a plurality of fluid connections, which may be produced by switching valves;

Figure 3 shows the phase changes of the circulation step in a p-h diagram of R744.

Figure 1 shows an embodiment of the service device in a circuit diagram, and the fluid system of the device may be separated into four regions: a low-pressure side region A, an over-pressure region B, a high-pressure side region C, and a storage region D.

The low-pressure side region A starts at the low-pressure side coupler 1, which connects the service device to the low-pressure side of the motor vehicle air conditioner. From the low-pressure side coupler 1, the pipe preferably runs inside a hose to a first shut-off valve 101, and measuring devices 16 are provided for the pressure and the temperature upstream of shut-off valve 101. When connecting the low-pressure side coupler to the air conditioner, shut-off valve 101 is closed and measuring devices 16 measure the values for the air conditioning medium on the low-pressure side of the air conditioner. An oil separator 2 is situated after shut-off valve 101 and, after an additional shut-off valve 102, the pipe leads via an evaporator 3 and a filter dryer 11 to an additional valve

103, which may be understood as the end of low-pressure side region A.

The oil from the air conditioner separated by oil separator 2 is collected in an old oil collection container 14 and is weighed by a scale to determine the amount of oil to be refilled.

Two connectors are located between evaporator 3 and filter dryer 11, the first connector leading to a shut-off valve 106, which is provided as a barrier to storage region D. The second connector leads via a shut-off valve 109 to a vacuum pump 10.

An additional connector leading to a first drain valve V1, via which the coolant is able to be released into the environment, is provided between the filter dryer 11 and valve 103.

A compressor 4 running into over-pressure region B is provided after valve 103 at the end of the low-pressure side region A. A liquid separator 12 , which serves to regain oil and operating means of the compressor carried by the coolant and to be fed back to the compressor, is provided in over-pressure region B after compressor 4. Safety valve 13 limits the system pressure to counteract possible destructions by possible defects and, thus, excessive pressure. After liquid separator 12, the fluid stream may be led by a switch valve 6 either via flow rate meter 8 and a gas cooler 7 or via a bypass 17 circumventing the flow rater meter and the gas cooler. A shut-off valve 104 is also located at the end of over-pressure region B and, after said valve, the pipe leads to a throttle device 5 situated between over-pressure region B and subsequent high-pressure side region C. A connector leading to a second drain valve V2 is provided between shut-off valve104 and throttle device 5. A controlled expansion valve is used as throttle device 5 in the illustrated embodiment. The throttle device may also be realized in a different manner, for example, by an orifice having a bypass or an orifice not having a bypass, or a fixed throttle in conjunction with a rotation-controlled compressor.

High-pressure side region C starting after throttle device 5 has a shut-off valve 105 and measuring devices 16', via which the pressure and the temperature may be measured at the supply hose leading to the high-pressure side of the air conditioner. A connector leading via a new oil valve 110 to a new oil container 15 is provided between throttle device 5 and shut-off valve 105. High-pressure side region C ends at high-pressure side coupler 1', which connects the service device to the high-pressure side of the air conditioner.

As can be seen from Figure 1, by opening connection valves 101 and 105 and inboard valves 102, 103, and 104, a continuous fluid connection, leading from low-pressure side coupler 1 via oil separator 2, evaporator 3, filter dryer 11, compressor 4, liquid separator 12, switching valve 6 switched to bypass 17, bypass 17, and throttle device 5 to high-pressure side coupler 1', may be established between low-pressure side coupler 1 and high-pressure side coupler 1'. In the following, this path is referred to as circuit fluid connection 201, which is illustrated schematically and in a highly simplified overview once more in Figure 2A. Circuit fluid-system 201 forms, in conjunction with the pipes of the air conditioner, a continuous circuit system. It shall be noted that circuit fluid connection 201 circumvents gas cooler 7 situated in the over-pressure region in that switch valve 6 is switched in the direction of bypass 17. The functional relevance of circuit fluid connection 201 is explained in detail within the context of the description of the method according to the present invention.

The fourth region of the device is storage region D, made up of a storage container 9 and a weighing unit 19 situated at said storage container 9. The pipe running into storage container 9 may be shut off by a shut-off valve 108. A first pipe leads from storage region D via shut-off valve 106 to low-pressure side region A and a second pipe leads via shut-off valve107 to over-pressure region B, and this pipe runs into the outlet of gas cooler 7.

As it is clear to a skilled person, using valves 101-110 , V1 and V2, and switch valve 6, a plurality of different fluid connections may be realized by the components and pipes of the device illustrated in Figure 1. By opening valves 101,102,103, 107, and 108 and switching switch valve 6 in the direction of flow rate meter 8 and gas cooler 7, for example, a drain fluid connection 202 may be established, via which the coolant from the air conditioner is able to be pumped from compressor 4 via gas cooler 7 into storage container 9. Drain fluid connection 202 is schematically illustrated in Figure 2B.

By opening valves 108,106,103, 104, and 105 and switching switch valve 6 in the direction of flow rate meter 8 and gas cooler 7, for example, an in-pumping fluid connection 203 may be established, via which compressor 4 is able to pump coolant out from storage container 9 via flow rate meter 8, gas cooler 7, and throttle device 5 into the high-pressure side of the air conditioner. In-pumping fluid connection 203 is schematically illustrated in Figure 2C.

A method, by which the maintenance device illustrated in Figure 1 may be used in an advantageous manner for carrying out a coolant exchange in an air conditioner of a motor vehicle, is explained hereafter in an exemplary manner.

