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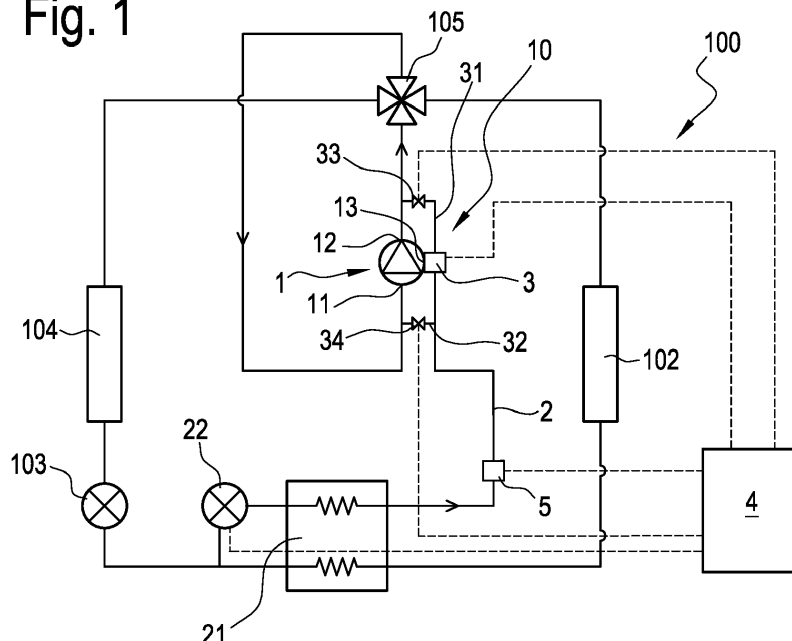
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(54) **AN APPARATUS FOR DAMPENING VIBRATIONS IN A REFRIGERATION SYSTEM**

(57) An apparatus for dampening vibrations in a refrigeration system (100) comprises: a check valve (3) operatively connectable between an economizer inlet (13) of a compressor (1) and the economizer branch (2), the check valve (3) including a housing (302) and a shutter (301) movable within the housing (302); a first bypass branch (31), having a first end (31A) connectable to the refrigeration circuit to receive a first flow of the refrigerant fluid, and a second end (31B) connected to the check

valve (3) on a first side of the shutter (301A), a second bypass branch (32), having a first end (32A) connectable to the refrigeration circuit to receive a second flow of the refrigerant fluid, and a second end (32B) connected to the economizer branch (2), wherein the shutter (301) is movable by effect of a pressure difference between the first side (301A) of the shutter (301), and the second side (301B) of the shutter (301).

Fig. 1



Description

[0001] This invention relates to an apparatus and a method for dampening vibrations in a refrigeration system. Also, this invention relates to a refrigeration system. Also, this invention relates to a method for controlling a check valve in a refrigeration system.

[0002] The invention relates to the technical field of refrigeration systems provided with an economizer. The economizer is connected to an intermediate stage of the compressor through an economizer pipe; when the economizer is off, the compressor determines gas pulsations in the economizer piping, which may excite the resonance frequency of the pipe, so causing vibrations, chattering and noise problems. Patent document JPH0510614A in the name of the same Applicant proposes, a solution to this problem, to provide a check valve between the economizer pipe and the compressor, in order to isolate the economizer pipe from the compressor and reduce the gas pulsation, so reducing the vibrations. However, the check valve is not always effective in reducing the vibrations; in fact, the compressor determines an oscillating pressure (e.g. in case of a screw compressor), which opens and closes the check valve, so that the valve still incurs chattering and gas pulsation still excites the resonance frequency of the pipe. A further refrigeration system including an economizer is disclosed in patent document WO2020/084545A1.

[0003] Scope of the present invention is to provide an apparatus and a method for dampening vibrations in a refrigeration system which overcome at least one of the aforementioned drawbacks. Also, scope of the present invention is to provide a method for controlling a check valve in a refrigeration system which overcome at least one of the aforementioned drawbacks.

[0004] This scope is achieved by the apparatus and the method for dampening vibrations according to one or more of the appended claims. Also, this scope is achieved by the method for controlling a check valve according to one or more of the appended claims.

[0005] The present disclosure regards an apparatus for dampening vibrations in a refrigeration system. The refrigeration system includes a refrigerant fluid. the refrigeration system includes a refrigeration circuit. The refrigeration system (or circuit) includes an evaporator. The refrigeration system (or circuit) includes an expansion device. The refrigeration system (or circuit) includes a condenser. The refrigeration system (or circuit) includes a compressor. In an embodiment, the compressor is a screw compressor; in an embodiment, the compressor is a scroll compressor. Preferably, the refrigeration system also includes an inverter (or Variable Frequency Drive VFD) for driving the compressor.

[0006] The refrigeration system (or circuit) includes an economizer heat exchanger. The refrigeration system (or circuit) includes an economizer expansion valve. The refrigeration system (or circuit) includes an economizer branch (or line). The economizer branch (or line) is con-

figured to take an economizer flow of refrigerant fluid from the refrigeration circuit and to feed this economizer flow to the compressor at an intermediate compression stage, through an economizer inlet of the compressor; the economizer heat exchanger is positioned in the economizer branch to provide heat exchange between the economizer flow and a main flow of refrigerant fluid flowing in the refrigeration circuit. In particular, the economizer branch is connected to the refrigeration circuit between the evaporator and the expansion device; more in particular, the economizer branch is connected to the refrigeration circuit between the economizer heat exchanger and the expansion device. The economizer heat exchanger is positioned in the economizer branch between the economizer expansion valve and the compressor. The economizer expansion valve is configured to expand the economizer flow of refrigerant fluid. Preferably, the economizer expansion valve is operable in an open position, to expand the refrigerant fluid and let it flow through the economizer branch, and in a closed position, to block the refrigerant fluid from flowing through the economizer branch. In an embodiment, the system comprises a further valve, associated with the economizer expansion valve: the economizer expansion valve expands the refrigerant fluid, and the further valve opens or closes to allow or not the economizer flow to pass through the economizer branch.

[0007] The apparatus comprises a check valve. The check valve is operatively connectable between the economizer inlet of the compressor and the economizer branch (or the economizer heat exchanger). In particular, the check valve is operatively connectable at the economizer inlet of the compressor. The check valve includes a housing and a shutter. The shutter is movable (in particular, slidable) within the housing. The check valve is movable, through movement of the shutter, between an open position, to allow the refrigerant fluid to flow from the economizer branch (or the economizer heat exchanger) to the compressor, and a closed position, to prevent the refrigerant fluid from flowing from the economizer branch (or the heat exchanger) to the compressor. Hence, the shutter can be positioned in a first position, in which the check valve is in the open position, so allowing the fluid to flow from the economizer branch to the compressor, and in a second position, in which the check valve is in the closed position and the fluid is blocked from flowing from the economizer branch to the compressor. The check valve, preferably, is a non-return valve.

[0008] The apparatus comprises a first bypass branch. The first bypass branch has a first end and a second end. The first end of the first bypass branch is operatively connectable (or connected) to the refrigeration circuit. The bypass branch receives from the refrigeration circuit a first flow of the refrigerant fluid. The second end of the first bypass branch is connected to the check valve (to release said first flow of refrigerant fluid); in particular, the second end is connected on a first side of the shutter.

