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(54) NOISE REDUCTION OF A COMPRESSOR

(57) A compressor is disclosed, comprising:
- a housing (2) comprising a compressor chamber (3) configured to compress a working fluid;
- at least one reservoir (4) configured to store working fluid before being compressed in the compressor chamber (3); and
- at least one inlet port (5, 11) in communication with the reservoir (4), wherein
the compressor is configured to supply working fluid from the reservoir (4) to the compressor chamber (3) through the inlet port (5, 11).

Further, a pneumatic system and a vehicle are disclosed.

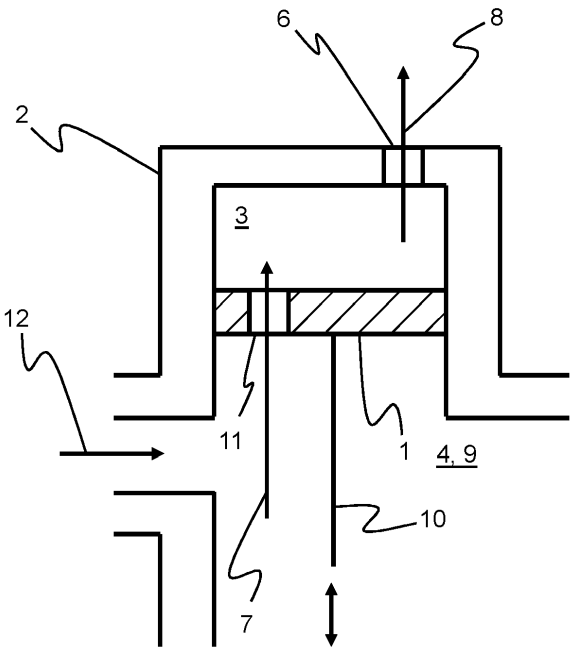

Fig. 1

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Description

[0001] The current invention relates to a compressor with a noise reducing design, a pneumatic system and a vehicle with such a compressor.

[0002] Compressors, in particular pneumatic compressors, are used for several vehicle applications. For example, compressors are used to supply a working fluid, such as air, to a system, in particular a pneumatic braking system, an air suspension, a container for compressed air and/or an air supply system for a fuel cell.

[0003] During operation, the compressor can produce noise in particular due to the suction of working fluid into the compressor or due to the vibration of the compressor housing.

[0004] It is therefore the object of the current invention to solve this problem.

[0005] This object is solved by the subject matters of the independent claims. Advantageous embodiments of the invention are the subject matters of the dependent claims.

[0006] According to the invention, a compressor is provided comprising:

- a housing comprising a compressor chamber configured to compress a working fluid;
- at least one reservoir configured to store working fluid before being compressed in the compressor chamber; and
- at least one inlet port in communication with the reservoir, wherein

the compressor is configured to supply working fluid from the reservoir to the compressor chamber through the inlet port.

[0007] The working fluid contained in the compressor chamber is compressed by reducing the volume of the compressor chamber.

[0008] In general, the compressor can comprise more than just one compressor chamber. In particular when two or more compressor chambers are provided, every compressor chamber is identical to the other(s). For example, when the compressor chambers are acting as cylinders, each cylinder advantageously has the same shape. When the compressor comprises more than one compressor chamber, one reservoir can be provided to store working fluid for each compressor chamber. Alternatively, when the compressor comprises more than one compressor chamber, more than one reservoir can be provided, wherein working fluid is supplied to one or a few compressor chambers from one reservoir and wherein it is supplied to the other compressor chamber(s) from another reservoir.

[0009] The reservoir preferably acts as huge volume in comparison to the maximum volume of the compressor chamber. In particular, the volume of the reservoir is ten times or more bigger than the volume of the maximum volume of the compressor chamber. Therefore, the amount of working fluid supplied to the compressor chamber is 10% or less of the volume of the reservoir. Accordingly, a pressure impulse caused by the supplying of the working fluid into the compressor chamber is damped. The damping effect is stronger the smaller the maximum volume of the compressor chamber is compared with the volume of the reservoir.