First, low-pressure side coupler 1 and high-pressure side coupler 1' are connected to respective service ports of the air conditioner of the motor vehicle, and connection valves 101 and 105 are closed. Low-pressure side coupler 1 and high-pressure side coupler 1' are located respectively at the end of a connection hose 20, 20', which is able to easily reach the service ports in the car. Preferably, a combined connector may also be used, by which both connectors may be connected to the air conditioner in a single process step. As soon as the connection is established, the mixture of coolant and compressor oil located in the air conditioner flows into connection hoses 20, 20', and an equilibrium state is established, the pressure and the temperature of the coolant being displayed on measuring devices 16,16'. In a typical, exemplary air conditioner of a motor vehicle having R744 as coolant, the CO_2 in the air conditioner has, after an equilibrium state has been established at room temperature (approximately 20°C), a pressure in the region of 60 bar. The filling degree of the unit for a full air conditioner of a motor vehicle is conventionally in the region of maximally 260 kg/m³ or, if applicable, below.

It is to be noted that the operating pressures of the air conditioner (which conventionally are, for example, at approximately 130 bar on the high-pressure side and approximately 40 bar on the low-pressure side) do not play a role when maintaining the unit because the compressor of the air conditioner (and the gas cooler and the evaporator of the air conditioner) is deactivated during service. When, within the context of this application, the term *high-pressure side of the air conditioner* is used, merely the pipe section of the air conditioner is meant that is located between the compressor and the throttle of the air conditioner and that runs via the gas cooler and, in the case of CO_2 as coolant, the inboard heat exchanger of the cooling system. As it is clear to a skilled person, when the compressor is standing still, the entire circuit of the air conditioner rapidly adjusts substantially the same pressure and phase state. This idle phase state lies, in the present example, at approximately 20 °C, 250 kg/m_3 and 57 bar and is referenced as point I in the phase diagram of Figure 3.

After connecting the service device, inboard valve 102 and vacuum pump valve 109 are opened and the volume of oil separator 2 is evacuated by the vacuum pump. Subsequently, after closing vacuum valve 109, shut-off valve 101 is opened, leading to that the coolant of the air conditioner flows into the oil separator. The change state taking place in this instance can be recognized as an isenthalpic expansion between the points I and II in the diagram of Figure 3. In the illustrated example, point II is approximately at -2°C and 33 bar, and resulting in approximately doubling the volume.

If one would now, proceeding from point II, start to drain the coolant via drain valves V1 and V2 (or to pump it into the storage container) and, by doing so, rapidly relax said coolant, the coolant would solidify to dry ice at a pressure of 5.18 bar (at a temperature of approximately -59 °C). Therefore, it so far has been common practice to wait, after a first relaxation to approximately 18 bar, until the CO_2 has completely evaporated in the cooling circuit. Subsequently, the drain or suction process may be continued now outside of the wet steam region.

The device according to the present invention makes it now possible to prevent this wait time and, thus, to shorten the complete duration required for the service. For this purpose, circulation fluid connection 201 (according to Figure 2A) is established in the next step by respective switching of the valves. Subsequently, the coolant is circulated in circulation fluid connection 201 via compressor 4, and the coolant runs sequentially from low-pressure side coupler 1 to high-pressure side coupler 1' through the following phases (Figure 3) or components (Figure 1):

Old oil carried by the coolant is separated in oil separator 2 and is collected in an old oil container 14. The amount of the collected old oil may, for example, be determined by a scale.

In the evaporator, the CO_2 is heated isobarically out of the wet steam curve (state change from point II to point III in Figure 3) and, thereafter, runs through a filter dryer in order to remove potential pollutants or humidity. In the present example, the coolant at point III has a pressure of approximately 33 bar and a temperature of approximately 15°C.

Compressor 4 compresses the coolant isentropically to a supercritical pressure of approximately 90 bar, and the pressure is controlled by throttle device 5 (state change from point III to point IV in Figure 3). The temperature at point IV is approximately 100 °C. Liquid separator 12 serves to lead swept-away oil of compressor 4 back to said compressor.

Via switch valve 6 and bypass 17, the coolant directly reaches throttle device 5 in circumventing gas cooler 7, in which an isenthalpic expansion (from point IV to point V in Figure 3) to a pressure of approximately 67 bar and a temperature of approximately 80°C occurs.

Then, a mixing with the coolant located in the accumulator of the air conditioner takes place in the air conditioner, and the coolant initially has the original phase state (point II in Figure 3). The mixing changes the phase state in the air conditioner at constant compression, and the phase state shifts to mixing point II', which in the diagram is indicated at approximately 4°C and approximately 38 bar. Mixing point II' only represents a virtual point because, in the actual circuit process, this point constantly shifts along the isodenses (at approximately 125 kg/m³).

Starting from mixing point II', the further course of the circuit process via the points III' (15 °C, 38 bar), IV' (85°C, 90 bar), V' (61 °C, 61 bar) to the next mixing point II" (approximately 10 °C, 43 bar) is indicated.

The circuit process is carried out until a phase state according to point II^E is reached in the air conditioner, and this point lies at an enthalpy which isenthalp lies completely outside of dry ice region 21. The precise position of end point II^E is highly dependent on the original filling degree of the unit and lies preferably at a specific enthalpy of approximately 450 kJ/kg or above. Proceeding from point II^E, the CO_2 may be drained and out-pumped without the coolant freezing.

Via measuring devices 16, 16', a value pair for the pressure and the temperature in the circuit may be read-out during the circuit process, from which it may be determined whether a sufficient enthalpy for draining is already reached at the specified filling degree. For this purpose, it is not compulsory to precisely know the actual filling degree (thus, the compression) of the unit. If the maximum filling degree is used as reference value for the method, the same circuit process would, in the case that the filling degree were actually lower, merely result in an end point II^E having a higher enthalpy, so that a freezing in the subsequent drain step still is not a concern.