[0009] The apparatus comprises a second bypass branch. The second bypass branch has a first end and a second end. The first end of the second bypass branch is operatively connectable (or connected) to the refrigeration circuit. The second end of the second bypass branch is connected to the economizer branch. In particular, the second end is connected to the economizer branch between the check valve and the economizer heat exchanger. The second bypass branch receives a second flow of the refrigerant fluid from the economizer branch. The second bypass releases the second flow of the refrigerant fluid to the refrigeration circuit, at its first end. The economizer branch is connectable to the check valve on a second side of the shutter, opposite to the first side. The shutter is movable by effect of a pressure difference between the first side of the shutter and the second side of the shutter. Hence, the check valve is operable in the open and/or in the closed position (or configuration) by effect of the pressure difference.

[0010] Preferably, the apparatus comprises a first valve. The first valve is positioned in the first bypass branch. Also, the apparatus comprises a second valve. The second valve is positioned in the second bypass branch. The first and second valves are controlled valves; for example, the first and second valves may be solenoid valves.

[0011] The apparatus comprises a control unit. The control unit is operatively connectable (or connected) to the economizer expansion valve. The control unit is connected to the first valve and to the second valve. The control unit, responsive to the economizer expansion valve moving to a closed position to prevent the refrigerant fluid from flowing in the economizer heat exchanger, is configured to command the first and second valve to move to their open position. In particular, the control unit may be configured to command the economizer expansion valve to move to the closed position and, when commanding the economizer expansion valve to move to the closed position, it also commands the first and second valve to move to their open position. In an embodiment, the control unit is configured to command the economizer expansion valve to move to the closed position as a function of a speed of the compressor (in particular, the economizer expansion valve moves to the closed position when the speed of the compressor decreases below a predetermined value). As a result of the first and second valves being in their open position, the refrigerant fluid can flow through the first and the second bypass branch. It is observed that the apparatus is connected to the refrigeration circuit in this manner: the first end of the first bypass branch is connected to a point of the refrigeration circuit (or system) having a higher pressure than the point to which the first end of the second bypass branch is connected.

[0012] So, upon opening the first and the second valves, the first flow of refrigerant fluid flows in the first bypass branch from the first end to the second end (namely, from the refrigeration circuit to the check valve),

while the second flow of refrigerant fluid flows in the second bypass branch from the second end to the first end (namely, from the economizer branch to the refrigeration circuit). The first flow is pushed against the first side of the shutter, so to cause a movement of the shutter. In particular, by effect of the first flow, the shutter moves away from the second end of the first bypass branch, towards the end of the economizer branch, until contacting the housing at the end of the economizer branch. So, the shutter obstructs the end of the economizer branch, so determining the closed position of the check valve. Hence, by effect of the first flow, the check valve is moved to the closed position.

[0013] Moreover, by effect of the second flow, the economizer branch is vacuumed. In fact, the refrigerant fluid remained in the economizer branch is sucked away in the second bypass branch; this is due to the fact that the first end of the second bypass branch is connected to a point having a lower pressure than the economizer branch; hence, the remained fluid in the economizer branch defines the second flow, which is sucked away from the economizer branch through the second bypass branch. As a result, a vacuum (or under pressure) is created in the economizer branch and, also, on the second side of the shutter. The vacuum which is created on the second side of the shutter (to which the economizer branch is connected), together with the pressure of the first flow pushing on the first side of the shutter, firmly keeps the check valve in the closed position. So, chattering of the valve is significantly reduced and, consequently, vibrations in the economizer branch are also reduced, so that the resonance frequency of the pipe is not excited.

[0014] Preferably, the apparatus comprises a pressure sensor. The pressure sensor is operatively connectable (or connected) to the economizer heat exchanger or to the economizer branch, to detect a pressure value of the refrigerant fluid in the economizer heat exchanger or in the economizer branch. The control unit is configured to control the first and second valves as a function of the pressure value detected by the pressure sensor.

[0015] The control unit is connected to a memory (which may be included in the apparatus) containing a predetermined value. The control unit is configured to command the first and second valves to move to their closed position (in a condition in which the first and second valves are in their open position), responsive to the pressure value decreasing below the predetermined value. In fact, if the pressure in the economizer branch is sufficiently low, the shutter is kept in its position corresponding to the closed position of the check valve by the under pressure (vacuum) of the economizer branch itself, without the need of the bypass branches.

[0016] Preferably, the control unit is further configured (in a condition in which the first and second valves are in the closed position), to command the first and second valves to move to the open position, responsive to the pressure value increasing above a further predetermined

value. The further predetermined value is also memorized in the memory. The further predetermined value may be equal or different with respect to the predetermined value; in particular, the further predetermined value may be greater than the predetermined value or lower than the predetermined value. In fact, it is possible that in the economizer branch the pressure rises again (for example because of a leakage); in this case, the under pressure in the economizer branch is no more sufficient to keep the shutter in its position corresponding to the closed position of the check valve, and the first and second bypass branches have to be reactivated.

[0017] Preferably, the housing of the check valve has a first inlet (or first inlet port), connected to the economizer branch (in particular, to an end thereof); the first inlet port faces the second side of the shutter. Preferably, the housing of the check valve has a first outlet (or first outlet port), connected to the economizer inlet of the compressor. As said above, the shutter is movable between a first and a second position, corresponding to the open and the closed position of the check valve, respectively. In the open position of the check valve (namely, in the first position of the shutter), the first outlet port faces the second side of the shutter, and, in the closed position the check valve (namely, in the second position of the shutter), the first outlet port faces the first side of the shutter.

[0018] So, in the first position of the shutter, both the first inlet port and the first outlet port are on the second side of the shutter, so that the shutter does not block the fluid from flowing from the first inlet port to the first outlet port. In the second position of the shutter, the shutter is interposed between the first inlet port and the first outlet port, so blocking the fluid from flowing from the first inlet port to the first outlet port.

[0019] It is observed that, in a less preferred embodiment, the second bypass branch could be connected, instead of to the economizer branch, directly to the check valve (on the second side of the shutter); in this case, the housing of the check valve has a second inlet (or second inlet port), connected to the first end of the first bypass branch; the second inlet port faces the first side of the shutter.

[0020] The present disclosure also provides a refrigeration system. The refrigeration system is according to one or more aspects of the present disclosure. In particular, the refrigeration system comprises a refrigerant fluid and a refrigeration circuit for circulating the refrigerant fluid. The refrigeration circuit includes: an evaporator, an expansion device, a condenser; a compressor, an economizer branch, an economizer heat exchanger, an economizer expansion valve. The compressor has a suction inlet for receiving the refrigerant fluid from the evaporator, an economizer inlet, for receiving the refrigerant fluid from the economizer heat exchanger (at an intermediate stage of compression between the suction and the discharge), and a discharge outlet, for releasing the refrigerant fluid to the condenser.

[0021] Also, the refrigeration system comprises an ap-

paratus for dampening vibrations according to one or more aspects of the present disclosure. The first end of the first bypass branch is connected to a point of the refrigeration circuit at a higher pressure and the second end of the first bypass branch is connected to a point of the refrigeration circuit at a lower pressure (with respect to the pressure of the point at which the first end of the first bypass branch is connected). In particular, the first end of the first bypass branch is connected to the refrigeration circuit downstream of the discharge outlet of the compressor (between the compressor and the condenser) and the first end of the second bypass branch is connected to the refrigeration circuit at the suction of the compressor (or upstream of the suction inlet of compressor, or between the evaporator and the compressor).

[0022] The refrigeration system may comprise a control unit connected to, or coinciding with, the control unit of the apparatus.

[0023] The present disclosure also provides a method for dampening vibrations in a refrigeration system. The refrigeration system is according to one or more aspects of the present disclosure.