[0010] Preferably, the at least one reservoir is provided in the housing and/or by a cavity of the housing. In particular, the cavity of the housing can be configured for another purpose, such as for comprising further elements of the compressor like a shaft, bearings or a control unit, such as an ECU. The working fluid contained in the reservoir can act as a cooling fluid for these elements. Advantageously, this leads to a compact design of the compressor.

[0011] Preferably, the at least one reservoir communicates directly or via intermediate elements with the atmosphere. In this case, as working fluid air is contained in the reservoir. In general, the reservoir is in communication to a source for working fluid. In the case that the working fluid contains air, the reservoir preferably comprises an inlet port to be supplied with air from the atmosphere. As intermediate elements an air dryer or humidifier, a valve and/or a throttle can be provided.

[0012] Preferably, the at least one reservoir is configured as or comprises a silencer. In particular, the reservoir can comprise or be configured as a quarter-wave tube for reducing resonance effects and therefore for reducing noise. Further preferably, the silencer or the quarter-wave tube can be provided on the inlet port of the reservoir to reduce noise from the inside of the reservoir.

[0013] The compressor preferably comprises at least one compressing element in the compressor chamber to compress the working fluid. In particular, the at least one compressing element is configured

[0014] Preferably, the compressor comprises a rotatable shaft, which is preferably provided in a cavity of the housing, and which is configured to move the least one compressing element.

[0015] Preferably, the compressing element comprises a piston guided in the compressor chamber, wherein the piston limits the compressor chamber, wherein the piston is configured to be moved between a maximum lifting position and a minimum lifting position, wherein the movement of the piston changes the volume of the compressor chamber. In this embodiment, the compressor chamber acts as a cylinder, wherein the piston is movable along the axis of the cylinder.

[0016] The compressor is preferably configured as a piston compressor, in particular, a multi-tumble piston compressor.

[0017] The compressor preferably comprises at least two pistons guided in separate cylinders. The cylinders are preferably arranged in an angular arrangement, in particular regularly spaced, to reduce vibration of the compressor.

[0018] Preferably, the compressing element compris-

es an impeller wheel and/or a screw element.

[0019] Preferably the cavity comprising the shaft is configured as the at least one reservoir. In this case, existing space in the housing can be used to store working fluid. Therefore, the size of the compressor can be reduced as there is no need for providing a separate reservoir.

[0020] In particular, the at least one reservoir is configured to guide working fluid flowing into the at least one reservoir in such way, that cooling of the shaft and/or bearings of the shaft is executed. If there is a permanent lubricant provided in the reservoir, for example in the bearings, cooling can avoid the lubricant to heat up too much and further to avoid the heated lubricant flowing out of the bearings or passing into the working fluid contained in the reservoir. Therefore, malfunction or damage of the compressor can be avoided.

[0021] Preferably, the compressor comprises an outlet port configured to guide compressed working fluid out of the compressor chamber, wherein at least a part of the outlet port is configured as a part of the housing, in particular forming a stiffening rib, to stabilize the housing and/or to reduce vibration and therefore in particular noise. This embodiment can also be realized as a separate or additional embodiment. Providing an outlet port extending at least partially as a part of the housing can be provided at a compressor as described above or at another compressor that has at least the housing in common with the above described compressor.

[0022] Preferably, the working fluid comprises air and further preferably, the compressor is configured to supply the working fluid to a pneumatic system, in particular a pneumatic braking system, an air suspension, a container for compressed air and/or an air supply system for a fuel cell.

[0023] The inlet port connecting the reservoir and the compressor chamber is preferably provided in the housing. In particular, if the compressor comprises a piston, the inlet port can comprise an opening in the side face of the cylinder, wherein the opening communicates with the reservoir. The inlet port is closed or disconnected from the compressor chamber when the piston moves up to the maximum lifting position and overruns the opening. Then the compressor chamber is closed and the working fluid is compressed due to the reducing volume of the compressor chamber.