For the illustrated circuit process it is assumed that neither the mass of the circulating coolant nor the volume of the fluid system changes and, thus, the compression of the cooling medium (considering the overall system in its state of equilibrium) remaining constant during the circuit process. For this reason, phase states II, II',II" through II^E in Figure 3 are located on the same isodense. It might, however, also be possible to drain a portion of the coolant during the circuit process, for example, by opening drain valve V2 in a controlled manner, in order to reach a point II^E, at which the coolant has a different compression than at point II. For example, it might be achieved that all points II, II', II" through II^E are located on one isobar. In this way, the method according to the present invention might also be realized by less powerful compressors that exhibit a lower performance and are, for example, suitable only for nominal pressures of only 80, 70, 60 bar or less.

Draining may occur by opening drain valves V1, V2; however, the device according to the present invention also enables to collect the coolant and to make it accessible to a recycle. For this purpose, inboard valve 104 is closed between over-pressure region B and high-pressure side region C and switch valve 106 is switched to the side of gas cooler 7. By opening shut-off valve 106 on the over-pressure side and storage container valve 108, a drain fluid connection 202 is able to be formed, which leads from low-pressure side coupler 1 via oil separator 2, evaporator 3, filter dryer 11, compressor 4, liquid separator 12, switch valve 6, flow rate meter 8, and gas cooler 7 to storage container 9. Now, compressor 4 is able to pump the coolant via low-pressure side coupler 1 out of the circuit of the air conditioner into the storage container.

After out-pumping the coolant, storage container valve 108 is closed and the remaining CO_2 is drained via drain valves V1 and V2 until the pressure in the unit has been lowered to ambient pressure. Subsequently, connection valves 101, 105, inboard valves 102, 103, 104 and vacuum pump valve 109 are opened and the system is evacuated via vacuum pump 10, and the vacuum pump is able to reach a pressure in the order of approximately 1 mbar. Water possibly situated in the unit may evaporate also at this pressure and is suctioned out together with the remaining coolant via vacuum pump 10.

Now that the system has been completely evacuated, the amount of compressor oil collected in old oil collection container 14 is measured and a respective amount of new oil is brought, by opening new oil valve 110 in a controlled manner into high-pressure side region C from new oil container 15. The vacuum dominating in the system results in that the oil is suctioned into the system without further action. In the subsequent in-pumping step, the inflowing coolant then flushes the oil into the circuit of the air conditioner.

For subsequently refilling the air conditioner, inboard valves 103, 104, 105 are then opened and the switch valve is switched in the direction of gas cooler 7. Furthermore, low-pressure side shut-off valve 106 and storage container valve 108 are opened, so that in-pumping fluid connection 203 is established, which leads from storage container 9 via filter dryer 11, compressor 4, liquid separator 12, switch valve 6, check valve 18, throttle device 5, and high-pressure side coupler 1' into the high-pressure side of the air conditioner. Then, compressor 4 pumps CO_2 from the storage container via in-pumping fluid connection 203 into the air conditioner, and the amount of the coolant to be pumped in is measured in flow rate meter 8, in order to fill the required amount of coolant into the air conditioner according to manufacturers' instructions. For this purpose, the high pressure of the compressor is controlled by throttle device 5. When in-pumping, connection valve 101 and first inboard valve 102 remain closed, so that the oil separator is not filed with coolant.

After in-filling, connection valve 105 is closed and couplers 1 and 1' are detached from the service ports of the air conditioner.

As a variation of the special exemplary embodiments illustrated in the figures, merely serving the purpose of explaining the present invention, the device according to the present invention may also be carried out in a plurality of other manners. In particular, the arrangement of components may be changed and specific components may also be completely removed, provided that the functionality and the execution of the method according to the present invention are not impacted.

For example, the order of oil separator 2 and evaporator 3 may be exchanged without impacting functionality. Flow rate meter 8 is not compulsory as the filling amount may, as known in professional circles, be determined differently, for example, by measuring the masses of the coolant bottle when simultaneously compensating for the amount of coolant in the service unit. The flow rate meter also may be situated in a different location in the system.

Filling the air conditioner of the motor vehicle and, if applicable, also the recycling in a bottle might be carried out also by a simplified system, in which a gas cooler 7 is not provided. If the CO_2 is not to be fed to a recycle, switch valve 6 would also not be necessary and valves 107 and 108 could also be omitted, and the flow rate meter could, if applicable, be situated in the circuit upstream of valve 104.

According to the present invention, skilled people may, without any innovative intervention, create a plurality of modified embodiments without deviating from the scope of protection of the appended claims.

Reference characters:

Low-pressure side coupler 1
High-pressure side coupler 1'

Oil separator 2

Evaporator 3

Compressor 4

Throttle device 5

Switch valve 6

Gas cooler 7

Flow rate meter 8

Storage container 9

Vacuum pump 10

Filter dryer 11

Liquid separator 12

Safety valve 13

Old oil collection container 14

New oil container 15

Measuring devices 16, 16'

Bypass 17

Check valve 18

Weighing unit 19

Connection hose 20, 20'

Dry ice region 21

Connection valves 101, 105
Inboard valves 102, 103, 104

High-pressure side and over-pressure side shut-off valve 106, 107

Storage container valve 108

Vacuum pump valve 109

New oil valve 110

Drain valves V1, V2

Circulation fluid connection 201

Out-pumping fluid connection 202

In-pumping fluid connection 203

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A device for maintaining an air conditioner, the device comprising: a low-pressure side region, which is connectable to a service port on a low-pressure side of the air conditioner via a low-pressure side coupler; and a high-pressure side region, which is connectable to a service port on a high-pressure side of the air conditioner via a high-pressure side coupler,

wherein a compressor is provided between the low-pressure side region and the high-pressure side region, and

wherein between the compressor and the high-pressure side region, an over-pressure region is provided, which is connected to the high-pressure side region via a throttle device.