[0024] The method provides a step of providing a check valve. The check valve is according to one or more aspects of the present disclosure. The method comprises a step of connecting the check valve to the refrigeration circuit, between the economizer inlet of the compressor and the economizer heat exchanger (in particular, the check valve is connected at the economizer inlet of the compressor).

[0025] The method comprises a step of providing a first bypass branch. The method comprises a step of providing a second bypass branch. The method comprises a step of connecting the first bypass branch (in particular, a second end thereof) to the check valve (in particular, it is connected on a first side of the shutter). The economizer branch is connected to the check valve on a second side of the shutter, opposite to the first side.

[0026] The method comprises a step of connecting the second bypass branch (in particular, a second end thereof) to the economizer branch. In particular, the second end of the second bypass branch is connected to the economizer branch and the first end of the second bypass branch is connected to the refrigeration circuit; however, the first end could be connected to another circuit or to an external reservoir.

[0027] The method comprises a step of receiving, at the first side of the shutter, a first flow of fluid, through the first bypass branch; the first flow of fluid is at a first pressure. The fluid in the first flow, preferably, is the refrigerant fluid flowing in the refrigeration circuit; however, the fluid in the first flow may be another fluid, taken from a first reservoir to which the first bypass branch may be connected. The first flow flows from the first end of the first bypass branch to the check valve, so to push the shutter and to cause it to move towards the end of the economizer branch; as a result, this end of the economizer branch is obstructed. Hence, the check valve is

moved to the closed position.

[0028] The method comprises a step of withdrawing a second flow of refrigerant fluid from the economizer branch, through the second bypass branch. The refrigerant fluid in the second flow is the remaining refrigerant fluid which was in the economizer branch and/or in the economizer heat exchanger when the economizer expansion valve was closed. The second flow flows from the second end of the second bypass branch to the first end by effect of the pressure difference between the second end and the first end: in fact, the pressure of the refrigeration circuit in the point of connection of the first end of the second bypass branch is lower than the pressure inside the economizer branch; hence, the refrigerant fluid is sucked away from the economizer branch by effect of this pressure difference. As a result, the economizer branch is vacuumed and the pressure on the second side of the shutter is less than the pressure on the first side of the shutter (which is determined by the first flow).

[0029] As a result of the first flow flowing in the first bypass branch and the second flow flowing in the second bypass branch, a pressure difference is created between the first side and the second side of the check valve. The pressure difference presses the shutter, to operate the check valve in the closed position. In fact, the pressure on the first side is the pressure of the first flow of fluid; the pressure on the second side is lower than on the first side, because of the vacuuming effect provided by the second flow. Thanks to this pressure difference, the check valve is firmly kept in the closed position.

[0030] Preferably, the method comprises a step of connecting the first bypass branch (in particular, a first end thereof) to the refrigeration system, to receive the first flow of the refrigerant fluid from the refrigeration system. Also, the method comprises a step of connecting the second bypass branch (in particular, a first end thereof) to the refrigeration circuit, to release the second flow of the refrigerant fluid to the refrigeration system. The first bypass branch is connected to a point of the refrigeration circuit having a higher pressure than the point to which the second bypass branch is connected. In both these points the refrigerant fluid is in the gaseous state (or mainly in the gaseous state).

[0031] Preferably, the first bypass branch is connected to a point of the refrigeration system at the discharge of the compressor (or downstream of the discharge outlet of the compressor, or between the discharge outlet of the compressor and the condenser). Preferably, the second bypass branch is connected to a point of the refrigeration system upstream of the suction inlet of the compressor. So, the pressure difference is due to the compression carried out by the compressor.

[0032] Preferably, the method also comprises a step of providing a first valve, in the first bypass branch and a step of providing a second valve, in the second bypass branch. Preferably, responsive to the economizer expansion valve moving to a closed position to prevent the refrigerant fluid from flowing in (or through) the economizer

heat exchanger, the method comprises a step of commanding the first valve to move to an open position, to allow the first flow to flow in the discharge bypass branch, and a step of commanding the second valve to move to an open position, to allow the second flow to flow in the suction bypass branch. As a result of the first and second valves being in the open position, the pressure difference between the first side and the second side of the shutter moves the check valve to the closed position and keeps the check valve in the closed position.

[0033] In an embodiment, the method further includes a step of monitoring a pressure value of the refrigerant fluid in the economizer branch or in the economizer heat exchanger. Then, when the check valve is in the closed position and the first and second valves are in their open position, the method includes a step of commanding the first and the second valves to move to their closed position, responsive to the pressure value decreasing below a predetermined value. In fact, as a result of the pressure value being lower than the predetermined value, the check valve remains in the closed position, even without the aid of the bypass branches. Also, the method may comprise, when the first and second valves are in the closed position, a step of commanding the first and second valves to move to the open position, responsive to the pressure value increasing above a further predetermined value.

[0034] Furthermore, the method may comprise, responsive to the economizer expansion valve moving to an open position to allow the refrigerant fluid to flow in the economizer heat exchanger, a step of commanding the first valve to move to a closed position, to block the first flow and commanding the second valve to move to a closed position, to block the second flow. Then, as a result of the first and second valves being in the closed position and the economizer expansion valve being in the open position, the pressure on the second side of the shutter of check valve is greater than the pressure on the first side of the shutter of the check valve and, consequently, the check valve is moved to the open position. In this open position of the check valve, the refrigerant fluid flows through the economizer heat exchanger, through the economizer branch and through the check valve, until entering the compressor through the economizer inlet.

[0035] The present disclosure also provides a method for controlling a check valve in a refrigeration system (in the following: controlling method). The check valve and the refrigeration system are according to one or more of the aspects of the present disclosure.

[0036] The controlling method comprises, responsive to the economizer expansion valve moving to a closed position to prevent the refrigerant fluid from flowing in the economizer heat exchanger, a step of commanding the first valve to move to the open position, to allow the first flow of the refrigerant fluid to flow in the discharge bypass branch, and a step of commanding the second valve to move to the open position, to allow a second flow of the

refrigerant fluid to flow in the suction bypass branch.

[0037] Preferably, the controlling method also comprises a step of monitoring a pressure value of the refrigerant fluid in the economizer branch or in the economizer heat exchanger (through a pressure sensor). Preferably, the controlling method comprises (when the check valve is in the closed position and the first and second valves are in their open position) commanding the first and the second valves to move to their closed position, responsive to the pressure value decreasing below a predetermined value. Preferably, the controlling method comprises (when the check valve is in the closed position and the first and second valves are in their closed position) commanding the first and second valves to move to the open position, responsive to the pressure value increasing above a further predetermined value (which may be equal or different from said predetermined value).

[0038] The present description also provides a computer program comprising operating instructions configured to perform the steps of the controlling method according to one or more aspects of the present description, when run on a computer.

[0039] This and other features of the invention will become more apparent from the following detailed description of a preferred, non-limiting example embodiment of it, with reference to the accompanying drawings, in which:

- Figure 1 schematically illustrates a refrigeration system according to the present disclosure;
- Figure 2 schematically illustrates an apparatus for dampening vibrations in the refrigeration system of figure 1;
- Figures 3A and 3B schematically illustrate a check valve of the apparatus of figure 2, in the closed position and in the open position, respectively;
- Figures 4A and 4B illustrate the check valve of figure 3, in perspective view and in exploded view, respectively;
- Figure 5 schematically illustrates a method for controlling the check valve, according to the present disclosure.

