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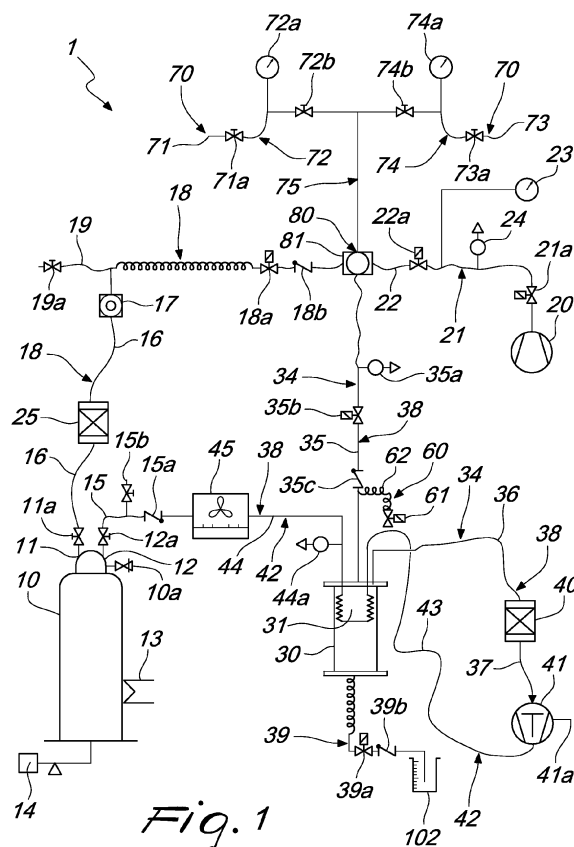
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(54) **Machine for recovering and refilling refrigerant fluid, particularly for aeronautic use**

(57) A machine (1) for recovering and refilling refrigerant fluid, particularly for aeronautic use, comprising means of connection (70) with the outside environment (100, 101) which are associated with a main line (75) that is connected, by means of a refill line (18) and by means of a recovery line (38), with a container (10) that is adapted to contain a refrigerant fluid, on the recovery line (38) a first filter (40) and a still (30) being provided for separating the contaminants and solid particles that are present in the refrigerant fluid, the machine (1) comprising, on the recovery line (38), a dry compressor (41) which defines a suction portion (34) for the suction of the refrigerant fluid from the main line (75) and a pressure portion (42) in order to send the refrigerant fluid into the container (10).



Description

[0001] The present invention relates to a machine for recovering and refilling refrigerant fluid, particularly for aeronautic use.

[0002] Currently machines are known that are capable of performing both the "refilling" operation, i.e. the introduction of refrigerant fluid into a cooling system, and the "recovery" operation, i.e. the removal of refrigerant fluid, in any state, from the cooling system and its collection in a container.

[0003] Moreover, machines of the known type also perform the "emptying" operation, i.e. the removal of non-condensable gases and humidity from the cooling system by means of a high vacuum pump.

[0004] In the cooling systems on board aircraft, it is necessary to use a refrigerant fluid that is highly pure, free from pollutant particles, according to the indications of the NAS1638 standards, and 100% free from oil or contaminants.

[0005] Machines of the known type suffer the drawback of not offering adequate guarantees that such standards are fully respected, since it cannot be definitively ruled out that, during their operation, they can introduce solid particles and oily contaminants into the cooling system.

[0006] The aim of the present invention is to provide a machine for recovering and refilling refrigerant fluid, particularly for aeronautic use, which is capable of overcoming the above mentioned drawback.

[0007] Within this aim, an object of the invention is to provide a machine that also operates at low temperatures.

[0008] A further object of the invention is to provide a machine that is capable of operating with any type of refrigerant fluid, such as CFCs (chlorofluorocarbons, which are sold under the name 'Freon'), HCFCs (hydrochlorofluorocarbons) and HFCs (hydrofluorocarbons).

[0009] Another object of the invention is to provide a machine that allows the recovery of cooling fluid, as well as the complete emptying and subsequent refilling of a cooling system, by way of a solution that is simple to implement and at low cost.