2. The device according to claim 1, wherein the air conditioner comprises an air conditioner using CO_2 or R744 as a coolant.

3. The device according to claim 1 or 2, wherein the low-pressure side region is connected to a vacuum pump.

4. The device according to any one of claims 1 to 3, wherein, starting from the low-pressure side coupler, a circuit fluid connection can be released by a first set of valves via

the low-pressure side region,

the compressor,

the over-pressure region,

the throttle device, and

the high-pressure side region

to the high-pressure side coupler.

5. The device according to claim 4, wherein at least one of an oil separator, an evaporator and a filter dryer is provided in the low-pressure side region, and wherein at least one of a liquid separator, a gas cooler and a flow rate meter is provided in the over-pressure region.

6. The device according to claim 4 or 5, wherein a switch valve, which is able to reroute the circuit fluid connection to a bypass circumventing the gas cooler, is provided in the over-pressure region between the compressor and the gas cooler.

7. The device according to any one of claims 1 to 6, wherein a storage region provides a storage container, which is connectable via a second set of valves to the over-pressure region, or the low-pressure side region, or both.

8. The device according to claim 7, wherein, starting from the low-pressure side coupler, an out-pumping fluid connection can be released by the valves via

the low-pressure side region,

the compressor, and

the over-pressure region

to the storage container.

9. The device according to claim 7 or 8, wherein, starting from the storage container, an in-pumping fluid connection can be released by the valves via

the compressor,

the over-pressure region, and

the high-pressure side region

to the high-pressure side coupler.

10. The device according to any one of claims 1 to 9, wherein drain valves are connected to the low-pressure side region, or the high-pressure side region, or both.

11. The device according to any one of claims 1 to 10, wherein a new oil container is connected to a fluid system of the air conditioner via a new oil valve.

12. A method of operating a service device for an air conditioner wherein, the service device for establishing a circuit is, via a low-pressure side coupler and a high-pressure side coupler, connected to a low-pressure side or a high-pressure side of the air conditioner, and wherein the method comprises transferring a coolant in the air conditioner from a phase state II within a wet steam curve via a circuit process to a

phase state II^E outside of the wet steam curve, wherein a specific enthalpy in phase state II^E has a value which isenthalp lays completely outside of a dry ice region.

13. The method according to claim 12, wherein the air conditioner comprises an air conditioner using CO_2 or R744 as the coolant.

14. The method according to claim 12 or 13, wherein the circuit process starting from phase state II comprises the following state changes:

a. isobaric heating of the coolant to outside of the wet steam curve (II => III);
b. isentropic compression to an over-pressure above the pressure of the initial phase state II;
c. isenthalpic expansion (I => V); and
d. mixing with the coolant in the air conditioner (V => II').

15. The method according to claim 14, wherein the circuit process starting from phase state II comprises isentropic compression to an over-pressure above the critical pressure of the coolant (III => IV).

16. The method according to any one of claims 12 to 15, further comprising, before the step of transferring, the following steps:

evacuating a sealed-off region of the service device that connects at the low-pressure side of the air conditioner and that is separated from said low pressure side by a closed valve; and

opening a fluid connection between the evacuated region of the service device and fluid system of the air conditioner (expansion I => II).

17. The method according to claim 16, further comprising evacuating the service device after draining.

18. The method according to claim 17, further comprising out-pumping the coolant with a vacuum pump.

19. The method according to claim 17 or 18, wherein old oil is separated and the amount of old oil separated from the air conditioner is determined during the circuit process, wherein, after removing the coolant and before refilling the air conditioner, new oil is brought into the evacuated fluid system, and wherein the amount of new oil is determined on the basis of the amount of separated old oil.

20. The method according to any one of claims 12 to 18, wherein old oil is separated and the amount of old oil separated from the air conditioner is determined during the circuit process.

21. The method according to any one of claims 12 to 20 further comprising, after the step of transferring, pumping the coolant out of the air conditioner into a storage container.