[0040] With reference to the accompanying drawings, number 100 indicates a refrigeration system. The refrigeration system 100 comprises a refrigeration circuit. The refrigeration system 100 (or the refrigeration circuit) includes a first heat exchanger 102, an expansion device 103 (in particular, an expansion valve), a second heat exchanger 104; a compressor 1. Preferably, the refrigeration system 100 also includes a four-way valve 105. The four-way valve 105 is operable in a first position to make the refrigeration circuit functioning in a refrigeration mode and in a second position to make the refrigeration circuit functioning in a heating mode. In the refrigeration mode, the refrigerant fluid exiting the compressor 1 is fed to the first heat exchanger 102 (functioning as a condenser), then it is fed to the expansion valve 103, and then to

the second heat exchanger 104 (functioning as an evaporator). In the heating mode the refrigerant fluid exiting the compressor 1 is fed to the second heat exchanger 104 (functioning as a condenser), while the first heat exchanger 102 functions as an evaporator. It is here observed that, in the context of the present description, the expressions "upstream" "downstream", "evaporator", "condenser" refer to a circulation of the refrigerant fluid in the refrigeration mode.

[0041] The refrigeration system 100 includes an economizer valve 22, configured to receive an economizer flow of refrigerant fluid from a branch the refrigeration circuit upstream of the expansion device 103. The economizer valve 22 is configured for providing an expansion of the refrigerant fluid, until a pressure which is intermediate between the pressure of the refrigerant fluid entering the compressor 1 and the pressure of the refrigerant fluid exiting the compressor 1. Preferably, the economizer valve 22 is adjustable to vary a (economizer) flow of refrigerant fluid passing thereof.

[0042] The refrigeration system 100 includes an economizer branch 2 configured for connecting the economizer valve 22 to the compressor 1. The refrigeration system 100 includes an economizer heat exchanger 21, configured to provide heat exchange between the economizer flow, flowing in the economizer branch 2, and the refrigerant fluid flowing in the branch of the refrigeration circuit located downstream of the condenser 102 (but upstream of the expansion device 103 and the economizer valve 22).

[0043] The compressor includes a suction inlet 11, a discharge outlet 12 and an economizer inlet 13. The suction inlet 11 is configured to receive the refrigerant fluid from the evaporator 104 (through the four-way valve 105); hence, the refrigerant fluid received at the suction inlet port 11 is in the gaseous state.

[0044] The economizer inlet 13 is configured to receive an economizer flow of the refrigerant fluid from the economizer heat exchanger 21. The economizer flow of refrigerant fluid is withdrawn from the refrigeration circuit downstream of the condenser 102; hence, the economizer flow is withdrawn from the refrigeration circuit in the liquid state. Then, the economizer flow expands in the economizer expansion valve 22 and, upon expanding, it partly evaporates. The evaporated part is fed to the economizer heat exchanger 21, wherein it absorbs heat from the liquid flowing in the refrigeration circuit downstream of the condenser 102; as a result, the economizer flow flowing in the economizer branch 2 is in the superheated gaseous state. Conversely, the liquid part is undercooled and fed back to the expansion valve 103. Hence, the refrigerant fluid which arrives at the economizer inlet 13 of the compressor is in the gaseous state (in particular, in the superheated gaseous state).

[0045] Also, the refrigerant fluid released at the discharge outlet 12 of the compressor is in the gaseous state.

[0046] The refrigeration system 100 comprises an ap-

paratus 10 for dampening the vibrations generated by the compressor in the economizer branch 2. The refrigeration system 100 (or the dampening apparatus 10) comprises a check valve 3. The check valve 3 includes a housing 302 and a shutter 301; the shutter 301 is positioned into the housing 302. The economizer branch 2 has an end 2B in fluid communication with the interior of the housing 302; in particular, the end 2B faces a second side 301B of the shutter 301. The economizer inlet of the compressor 13 is in fluid communication with the interior volume of the housing 302. The shutter 301 is movable between a first position and a second position. The shutter 301 in its second position obstructs the end 2B of the economizer branch 2, so to isolate the economizer branch 2 from the interior volume of the housing 302. It is here observed that the shutter 301 has a dimension (on its face perpendicular to the direction of movement of the selfsame shutter 301, namely on its face defining the second side 301B) which is greater than the economizer inlet port (which is in communication with the end 2B of the economizer branch 2). Hence, the shutter 301, when moved towards the end 2B, contacts the wall of the housing 302 surrounding the economizer inlet port, so to block the passage of fluid through the economizer inlet port.

[0047] The shutter 301 in its first position does not obstruct the end 2B of the economizer branch 2, so to allow the economizer flow from the economizer branch 2 to enter the interior volume of the housing 302 and, from there, to enter the compressor 1.

[0048] In particular, in the first position of the shutter 301, the economizer inlet 13 of the compressor 1 faces the second side 301B of the shutter 301, so that the fluid may flow from the economizer branch 2 to the compressor 1; in particular, the fluid passes through the check valve 3, on the second side 301B of the shutter 301. In the second position of the shutter 301, the economizer inlet 13 of the compressor 1 faces a first side 301A of the shutter 301, opposite to the second side 301B, so that the fluid cannot flow from the end 2B of the economizer branch 2 to the economizer inlet 13 of the compressor 1.

[0049] The refrigeration system 100 (or the dampening apparatus 10) comprises a first discharge bypass branch 31 elongated between a first end 31A and a second end 31B. The first end 31A of the first bypass branch 31 is connected to the refrigeration system at the discharge of the compressor 1. The second end 31B of the first bypass branch 31 is connected to the check valve 3. The refrigeration system 100 (or the dampening apparatus) comprises a first valve 33 (solenoid valve) configured to allow or block the passage of fluid from the first end 31A to the second end 31B of the first bypass branch 31.

[0050] The refrigeration system 100 (or the dampening apparatus 10) comprises a second suction bypass branch 32 elongated between a first end 32A and a second end 32B. The first end 32A of the second bypass branch 32 is connected to the refrigeration system at the suction of the compressor 1. The second end 32B of the

second bypass branch 32 is connected to the economizer branch 2. The refrigeration system 100 (or the dampening apparatus) comprises a second valve 34 (solenoid valve) configured to allow or block the passage of fluid from the first end 32A to the second end 32B of the second bypass branch 32.

[0051] The refrigeration system 100 (or the dampening apparatus 10) comprises a control unit 4, connected to the first valve 33 and to the second valve 34. Also, the control unit 4 is connected to the economizer expansion valve 22.

[0052] Preferably, the refrigeration system 100 includes an inverter for driving the compressor. The inverter is connected to the compressor 1, to vary the speed of the compressor. The control unit 4 is connected to the inverter.

[0053] The control unit 4 is configured to command the economizer expansion valve 22 to move to the open position or to the closed position, so as to activate a flow of refrigerant fluid in the economizer branch, or block it. In particular, the control unit 4 commands the economizer expansion valve 22 to move to the open position or to the closed position as a function of the speed of the compressor 1; for instance, the control unit 4 commands the economizer expansion valve 22 to move to the open position when the speed of the compressor increases above a predetermined threshold value, and/or to move to the closed position when the speed of the compressor 1 decreases below said predetermined threshold value (or below another predetermined threshold value).