[0010] This aim, as well as these and other objects which will become better apparent hereinafter, are achieved by a machine for recovering and refilling refrigerant fluid, particularly for aeronautic use, comprising means of connection with the outside environment which are associated with a main line that is connected, by means of a refill line and by means of a recovery line, with a container that is adapted to contain a refrigerant fluid; there being provided, on said recovery line, a first filter and a still for separating the contaminants and solid particles that are present in said refrigerant fluid; characterized in that it comprises, on said recovery line, a dry compressor which defines a suction portion for the suction of said refrigerant fluid from said main line and a pressure portion in order to send said refrigerant fluid

into said container.

[0011] Further characteristics and advantages will become better apparent from the detailed description of a machine for recovering and refilling refrigerant fluid, particularly for aeronautic use, according to the invention, illustrated by way of non-limiting example in the accompanying drawings wherein:

Figure 1 is a hydraulic diagram of the machine, according to the invention, for recovering and refilling refrigerant fluid, particularly for aeronautic use;

Figure 2 is a hydraulic diagram of the machine, according to the invention, during the operating step of recovering the refrigerant fluid from a cooling system;

Figure 3 is a hydraulic diagram of the machine, according to the invention, during the operating step of recovering the refrigerant fluid from an external cylinder;

Figure 4 is a hydraulic diagram of the machine, according to the invention, during the operating step of emptying a cooling system;

Figure 5 is a hydraulic diagram of the machine, according to the invention, during the operating step of refilling the refrigerant fluid in a cooling system;

Figure 6 is a front elevation view of a schematic layout of the individual components in the machine, according to the invention, for recovering and refilling refrigerant fluid, particularly for aeronautic use;

Figure 7 is a side elevation view of a schematic layout of the individual components in the machine, according to the invention.

[0012] With reference to the figures, the machine according to the invention, generally designated with the reference numeral 1, comprises means of connection 70 with the outside environment, and in particular for coupling with an external cooling system 100 or with a service cylinder 101.

[0013] More specifically, the means of connection 70 comprise two couplings: a first coupling 71 for a low-pressure line 72 of the machine 1 and a second coupling 73 for a high-pressure line 74 of the machine 1.

[0014] More specifically, at each of the two couplings 71 and 73 a first manually actuated valve, respectively 71a and 73a, is provided.

[0015] The pressure lines 72 and 74 are preferably defined by flexible tubes and on each of them there is a first pressure gauge, respectively 72a and 74a, and a second manually actuated valve, respectively 72b and 74b.

[0016] The means of connection 70 with the outside environment are associated, by means of the low-pressure line 72 and the high-pressure line 74, with a main line 75.

[0017] The main line 75 is connected by means of a refill line 18 to a container 10 which is adapted to contain a refrigerant fluid and is preferably in the form of a cylinder.

[0018] In more detail, the container 10 has two connections: a first connection 11, which has a riser and is provided for the refrigerant fluid in the liquid phase, and a second connection 12, which does not have a riser and is provided for the refrigerant fluid in the gaseous phase. Both the first connection 11 and the second connection 12 have third manually actuated valves, respectively 11a and 12a.

[0019] Conveniently, the container 10 has a safety valve 10a for discharging non-condensable gases.

[0020] Advantageously, the container 10 comprises a resistor with thermostat 13 and an electronic weighing scales 14 for measuring the quantity of refrigerant fluid that is present in the container 10.

[0021] The main line 75 is connected to the container 10 by means of a recovery line 18 and a refill line 38 on which there is a still 30 and a first filter 40 for separating the refrigerant fluid from contaminant substances and solid particles which are present within it.

[0022] In more detail, the refill line 18 comprises a line for conveying the refrigerant fluid in the liquid phase 16, which is associated with the first connection 11 of the container 10 and is provided with a humidity gauge 17.

[0023] On the refill line 18 a second filter 25 is provided for purifying the liquid refrigerant fluid of the solid particles present within it during the refill step, that is to say, as will be better described below, on the line that brings the refrigerant fluid from the container 10 to the cooling circuit 100.

[0024] Advantageously, the second filter 25 can be positioned on the line for conveying the liquid refrigerant fluid 16.

[0025] The refill line 18 is provided with a first solenoid valve 18a and with a first non-return valve 18b.