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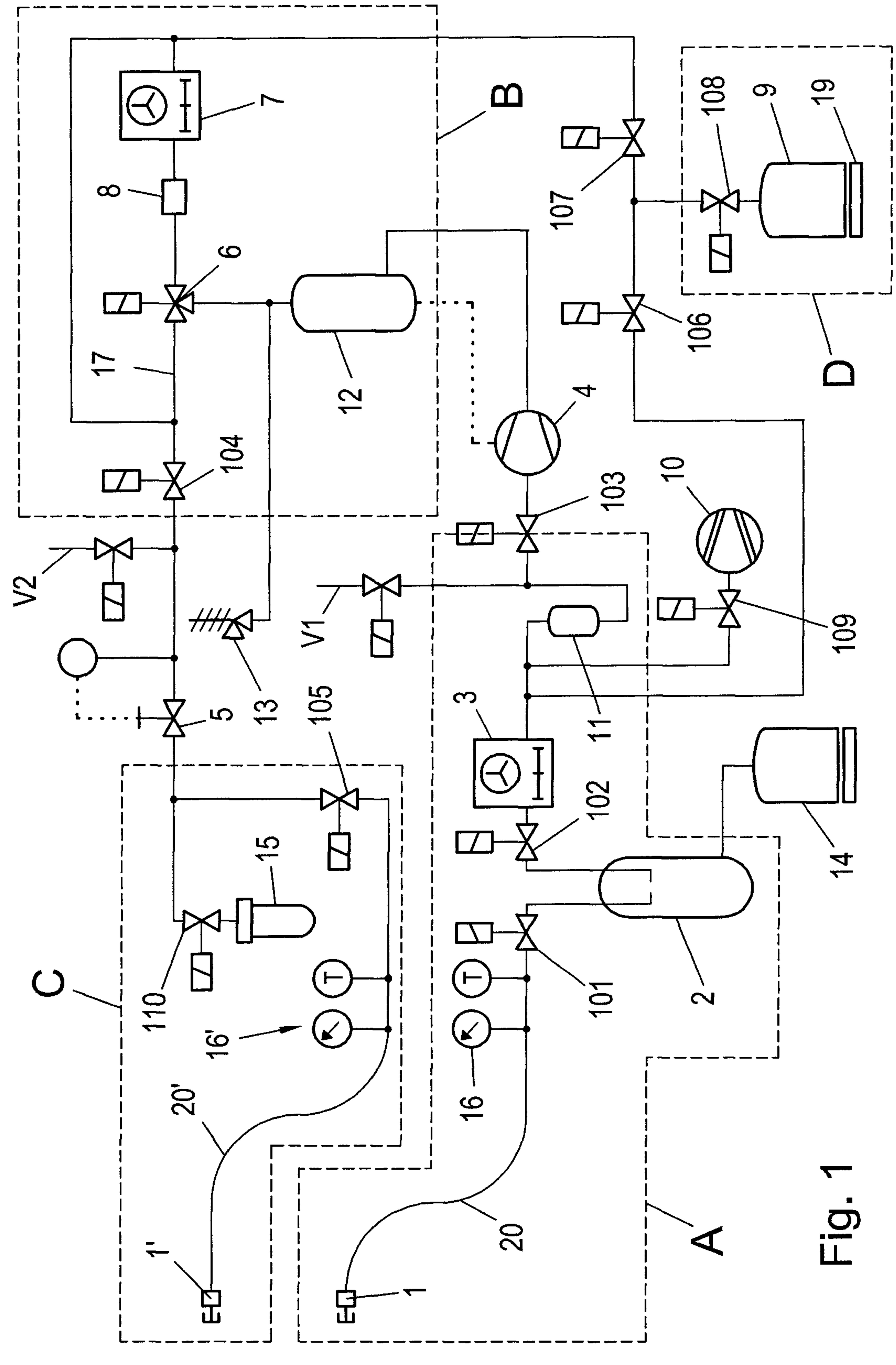
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V1
V2
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T