[0054] The control unit 4 is configured, responsive to the economizer expansion valve 22 moving to the closed position, to open the first valve 33 and the second valve 34. Preferably, the first valve 33 and the second valve 34 are simultaneously moved to the open position. Then, the control unit 4 is configured to monitor a pressure value P measured by a pressure sensor 5. The pressure sensor 5 is connected to the economizer branch 2 and/or to the economizer heat exchanger 21. Hence, the pressure value P is representative of the pressure of the refrigerant fluid flowing in the economizer branch 2 and/or in the economizer heat exchanger 21. Until the pressure value P is greater than a predetermined pressure value Pref1, the control unit 4 is configured to keep the first valve 33 and the second valve 34 in their open position. So, the refrigerant fluid flows into the first bypass branch 31 and the second bypass branch 32 and keeps closed the check valve 3. When the pressure value P decreases below the predetermined pressure value Pref1, the control unit 4 is configured to command to close the first valve 33 and the second valve 34. Preferably, the control unit 4 firstly commands the first valve 33 to close and, after a predetermined period (e.g. 10 seconds), it commands the second valve 34 to close. In such a way, the economizer branch 2 is further depressurized. Therefore, the depressurization of the economizer branch 2 keeps the check valve 3 closed, without the aid of the first and second bypass branches 31, 32. Then, the control unit 4 is con-

figured to continue to monitor the pressure value P measured by a pressure sensor 5. Until the pressure value P is lower than a further predetermined pressure value Pref2 (or, possibly, than the predetermined pressure value Pref1), the control unit 4 is configured to keep the first valve 33 and the second valve 34 in their closed position. If the pressure value P increases above the further predetermined pressure value Pref2, the control unit 4 is configured to command to open the first valve 33 and the second valve 34. In fact, if the pressure value P increases above the further predetermined pressure value Pref2 the depressurization of the economizer branch 2 would not be sufficient to keep the check valve 3 closed.

[0055] The control unit 4 is configured, responsive to the economizer expansion valve 22 moving to the open position, to close the first valve 33 and the second valve 34. Hence, the check valve 3 is open and the refrigerant fluid can flow from the economizer branch 2 to the compressor 1.

Claims

1. An apparatus (10) for dampening vibrations in a refrigeration system (100), the refrigeration system (100), including: a refrigerant fluid and a refrigeration circuit including an evaporator (102), an expansion device (103), a condenser (104), a compressor (1), an economizer branch (2), an economizer heat exchanger (21), an economizer expansion valve (22), wherein the economizer heat exchanger (21) is positioned in the economizer branch (2) between the economizer expansion valve (22) and the compressor (1); wherein the apparatus (10) comprises a check valve (3) operatively connectable between an economizer inlet (13) of the compressor (1) and the economizer branch (2), the check valve (3) including a housing (302) and a shutter (301) movable within the housing (302), wherein the check valve (3) is movable, through movement of the shutter (301), between an open position, to allow the refrigerant fluid to flow from the economizer branch (2) to the compressor (1), and a closed position, to prevent the refrigerant fluid from flowing from the economizer branch (2) to the compressor (1), **characterized in that** the apparatus (10) further comprises:

- a first bypass branch (31), having a first end (31A) operatively connectable to the refrigeration circuit, and a second end (31B) connected to the check valve (3) on a first side (301A) of the shutter (301), wherein the economizer branch (2) is connectable to the check valve (3) on a second side (301B) of the shutter (301), opposite to the first side (301A);
- a second bypass branch (32), having a first end (32A) operatively connectable to the refrigeration circuit, and a second end (32B) connectable to the economizer branch (2), wherein the shutter (301) is movable by effect of a pressure difference between the first side (301A) of the shutter (301), and the second side (301B) of the shutter (301).

2. The apparatus (10) of claim 1, further comprising:

- a first valve (33), positioned in the first bypass branch (31);
- a second valve (34), positioned in the second bypass branch (32);
- a control unit (4) operatively connectable to the economizer expansion valve (22), to the first valve (33) and to the second valve (34), wherein, responsive to the economizer expansion valve (22) moving to a closed position to prevent the refrigerant fluid from flowing in the economizer heat exchanger (21), the control unit (4) is configured to command the first valve (33) to move to the open position, to allow a first flow of the refrigerant fluid to flow in the discharge bypass branch (31), and to command the second valve (34) to move to the open position, to allow a second flow of the refrigerant fluid to flow in the suction bypass branch (32).

3. The apparatus (10) of claim 2, comprising a pressure sensor (5) operatively connectable to the economizer heat exchanger (21) or to the economizer branch (2), to detect a pressure value of the refrigerant fluid in the economizer heat exchanger (21) or in the economizer branch (2), wherein the control unit (4) is configured, in a condition in which the first and second valves (33, 34) are in their open position, to command the first and second valves (33, 34) to move to their closed position, responsive to the pressure value decreasing below a predetermined value.

4. The apparatus (10) of claim 3, wherein, the control unit (4) is configured, in a condition in which the first and second valves (33, 34) are in the closed position, to command the first and second valves (33, 34) to move to the open position, responsive to the pressure value increasing above a further predetermined value.

5. The apparatus (10) of any of the previous claims, wherein the housing of the check valve (3) has:

- a first inlet port, connected to the economizer branch (2) and facing the second side (301B) of the shutter (301);
- a first outlet port, connected to the economizer inlet (13) of the compressor (1);
- a second inlet port, connected to the first end (31A) of the first bypass branch (31) and facing

the first side (301A) of the shutter (301),

wherein, in the open position of the check valve (3), the first outlet port faces the second side (301B) of the shutter (301), and, in the closed position the check valve (3), the first outlet port faces the first side (301A) of the shutter (301).

6. A refrigeration system (100), comprising:

- a refrigerant fluid;
- a refrigeration circuit for circulating the refrigerant fluid, said refrigeration circuit including: an evaporator (102), an expansion device (103), a condenser (104); a compressor (1), an inverter for driving the compressor, an economizer branch (2), an economizer heat exchanger (21), an economizer expansion valve (22), wherein the economizer heat exchanger (21) is positioned in the economizer branch (2) between the economizer expansion valve (22) and the compressor (1),

wherein the compressor (1) has a suction inlet (11) for receiving the refrigerant fluid from the condenser (104), an economizer inlet (13), for receiving the refrigerant fluid from the economizer heat exchanger (21), and a discharge outlet (12), for releasing the refrigerant fluid to the evaporator (102);

- an apparatus (10) for dampening vibrations according to any of previous claims.

7. The refrigeration system (100) of claim 6, wherein the first end (31A) of the first bypass branch (31) is connected to the refrigeration circuit at the discharge of the compressor (1), and the first end (32A) of the second bypass branch (32) is connected to the refrigeration circuit at the suction of the compressor (1).

8. A method for dampening vibrations in a refrigeration system (100), said refrigeration system (100) including: an evaporator (102), an expansion device (103), a condenser (104), a compressor (1), an economizer branch (2), an economizer heat exchanger (21), an economizer expansion valve (22), wherein the economizer heat exchanger (21) is positioned in an economizer branch (2) between the economizer expansion valve (22) and the compressor (1), wherein the compressor (1) has a suction inlet (11) for receiving the refrigerant fluid from the condenser (104), an economizer inlet (13), for receiving the refrigerant fluid from the economizer heat exchanger (21), and a discharge outlet (12), for releasing the refrigerant fluid to the evaporator (102), wherein the method comprises the following steps:

- providing a check valve (3);

- connecting the check valve (3) to the refrigeration circuit, between the economizer inlet (13) of the compressor (1) and the economizer heat exchanger (21), the check valve (3) including a housing (302) and a shutter (301) movable within the housing (302), wherein the check valve (3) is movable, through movement of the shutter (301), between an open position, to allow the refrigerant fluid to flow from the economizer branch (2) to the compressor (1), and a closed position, to prevent the refrigerant fluid from flowing from the economizer branch (2) to the compressor (1),

characterized by comprising the following steps:

- providing a first bypass branch (31) and a second bypass branch (32);
- connecting the first bypass branch (31) to the check valve (3) on a first side of the shutter (301A), wherein the economizer branch (2) is connected to the check valve (3) on a second side (301B) of the shutter (301), opposite to the first side (301A);
- connecting the second bypass branch (32) to the economizer branch (2),
- receiving, at the first side of the shutter (301A), a first flow of fluid, through the first bypass branch (31);
- withdrawing a second flow of refrigerant fluid from the economizer branch (2), through the second bypass branch (32),

so as to generate a pressure difference between the first side (301A) and the second side (301B) of the check valve (3), wherein said pressure difference presses the shutter (301), to operate the check valve (3) in the closed position.