[0026] The refill line 18 can also be associated with a service line 19 for refilling the refrigerant fluid, which is provided at its entry point with a fourth manually actuated valve 19a.

[0027] As mentioned previously, the recovery line 38 is provided with the still 30 and the first filter 40.

[0028] According to the invention, on the recovery line 38 there is a dry compressor 41, i.e. a compressor without lubricants, which divides the recovery line 38 into a suction portion 34 for the suction of the refrigerant fluid present in the main line 75 and a pressure portion 42 in order to send the refrigerant fluid into the container 10.

[0029] By means of the suction portion 34, which is preferably defined by a flexible tube, the refrigerant fluid that is present in the main line 75, and which comes from the cooling system 100 or is introduced from the outside by means of a service cylinder 101, is sucked into the still 30.

[0030] In more detail, the suction portion 34 comprises a first portion 35 which runs between the main line 75 and the still 30, a second portion 36 which runs between the still 30 and the first filter 40, and a third portion 37 which runs from the first filter 40 to the dry compressor 41, which is provided with a service connection 41a.

[0031] Conveniently, on the first portion 35 of the suction portion 34 there are: a vacuum pressure switch 35a, a second solenoid valve 35b and a second non-return valve 35c.

[0032] The pressure portion 42 comprises two parts: a first part 43 which goes from the dry compressor 41 back to the still 30 and a second part 44 which runs from the still 30 to the container 10.

[0033] In more detail, the still 30 comprises a distillation chamber 31 inside which the separation occurs of the refrigerant fluid from oil and from contaminant substances. Moreover, the still 30 comprises a chamber for heat exchange between the exhaust gas and the recovered refrigerant fluid and a coiled duct for heat exchange between the exhaust gas and the recovered refrigerant fluid.

[0034] Preferably, the still 30 is of the type disclosed in Italian patent 1,252,639.

[0035] Advantageously, the still 30 can be provided with a device 60 for automatically controlling the flow. The device 60 comprises a third solenoid valve 61 which is positioned on a capillary tube 62 interposed between the first portion 35 of the suction portion 34 and the first part 43 of the pressure portion 42. By means of the third solenoid valve 61, the capillary tube 62 regulates the fall in pressure upstream and downstream of the dry compressor 41.

[0036] More specifically, the first filter 40 is of the antiacid dehydrator type with an absorption capacity that is substantially equal to 40 grams of water. Moreover, the first filter 40 can be of the cartridge type, with a filtering surface of substantially 2.5 micrometers.

[0037] Advantageously, a discharge line 39 exits from the still 30 and terminates in a receptacle 102 for collecting the contaminant oil that has been separated from the refrigerant fluid by distillation. The discharge line 39 has a fourth solenoid valve 39a and a third non-return valve 39b.

[0038] Therefore, with reference to Figures 2 and 3, the refrigerant fluid is sucked by the dry compressor 41 in the first portion 35 of the suction portion 34 until it arrives in the still 30. From here the refrigerant fluid is sucked into the second portion 36 of the suction portion 34 until it reaches the first filter 40 where it undergoes separation from the solid particles that are present within it. Through the third portion 37 of the suction portion, the filtered refrigerant fluid goes through the dry compressor 41 in order to be sent to the first part 43 of the pressure portion 42, which brings it into the still 30 where it undergoes distillation. Subsequently, through the second part 44 of the pressure portion 42, which is preferably defined by a flexible tube, the refrigerant fluid vapors, which have been filtered of solid components by the first filter 40 and separated from oily contaminants by distillation, exit from the still 30. Conveniently, on the second part 44 of the pressure portion 42 a safety pressure switch 44a is provided.

[0039] Conveniently, the second part 44 of the pres-

sure portion 42 comprises a condenser 45 that causes the cooling of the refrigerant fluid vapors, which are then introduced into the container 10 through a line for conveying the refrigerant fluid in the gaseous phase 15 which is connected to the second connection 12 of the container 10 (the connection provided for the refrigerant fluid in the gaseous phase).

[0040] On the aforementioned line for conveying the refrigerant fluid in the gaseous phase 15 there is a fourth non-return valve 15a and a fifth manually actuated valve 15b for draining the container 10.