Fig. 1

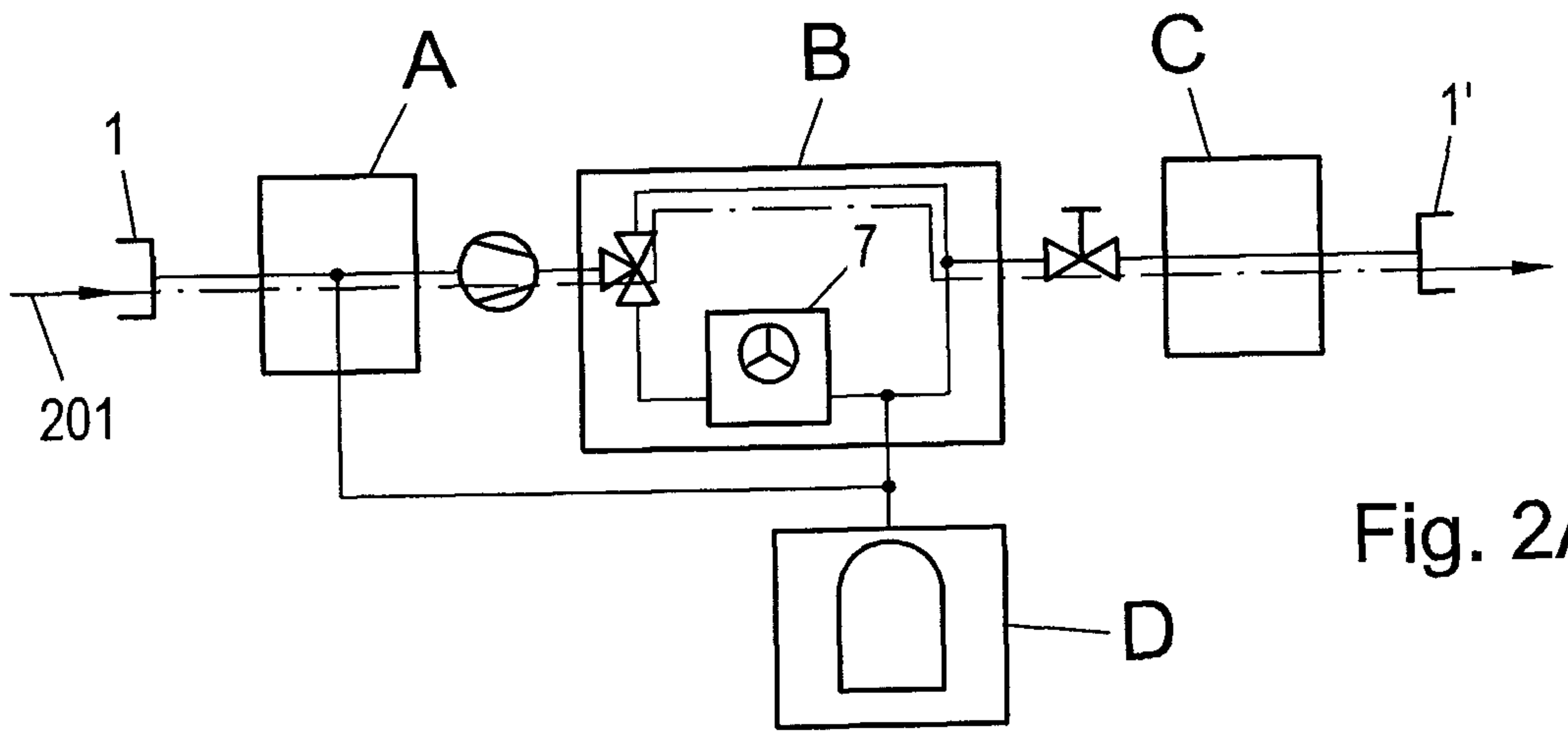


Fig. 2A

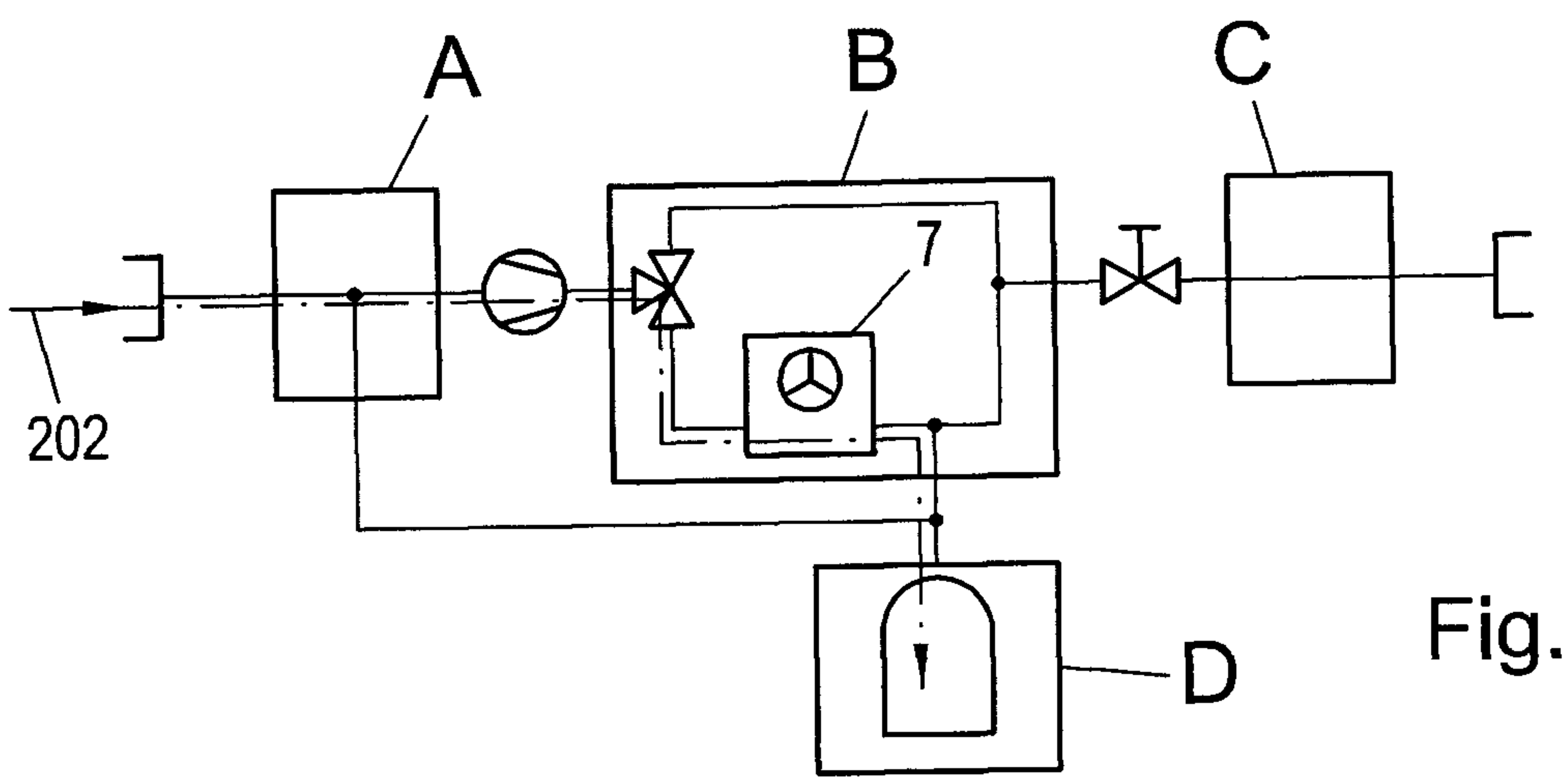