[0024] Alternatively or additionally, the inlet port is provided in the compressing element. In particular, if the compressor comprises a piston, the inlet port can comprise a through hole extending through the piston and connecting the compressor chamber to the reservoir. The inlet port can further be configured as a self-closing inlet port, wherein the inlet port is closed due to the increasing pressure of the compressed working fluid when the piston is moved to the maximum lifting position.

[0025] Preferably, the at least one reservoir comprises at least two containers to store the working fluid at least partially. Preferably, the at least two containers are in serial or in parallel communication with each other or in communication witch each other via the compressor chamber.

[0026] The at least two containers are preferably in communication with each other, wherein the at least two containers can be connected in serial and/or in parallel. The serial connection between the at least two containers can be realized directly or via one or more intermediate elements. As intermediate elements an air dryer or humidifier, a valve and/or a throttle can be provided. A parallel connection between the at least two containers can be provided directly or via one or more intermediate elements. As intermediate elements an air dryer or humidifier, a valve and/or a throttle can be provided. Further, the at least two containers can be configured to supply working fluid stored in the at least two containers separately to the compressor chamber via at least two separate inlet ports, accordingly. At least one of the at least two containers can be configured as a part of the housing or be provided by a cavity of the housing.

[0027] Providing at least two containers to store the working fluid before compressing in the compressor chamber advantageously enlarges the volume of the at least one reservoir leading to a reduction or damping of a pressure impulse caused by the supplying of the working fluid into the compressor chamber. According to an advantageous embodiment, each container of the at least two containers can be configured for damping an impulse caused by a particular resonance effect of the supplying of the working fluid into the compressor chamber. A connection, in particular a serial connection, of the containers can be configured in such way, that a pressure impulse is continuously damped from one container to the next container. A parallel connection causes advantageously a reduction of the flow resistance when working fluid is supplied to the compressor chamber.

[0028] According to the invention, a pneumatic system, in particular a pneumatic braking system, an air suspension, a container for compressed air and/or an air supply system for a fuel cell, is provided. This pneumatic system comprises a compressor as described above.

[0029] According to a further aspect of the invention, a vehicle, in particular a commercial vehicle, is provided. This vehicle comprises a compressor as described above or a pneumatic system as described above.

[0030] Preferably, the compressor of the vehicle is configured to supply air to at least one of these systems of the vehicle:

- a fuel cell,
- a pneumatic braking system,
- an air suspension,
- a compressed air reservoir.

[0031] Preferably, the vehicle is configured as a commercial vehicle, a truck, a trailer, a bus, and/or a combination of a towing vehicle and a trailer.

[0032] Additionally or alternatively, the vehicle is con-

figured as an electric, hybrid or conventional vehicle. As an electric or hybrid vehicle, the vehicle can be driven by a fuel cell based system and/or by a battery system.

[0033] In particular, the compressor can act as an air supply unit, preferably exclusively, for a trailer, wherein the compressor is installed in the trailer or in a corresponding towing vehicle.

[0034] In the following preferred embodiments of the invention are described referring to the attached drawings.

Fig. 1 shows a first embodiment of the invention, and

Fig. 2 shows a second embodiment of the invention.

[0035] **Fig. 1** shows a first embodiment of the invention. This embodiment refers to a piston compressor.

[0036] A housing 2 is shown in a sectional view comprising a piston 1 that is guided in the housing 2, in particular in a cylinder, and configured to be movable in a perpendicular direction between a maximum lifting position and a minimum lifting position as indicated by the double arrow in the drawing. The piston 1 is moved generally according to the movement of a driving device (not shown) of the compressor. In this embodiment, the driving device comprises a rotatable shaft (not shown) provided in a cavity 9 of the housing 2, wherein the movement is transmitted to the piston 1 via a connection rod 10. The housing 2 and the piston 1 form a compressor chamber 3 for compressing a working fluid, wherein the movement of the piston 1 adjusts the volume of the compressor chamber 3.

[0037] The cavity 9 acts as a reservoir 4 for the working fluid. The working fluid is supplied to the reservoir 4 as indicated by the arrow 12. For example, air can be supplied to the reservoir.