[0041] Advantageously, the main line 75 is also connected, by means of an emptying line 21, to a high vacuum pump 20 for aspirating and emptying the cooling system 100 connected to the machine 1 of the residues of the technical gases used for pressing, of the atmospheric air and of the vapor which is due to it, and of any water fractions that have formed through the condensation of the vapor.

[0042] More specifically, the emptying line 21 comprises a vacuum switch 24 which controls the action of the high vacuum pump 20 so that the pressure value is kept constant over time. The high vacuum pump 20 is also associated with a fifth solenoid valve 21a.

[0043] Preferably, the high vacuum pump 20 is of the multi-vane rotary type, is lubricated by oil injection and has a flow capacity that is substantially comprised between 250 l/min and 440 l/min.

[0044] Advantageously, on the emptying line 21 of the high vacuum pump 20 there is a vacuum test line 22 provided with a sixth solenoid valve 22a for controlling the pressure inside the line 22. There is also a connection to a second pressure gauge 23 for measuring and indicating to the operator the level of pressure that is present in the vacuum test line 22.

[0045] Preferably, the refill line 18, the main line 75, and the recovery line 38 all meet at a common connection point 80 at which there is an indicator 81 for verifying the flow of refrigerant fluid. The indicator 81 can be either electronic or it can be a simple transparent window through which the operator can visually verify the flow of the refrigerant fluid.

[0046] Advantageously, the emptying line 21 is also connected to the common connection point 80.

[0047] Preferably, the machine 1 is entirely accommodated on a supporting structure 2 which is provided with means for movement 2a.

[0048] More specifically, the supporting structure 2 comprises in a downward region a base 3, substantially box-shaped, which is designed to accommodate the dry compressor 41, the high vacuum pump 20 and the condenser 45. Moreover the supporting structure 2 comprises a wall 4, inside which the still 30 is accommodated, and which extends vertically from the upper face 5 of the base 3. The bottom 6 of the base 3 is a quadrilateral and is provided at its corners with means for movement 2a, such as for example castors.

[0049] The container 10 is positioned on the part 7 of

the upper face 5 that is not occupied by the wall 4 and preferably has a maximum capacity of ten kilograms and a weight, when empty, of eight kilograms. Moreover, on one face of the wall 4 a shelf 8 for supporting the receptacle 102 is provided.

[0050] At the part 7, beside the container 10 and interposed between two flexible tubes, there is the cartridge filter 40. The two flexible tubes between which the aforementioned first filter 40 is interposed are the second portion 36 and the third portion 37 of the suction portion 34.

[0051] The wall 4 ends with an inclined portion 9 on the outer face of which an interface 90 for the operator is provided.

[0052] More specifically, the interface 90 comprises an on/off switch 91, two buttons 92 and 93 for activating the second manually actuated valves 72b and 74b and two displays 94 and 95 for indicating the pressure values detected respectively by the first pressure gauges 72a and 74a. The interface 90 further comprises command buttons 96 for setting the recovery, refill and emptying functions and an electronic display 97 for indicating the pressure values measured by the second pressure gauge 23, as well as the quantity of refrigerant fluid measured by the electronic weighing scales 14. Moreover, in the interface 90 there is also the indicator 81 for verifying the flow of refrigerant fluid.

[0053] Use of the machine 1 according to the invention, in terms of the various operating steps, is the following.

[0054] In the operational step of recovering the refrigerant fluid from the cooling system 100, the couplings 71 and 73 are associated with the attachments 103 and 104 of the cooling system 100, respectively for low pressure and for high pressure. After opening the first manually actuated valves 71a and 73a and the second manually actuated valves 72b and 74b, the fluid is aspirated by the dry compressor 41 into the main line 75 and then into the recovery line 38. After being filtered by the first filter 40, the dry compressor 41 sends the refrigerant fluid into the still 30, where it is separated from oily contaminants by distillation. The refrigerant fluid in the gaseous phase which leaves the still 30 is then cooled by the condenser 45 and arrives inside the container 10.

[0055] With reference to Figure 3, the refrigerant fluid can also be recovered from a service cylinder 101 and, in this situation, only one of the two couplings 71 and 73 is connected with the attachment 105 of the service cylinder 101. The operation of the machine 1, according to the invention, during the operating step of recovery from a service cylinder 101 is substantially identical to what is described above for the step of recovery from the external cooling system 100.