9. The method of claim 8, comprising the following steps:

- connecting the first bypass branch (31) to a first point of the refrigeration system (100), to receive the first flow of the refrigerant fluid from the refrigeration system (100);
- connecting the second bypass branch (32) to a second point of the refrigeration system (100), different from the first point, to release the second flow of the refrigerant fluid to the refrigeration system (100).

10. The method of claim 8 or 9, comprising the following steps:

- providing a first valve (33), in the first bypass branch (31);
- providing a second valve (34), in the second

bypass branch (32);

and, responsive to the economizer expansion valve (22) moving to a closed position to prevent the refrigerant fluid from flowing to the economizer heat exchanger (21),

- commanding the first valve (33) to move to an open position, to allow the first flow to flow in the discharge bypass branch (31);
- commanding the second valve (34) to move to an open position, to allow the second flow to flow in the suction bypass branch (32);

wherein, as a result of the first and second valves (33, 34) being in the open position, the pressure difference between the first side (301A) and the second side (301B) of the shutter (301) moves the check valve (3) to the closed position.

11. The method of claim 10, comprising the following steps:

- monitoring a pressure value of the refrigerant fluid in the economizer branch (2) or in the economizer heat exchanger (21),
- when the check valve (3) is in the closed position and the first and second valves (33, 34) are in their open position, commanding the first and the second valves (33, 34) to move to their closed position, responsive to the pressure value decreasing below a predetermined value.

12. The method of claim 10 or 11, comprising, responsive to the economizer expansion valve (22) moving to an open position to allow the refrigerant fluid to flow in the economizer heat exchanger (21),

- commanding the first valve (33) to move to a closed position, to block the first flow;
- commanding the second valve (34) to move to a closed position, to block the second flow.

13. A method for controlling a check valve (3) in a refrigeration system (100), the refrigeration system (100), including: a refrigerant fluid, an evaporator (102), an expansion device (103), a condenser (104), a compressor (1), an economizer branch (2), an economizer heat exchanger (21) in the economizer branch (2), an economizer expansion valve (22), wherein the economizer heat exchanger (21) is positioned in the economizer branch (2) between the economizer expansion valve (22) and the compressor (1), wherein the check valve (3) is connected between an economizer inlet (13) of the compressor (1) and the economizer heat exchanger (21), and comprises a housing (302) and a shutter (301) movable within the housing (302), wherein the check valve (3) is mov-

able, through movement of the shutter (301), between an open position, to allow the refrigerant fluid to flow from the economizer branch (2) to the compressor (1), and a closed position, to prevent the refrigerant fluid from flowing from the economizer branch (2) to the compressor (1), and wherein the refrigeration system (100) further comprises a first bypass branch (31), connected to the refrigeration circuit to receive a first flow of the refrigerant fluid, and to the check valve (3) on a first side of the shutter (301A), and a second bypass branch (32), connected to the economizer branch (2), to receive a second flow of the refrigerant fluid, and to the refrigeration circuit, wherein the economizer branch (2) is connected to the check valve (3) on a second side (301B) of the shutter (301), opposite to the first side (301A),

the method comprising the following steps, responsive to the economizer expansion valve (22) moving to a closed position to prevent the refrigerant fluid from flowing to the economizer heat exchanger (21):

- commanding the first valve (33) to move to the open position, to allow the first flow of the refrigerant fluid to flow in the discharge bypass branch (31),
- commanding the second valve (34) to move to the open position, to allow a second flow of the refrigerant fluid to flow in the suction bypass branch (32).

14. The method of claim 13, comprising the following steps:

- monitoring a pressure value of the refrigerant fluid in the economizer branch (2) or in the economizer heat exchanger (21),
- when the check valve (3) is in the closed position and the first and second valves (33, 34) are in their open position, commanding the first and the second valves (33, 34) to move to their closed position, responsive to the pressure value decreasing below a predetermined value.
- when the check valve (3) is in the closed position and the first and second valves (33, 34) are in their closed position, commanding the first and second valves (33, 34) to move to the open position, responsive to the pressure value increasing above a further predetermined value.

15. A computer program comprising operating instructions configured to perform the steps of the method according to claim 13 or 14, when run on a computer.