Fig. 2B

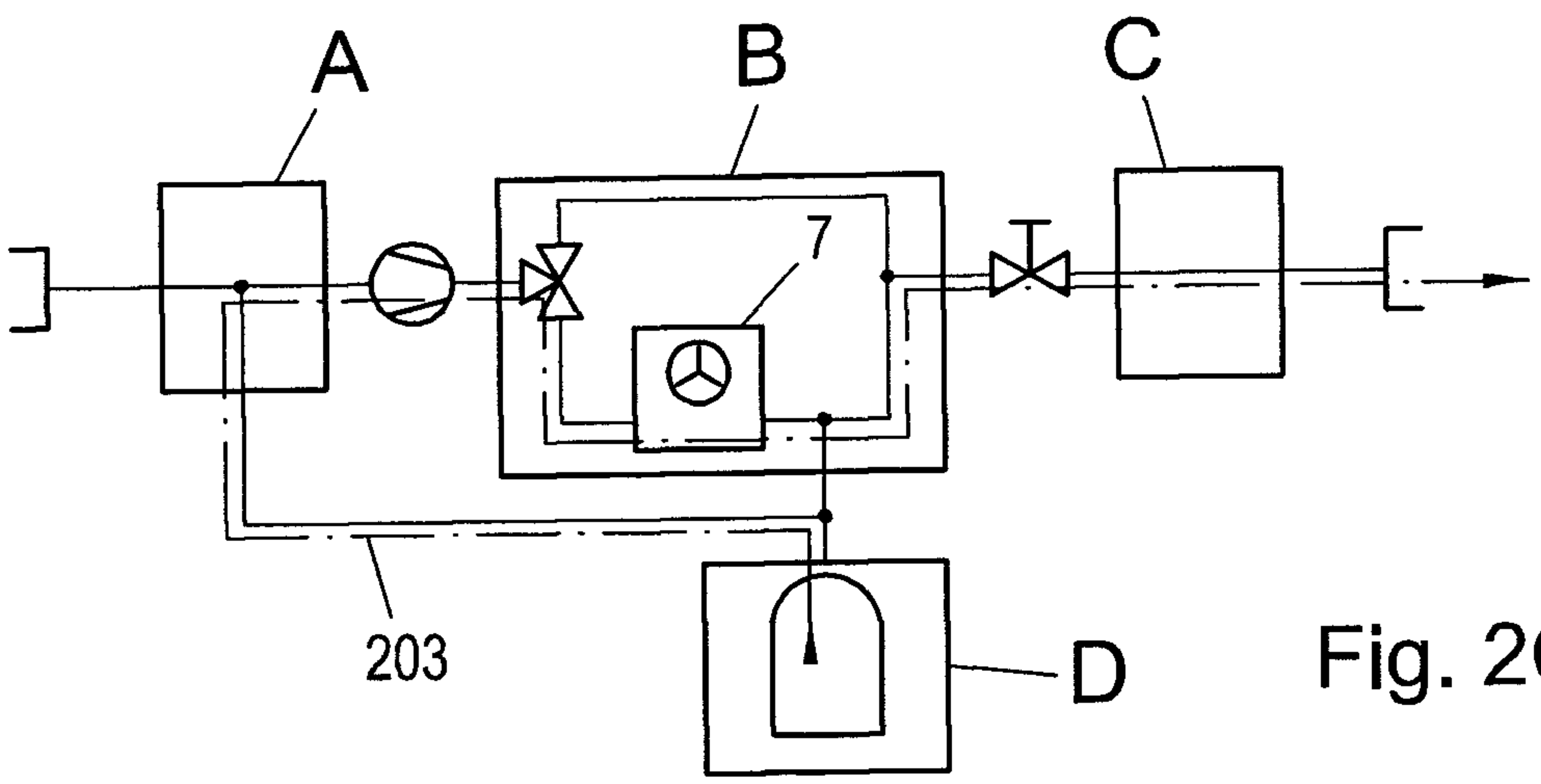
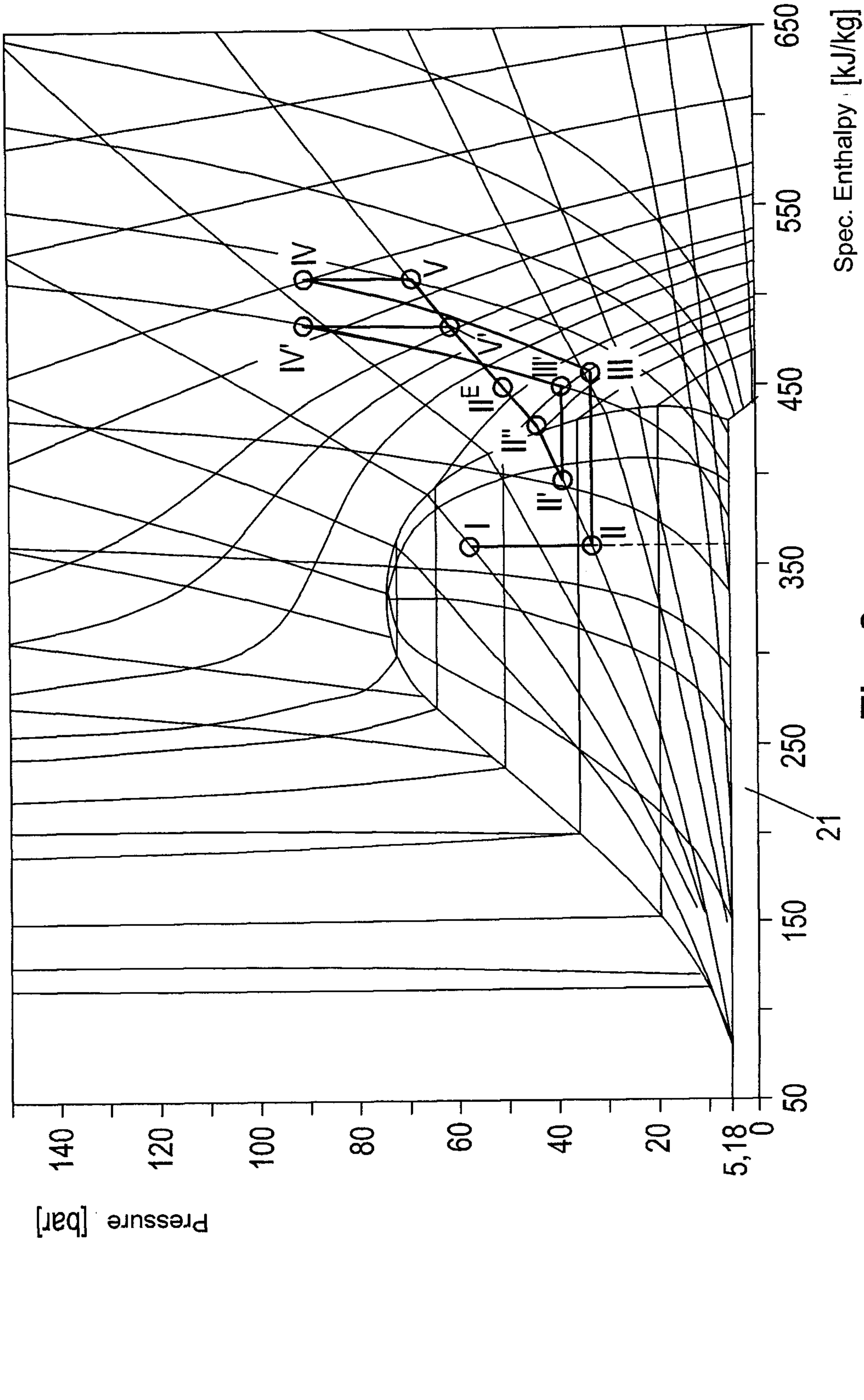