[0056] With reference to Figure 4, during the operating step of emptying the cooling system 100, the cooling system 100 is connected to the machine 1 as described previously for the recovery step. In the emptying step, the high vacuum pump 20 is activated and aspires, from the cooling system 100, into the main line 75 and then into the emptying line 21, the residues of the technical gases

used for pressing, the atmospheric air and the vapor associated with it, and any water fractions that have formed through the condensation of the vapor. In this way, the cooling system 100 is completely emptied.

[0057] With reference to Figure 5, during the step of refilling the refrigerant fluid in the cooling system 100, only one of the two couplings 71 and 73 of the machine 1, preferably the first coupling 71, remains associated with the respective attachment 103 and 104 of the cooling system 100. By activating the cooling system 100 the refrigerant fluid that is present in the container 10 is sucked into the refill line 18, passing through the second filter 25 which is positioned on the line for conveying the refrigerant fluid in the liquid phase 16. From the refill line 18 it then passes to the main line 75, and after that it goes through the low-pressure line 72 or the high-pressure line 74 and into the cooling system 100.

[0058] In practice it has been found that the machine, according to the invention, for recovering refrigerant fluid, as well as for emptying and refilling cooling systems, particularly for aeronautic use, fully achieves the intended aim, in that the use of a dry compressor makes it possible to prevent, during the step of recovering the refrigerant fluid from the external cooling system or from the external cylinder, the introduction of oily contaminants and solid particles into the refrigerant fluid which is deposited in the container.

[0059] Moreover, the presence of a second filter on the line for the refrigerant fluid in the liquid phase merging with the refill line, allows, during the step of refilling the cooling system, a further filtering of the refrigerant fluid withdrawn from the container and thus a further separation from the solid particles and from the contaminants present in the refrigerant fluid.

[0060] It should be noted that the concept underlying the invention, although it has been described with particular reference to utilisation in the aeronautic sector, can be used also for similar applications in which a high purity of the refrigerant fluid is required.

[0061] In practice the materials employed, provided they are compatible with the specific use, and the dimensions, may be any according to requirements and to the state of the art.

[0062] The disclosures in Italian Utility Model Application No. MI2010U000097 from which this application claims priority are incorporated herein by reference.

[0063] Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly, such reference signs do not have any limiting effect on the interpretation of each element identified by way of example by such reference signs.

Claims

1. A machine for recovering and refilling refrigerant flu-

id, particularly for aeronautic use, comprising means of connection (70) with the outside environment (100; 101) which are associated with a main line (75) that is connected, by means of a refill line (18) and by means of a recovery line (38), with a container (10) that is adapted to contain a refrigerant fluid; there being, on said recovery line (38), a first filter (40) and a still (30) for separating the contaminants and solid particles that are present in said refrigerant fluid; **characterized in that** it comprises, on said recovery line (38), a dry compressor (41) which defines a suction portion (34) for the suction of said refrigerant fluid from said main line (75) and a pressure portion (42) in order to send said refrigerant fluid into said container (10).

2. The machine according to one or more of the preceding claims, **characterized in that** it comprises a second filter (25) on said refill line (18).

3. The machine according to claim 1, **characterized in that** said main line (75) is connected by means of an emptying line (21) to a high vacuum pump (20).

4. The machine according to claim 1, **characterized in that** said suction portion (34) comprises a first portion (35) which runs between said main line (75) and said still (30), a second portion (36) which runs between said still (30) and said first filter (40), and a third portion (37) which is comprised between said first filter (40) and said dry compressor (41); said pressure portion (42) comprising a first part (43) which is comprised between said dry compressor (41) and said still (30) and a second part (44) which is comprised between said still (30) and said container (10).

5. The machine according to one or more of the preceding claims, **characterized in that** said container (10) comprises a first connection (11) which is for said refrigerant fluid in the liquid phase and is associated with a line for conveying said refrigerant fluid in the liquid phase (16) and a second connection (12) which is for said refrigerant fluid in the gaseous phase and is associated with a line for conveying said refrigerant fluid in the gaseous phase (15).