[0038] The piston 1 comprises an inlet port 11 as a through-hole connecting the compressor chamber 3 and the reservoir 4. The inlet port 11 is configured as a self-closing inlet port that closes due to increasing pressure in the compressor chamber when the piston 1 is moved to the maximum lifting position. Further, the housing 2 comprises an outlet port 6, wherein compressed working fluid can flow out of the compressor chamber 3 as indicated by the arrow 8. Valves or in general devices controlling the working fluid flowing through the ports 6, 11 are not shown to keep the drawing simple.

[0039] The compressor works as follows. When the piston 1 is moved to its minimum lifting position, the volume of the compressor chamber 3 is increased. Therefore, the pressure in the compressor chamber 3 is lower than the pressure in the reservoir 4. This leads to the opening of the inlet port 11 and therefore, working fluid flows from the reservoir 4 into the compressor chamber 3.

[0040] When the piston 1 is moved to the maximum lifting position again, the pressure in the compressor chamber 3 increases. Therefore, the inlet port 11 closes again and the working fluid contained in the compressor chamber 3 is compressed. The compressed working fluid is then exhausted via the outlet port 6.

[0041] According to this advantageous embodiment, the volume of the reservoir 4 is more than ten times bigger than the volume of the compressor chamber 3 when the piston 1 is in its minimum lifting position. Accordingly, a pressure impulse caused by the supplying of the working fluid from the reservoir 4 into the compressor chamber 3 is damped as described in the general part of the description.

[0042] Further, elements, such as the shaft, bearings etc. contained in the reservoir 4 respectively in the cavity 9 can be cooled by the inflowing working fluid 12, which can be guided to the elements, accordingly.

[0043] Further, designing the cavity 9, which is primary used as a crank shaft housing, as a reservoir 4 allows a compact design of the compressor, since no separate reservoir has to be provided.

[0044] **Fig. 2** shows a second embodiment of the invention. As this embodiment is similar to the embodiment shown in Fig. 1, only the differences thereto are explained in the following. Otherwise, reference is made to the description of Fig. 1.

[0045] According to this embodiment, the piston 1 does not comprise an inlet port 11 as shown in Fig. 1. Instead, an inlet port 5 is provided in the housing 2 comprising a channel that is configured to provide a connection between the compressor chamber 3 and the reservoir 4. The channel ends in a side face of the compressor chamber 3 and is located in such way that it is overrun by the piston 1 when the piston 1 is moved to the maximum lifting position. The other end of the channel is permanently connected to the reservoir 4. In particular, it is located in such way, that it is not overrun by the piston 1 moving into the minimum lifting position.

[0046] To supply working fluid from the reservoir 4 to the compressor chamber 3, the piston 1 is moved down to its minimum lifting position. Thereby, the volume of the compressor chamber 3 is increased, causing a lower pressure in the compressor chamber 3 compared to the pressure in the reservoir 4. According to this pressure difference, working fluid is supplied through the inlet port 5 into the compressor chamber 3 as indicated by the arrows 7. When the piston 1 is then moved upwards to its maximum lifting position, the inlet port 5 is closed when it is overrun by the piston 1. From this moment on the compressor chamber 3 is closed and the working fluid contained therein is compressed according to the movement of the piston 1.

[0047] The embodiments shown in the Figures 1 and 2 are not limiting the invention. Furthermore, further embodiments of the invention can be obtained, by combining individual features, of the embodiments.

[0048] For example, an embodiment can comprise an inlet port 11 and an inlet port 5, which are connected to the same or to different compressor chambers 3.

[0049] According to particular embodiments according to the Figures 1 and 2, the working fluid comprises air

and the compressors are configured for supplying the working fluid to a pneumatic system, in particular a pneumatic braking system, an air suspension, a container for compressed air and/or an air supply system for a fuel cell.