Fig. 2C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0
Spec. Enthalpy [kJ/kg]
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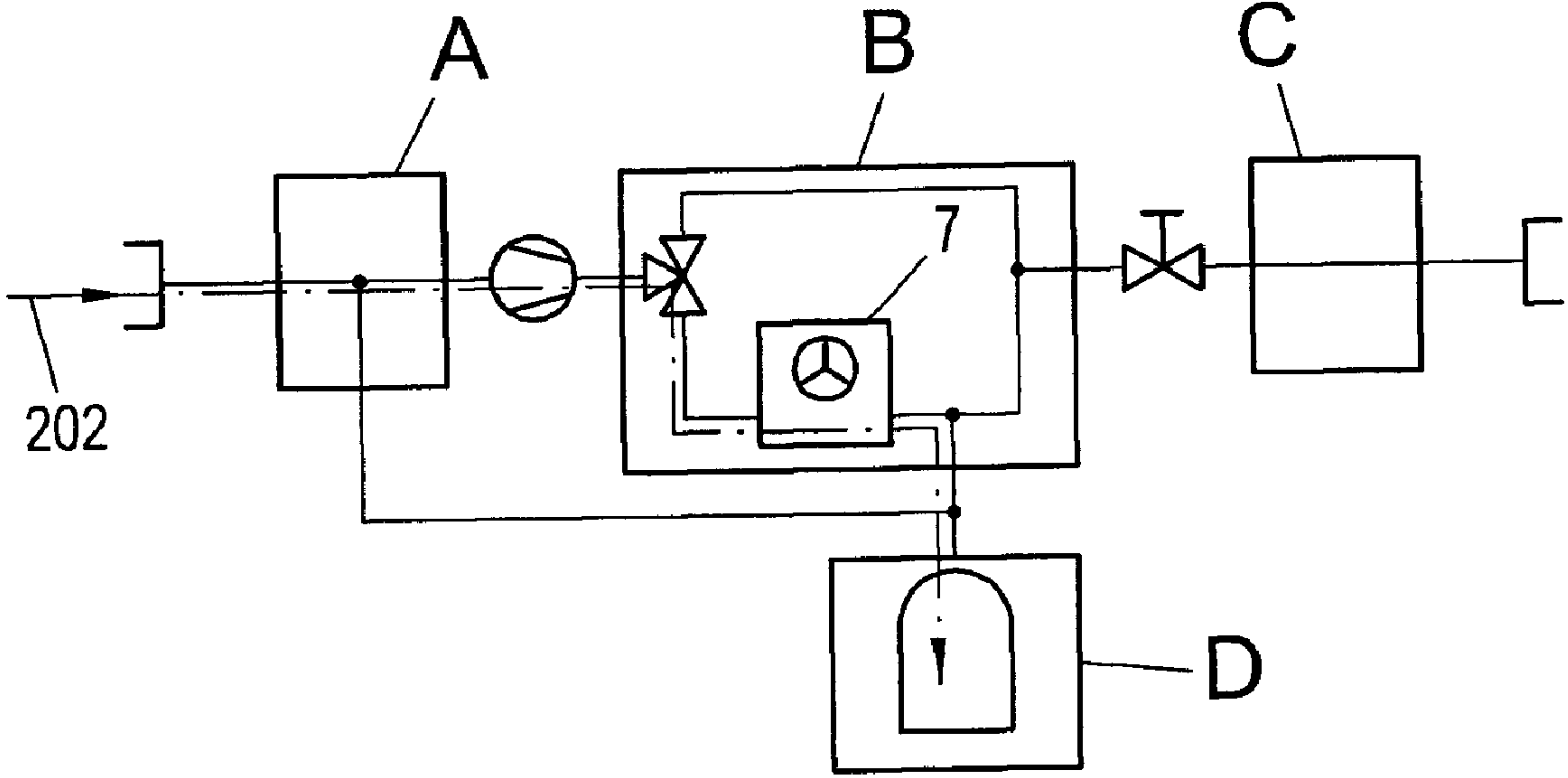
450
550
650
I
II
II'
II''
II^E
III
III'
IV
IV'
V
V'
21

Fig. 3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