Fig. 1

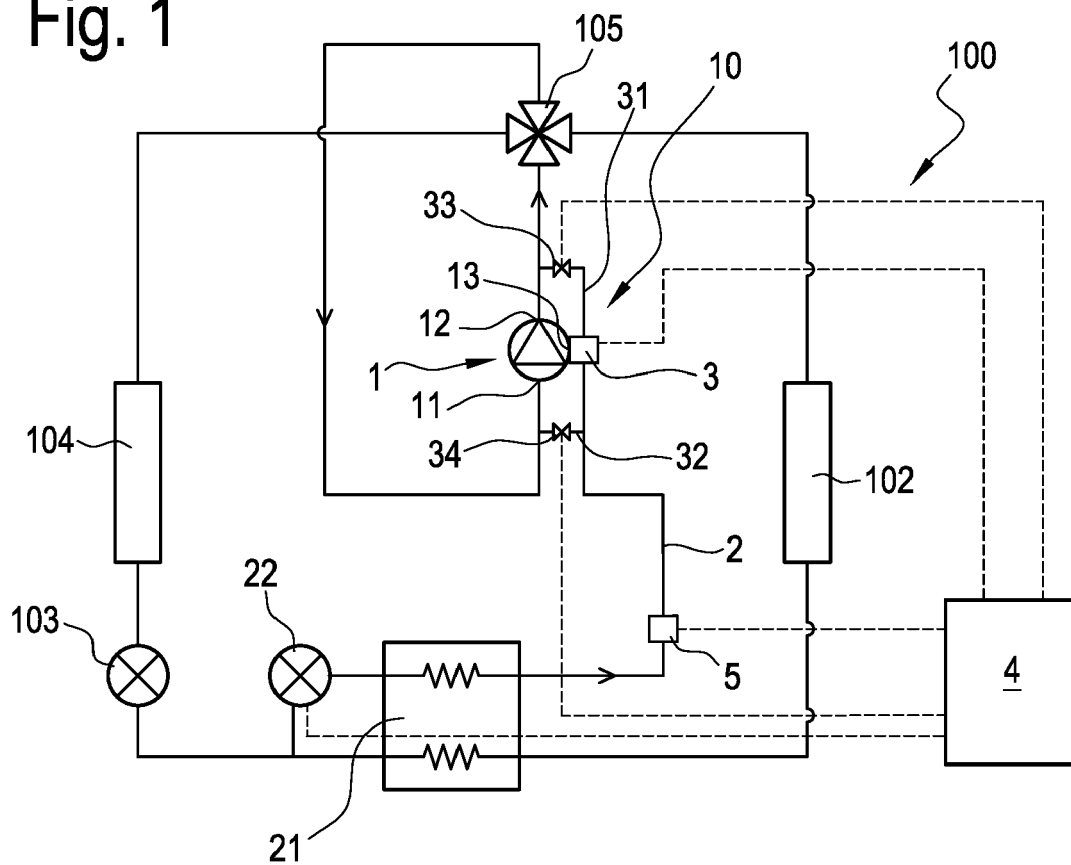


Fig. 2

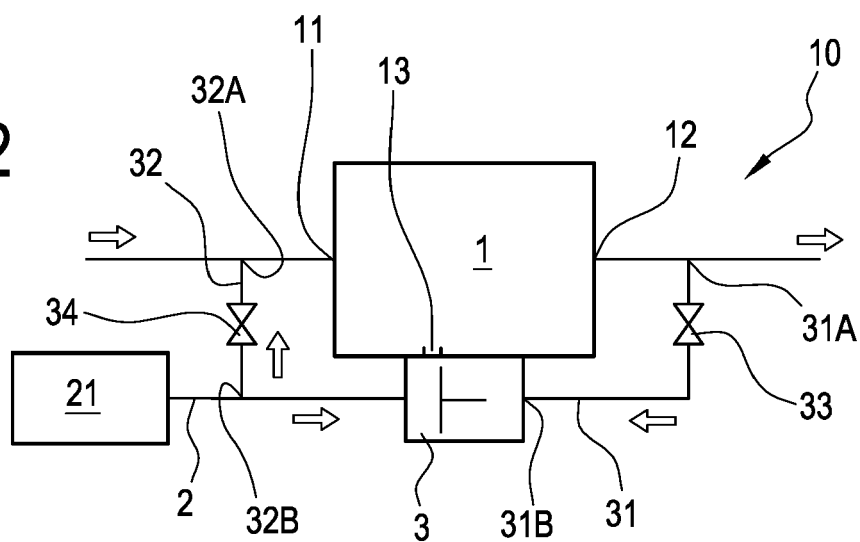


Fig. 3A

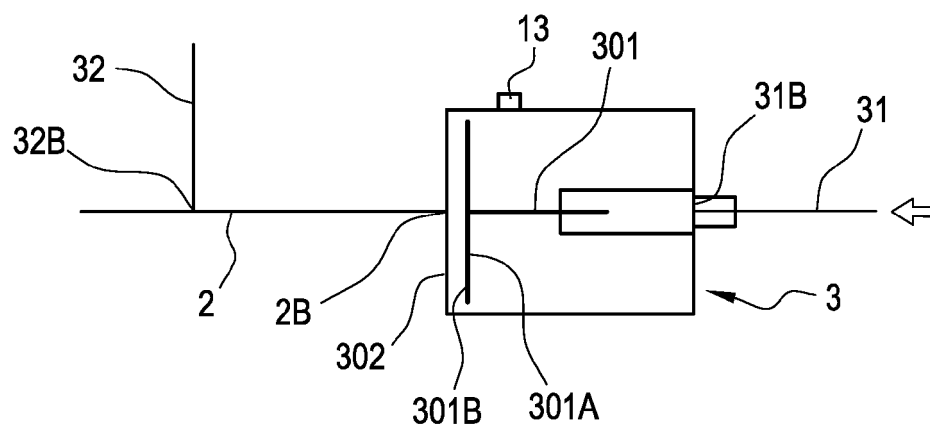


Fig. 3B

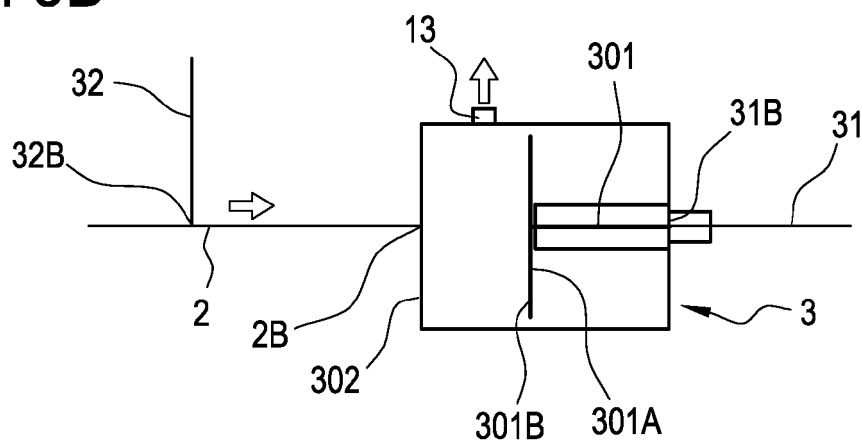


Fig. 4A

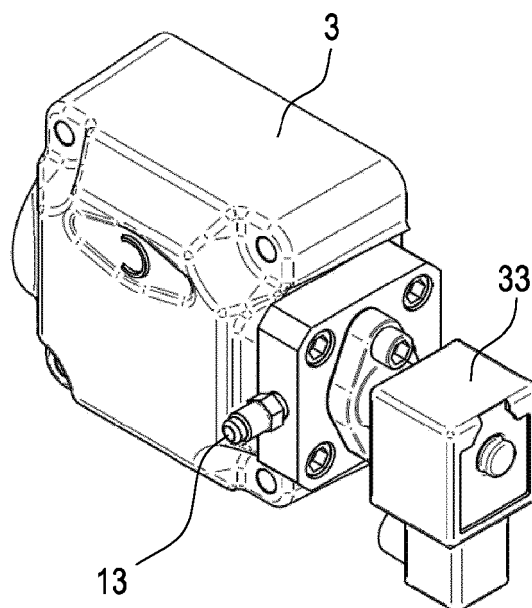


Fig. 4B

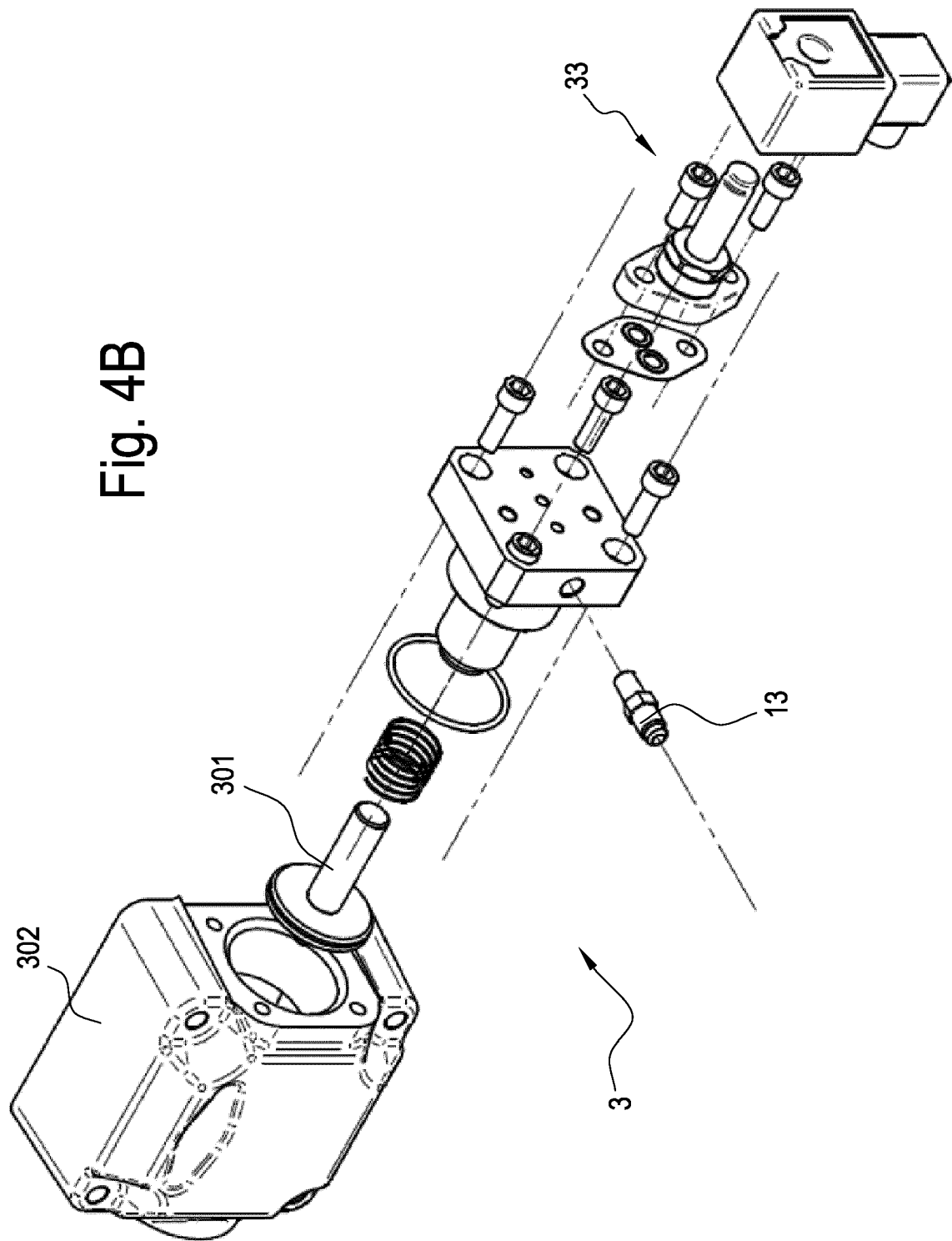
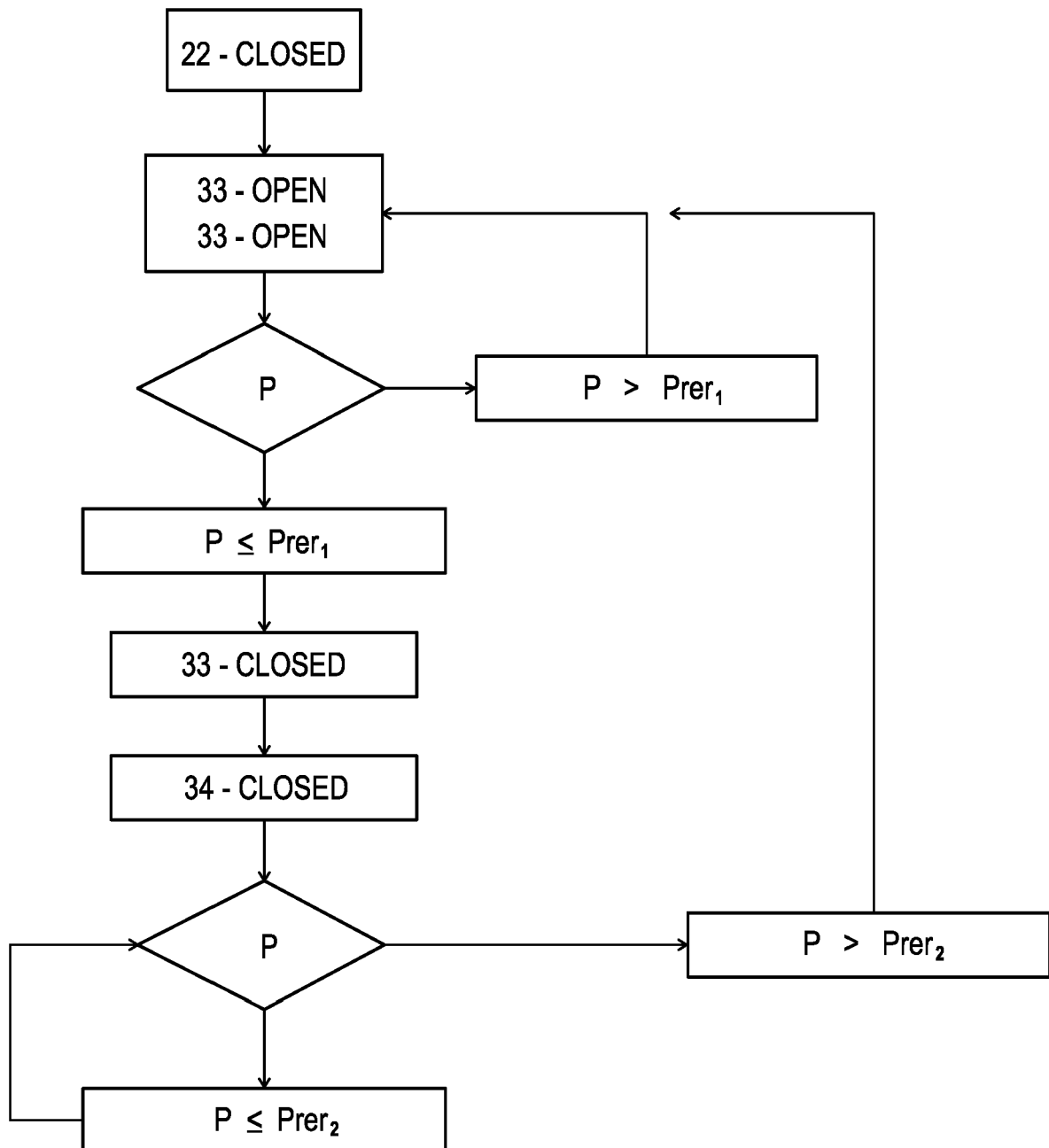


Fig. 5



**PARTIAL EUROPEAN SEARCH REPORT**

Application Number

under Rule 62a and/or 63 of the European Patent Convention.
This report shall be considered, for the purposes of
subsequent proceedings, as the European search report

EP 21 16 9588

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 2020/084545 A1 (TURBOALGOR S R L [IT]) 30 April 2020 (2020-04-30) * the whole document *	1-12	INV. F25B49/02 F16K15/00
A	WO 2006/118573 A1 (CARRIER CORP [US]; LIFSON ALEXANDER [US]; TARAS MICHAEL F [US]) 9 November 2006 (2006-11-09) * the whole document *	1-12	ADD. F25B13/00 F25B1/10 F04B49/24
A	WO 2015/029421 A1 (DENSO CORP [JP]) 5 March 2015 (2015-03-05) * the whole document *	1-12	
			TECHNICAL FIELDS SEARCHED (IPC)
			F25B F04B F16K

INCOMPLETE SEARCH

The Search Division considers that the present application, or one or more of its claims, does/do not comply with the EPC so that only a partial search (R.62a, 63) has been carried out.

Claims searched completely :

Claims searched incompletely :

Claims not searched :

Reason for the limitation of the search:

see sheet C

1

Place of search	Date of completion of the search	Examiner
Munich	18 November 2021	Lucic, Anita
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document		

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**INCOMPLETE SEARCH
SHEET C**

Application Number

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Claim(s) completely searchable:
1-12

Claim(s) not searched:
13-15

Reason for the limitation of the search:

The search has been restricted to the subject-matter indicated by the Applicant in their letter of 14.10.2021 filed in reply to the invitation pursuant to Rule 62a(1) EPC. Thus, the search report has been drawn up on the basis of independent claims 1 and 8 and their associated dependent claims 2-7 and 9-12.

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

EP 21 16 9588

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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18-11-2021

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REFERENCES CITED IN THE DESCRIPTION

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