LIST OF REFERENCE SIGNS

[0050]

1	piston
2	housing
3	compressor chamber
4	reservoir
5	inlet port
6	outlet port
7	inflowing working fluid
8	outflowing working fluid
9	cavity of the housing
10	connection rod
11	inlet port
12	inflowing working fluid

Claims

1. Compressor comprising:

- a housing (2) comprising a compressor chamber (3) configured to compress a working fluid;
- at least one reservoir (4) configured to store working fluid before being compressed in the compressor chamber (3); and
- at least one inlet port (5, 11) in communication with the reservoir (4), wherein

the compressor is configured to supply working fluid from the reservoir (4) to the compressor chamber (3) through the inlet port (5, 11).

2. Compressor according to claim 1, wherein
the at least one reservoir (4) is provided in the housing (2) and/or by a cavity (9) of the housing (2).

3. Compressor according to one of the preceding claims, wherein
the at least one reservoir (4) communicates directly or via intermediate elements with the atmosphere and as working fluid air is contained.

4. Compressor according to one of the preceding claims, wherein
the at least one reservoir (4) is configured as or comprises a silencer.

5. Compressor according to one of the preceding claims, wherein
the compressor comprises a rotatable shaft, which is preferably provided in a cavity (9) of the housing (2), and which is configured to move at least one compressing element in the compressor chamber (3) to compress the working fluid.

6. Compressor according to claim 5, wherein
the compressing element comprises a piston (1) guided in the compressor chamber (3), wherein the piston (1) limits the compressor chamber (3), wherein the piston (1) is configured to be moved between a maximum lifting position and a minimum lifting position, wherein the volume of the compressor chamber (3) is changed by the movement of the piston (1).

7. Compressor according to one of the claims 5 or 6, wherein
the compressing element comprises an impeller wheel and/or a screw element.

8. Compressor according to one of the claims 5 to 7, wherein
the cavity (9) comprising the shaft is configured as the at least one reservoir (4).

9. Compressor according to claim 8, wherein
the at least one reservoir (4) is configured to guide working fluid flowing into the at least one reservoir (4) in such way, that cooling of the shaft and/or bearings of the shaft is executed.

10. Compressor according to one of the preceding claims, comprising
an outlet port (6) configured to guide compressed working fluid out of the compressor chamber (3), wherein at least a part of the outlet port is configured as a part of the housing (2), in particular forming a stiffening rib, to stabilize the housing and/or to reduce vibration.

11. Compressor according to one of the preceding claims, wherein
the working fluid comprises air and the compressor is configured to supply the working fluid to a pneumatic system, in particular a pneumatic braking system, an air suspension, a container for compressed air and/or an air supply system for a fuel cell.

12. Compressor according to one of the preceding claims, wherein
the inlet port (5) is provided in the housing (2).

13. Compressor according to one of the claims 5 to 12, wherein
the inlet port (11) is provided in the compressing element.

14. Compressor according to one of the preceding claims, wherein
the at least one reservoir (4) comprises at least two

containers to store the working fluid at least partially, wherein preferably,
the at least two containers are in serial or in parallel communication with each other or in communication witch each other via the compressor chamber (3).

15. Pneumatic system, in particular a pneumatic braking system, an air suspension, a container for compressed air and/or an air supply system for a fuel cell, comprising a compressor according to one of the claims 1 to 14.

16. Vehicle, in particular a commercial vehicle, comprising a compressor according to one of the claims 1 to 14 or a pneumatic system according to claim 15, wherein preferably,
the compressor is configured to supply air to at least one of these systems of the vehicle:

- a fuel cell,
- a pneumatic braking system,
- an air suspension,
- a compressed air reservoir, and/or wherein

the vehicle is preferably configured as a commercial vehicle, a truck, a trailer, , bus, and/or a combination of a towing vehicle and a trailer, and/or wherein
the vehicle is preferably configured as an electric, hybrid or conventional vehicle.

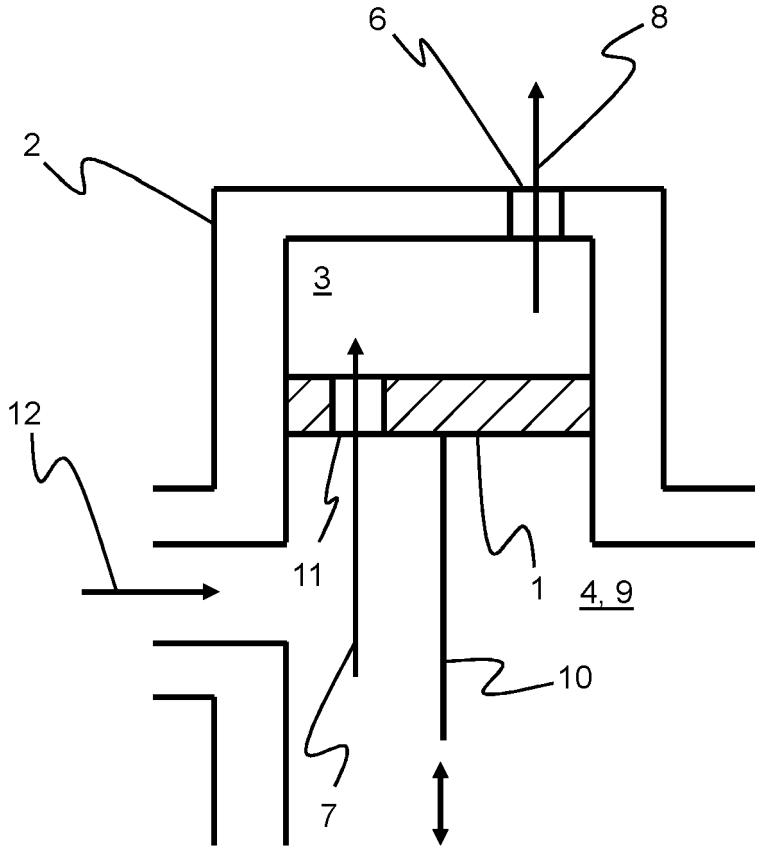

Fig. 1

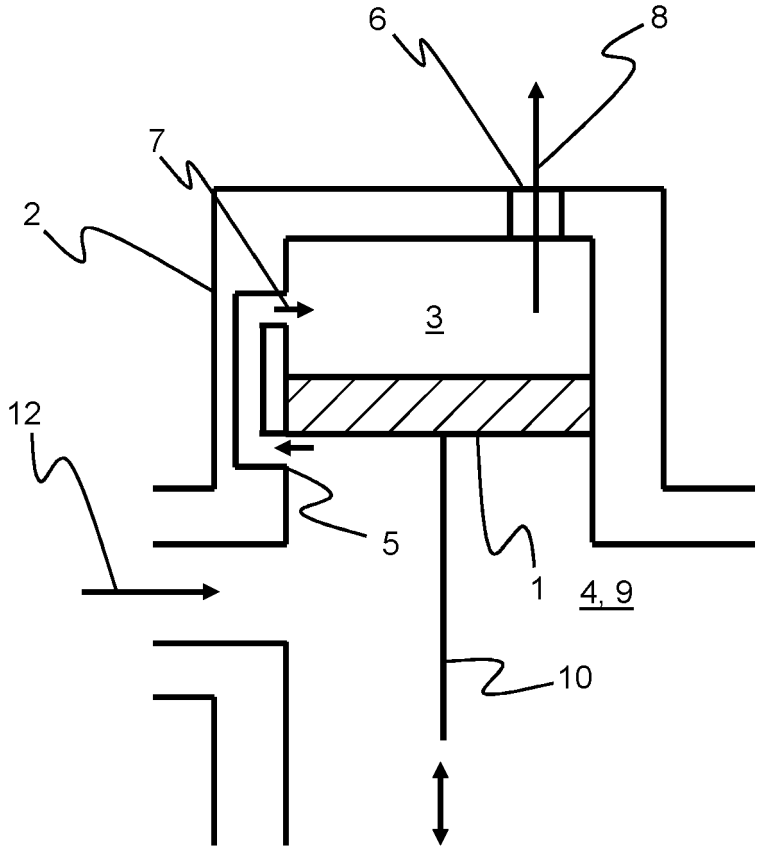

Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 21 18 2870

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	15 November 2021	Pinna, Stefano

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 21 18 2870

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