6. The machine according to one or more of the preceding claims, **characterized in that** said second filter (25) is arranged on said line for conveying said refrigerant fluid in the liquid phase (16).

7. The machine according to one or more of the preceding claims, **characterized in that** it comprises, on said second part (44) of said pressure portion (42), a condenser (45) for cooling the vapors of the distilled refrigerant fluid.

8. The machine according to one or more of the preceding claims, **characterized in that** said main line (75), said refill line (18) and said recovery line (38) all meet at a common connection point (80) at which an indicator (81) of the flow of said refrigerant fluid is provided. 5
9. The machine according to one or more of the preceding claims, **characterized in that** said emptying line (21) is connected to said common connection point (80). 10
10. The machine according to one or more of the preceding claims, **characterized in that** it is mounted entirely on a supporting structure (2) which is provided with means of movement (2a). 15

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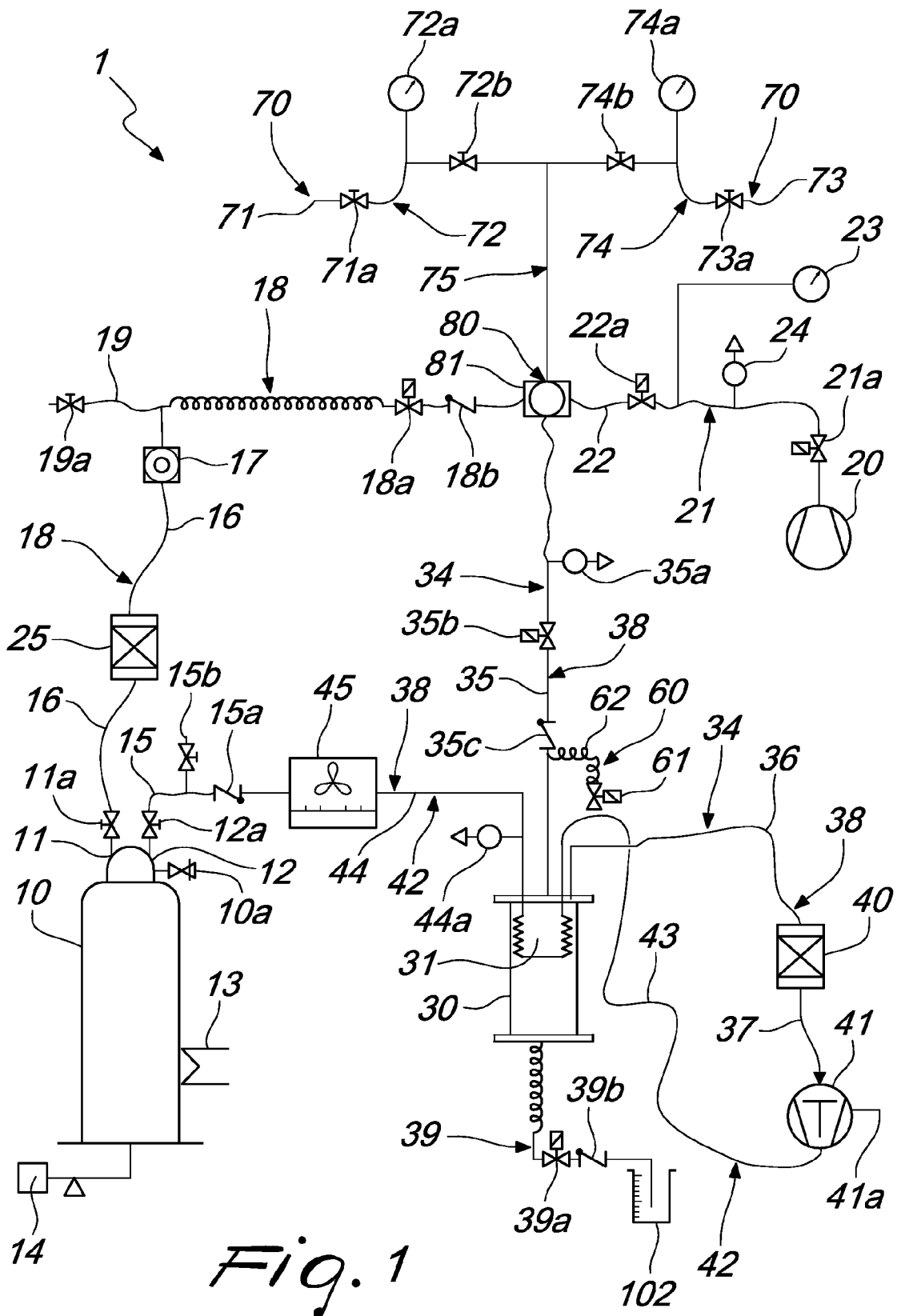
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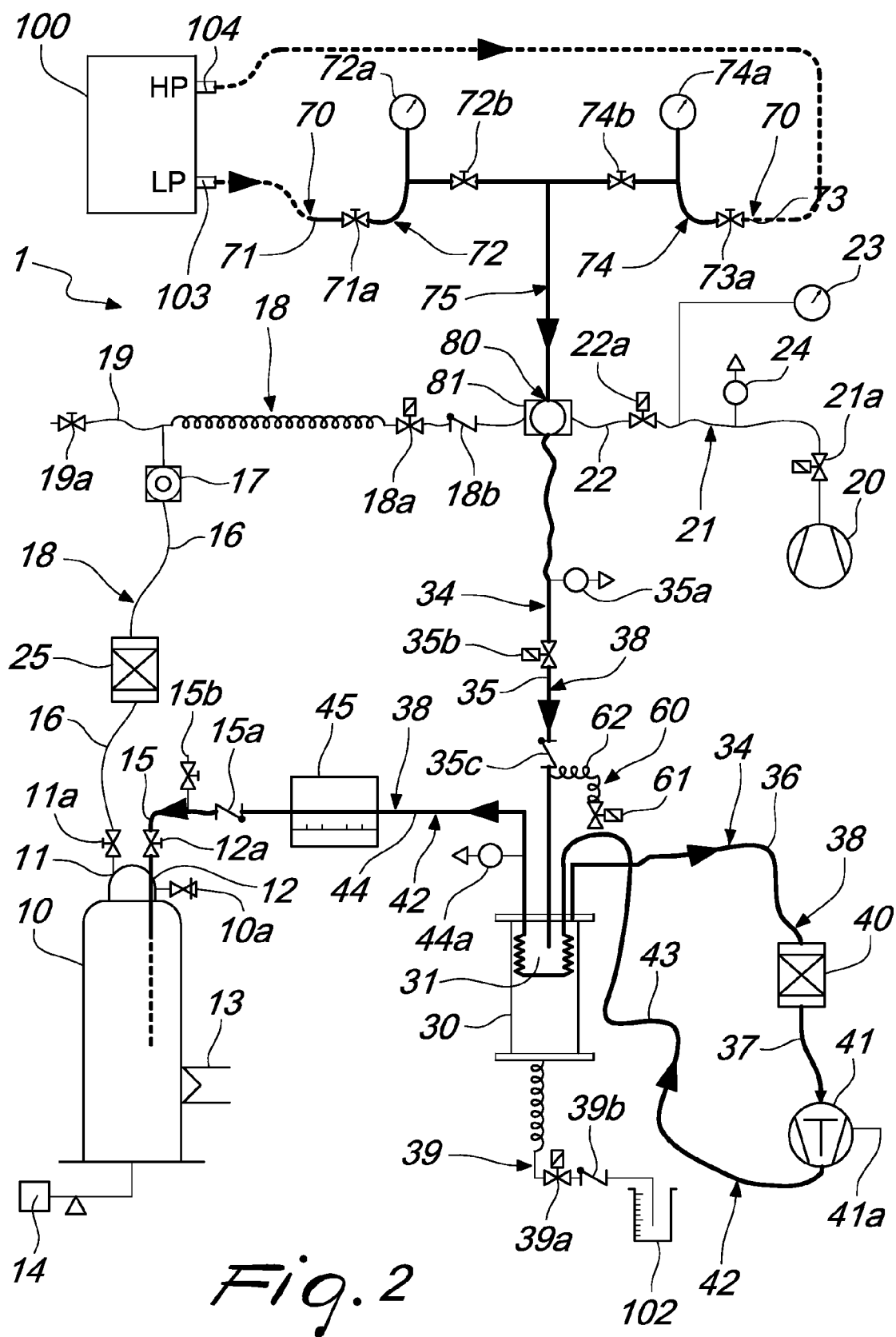
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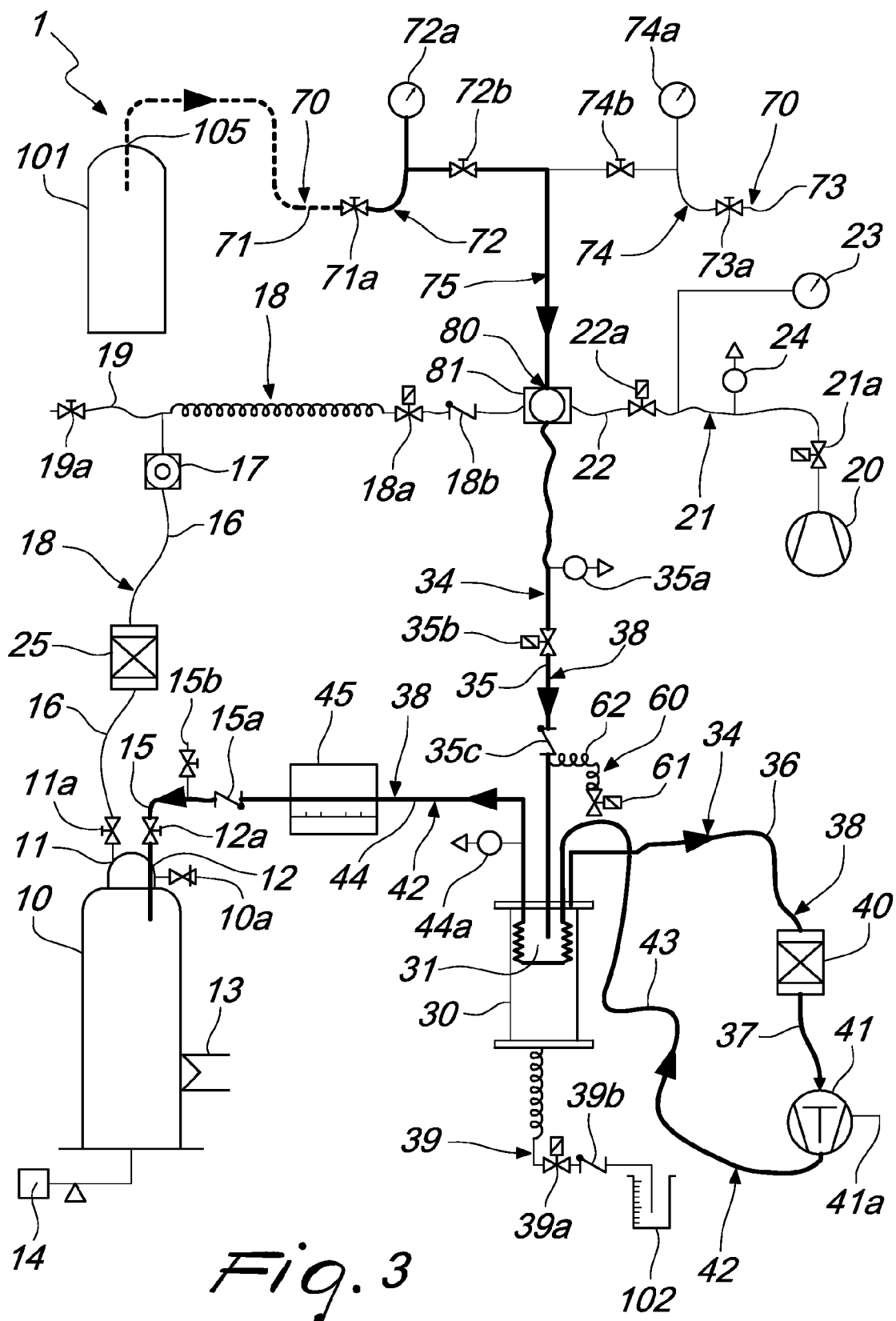
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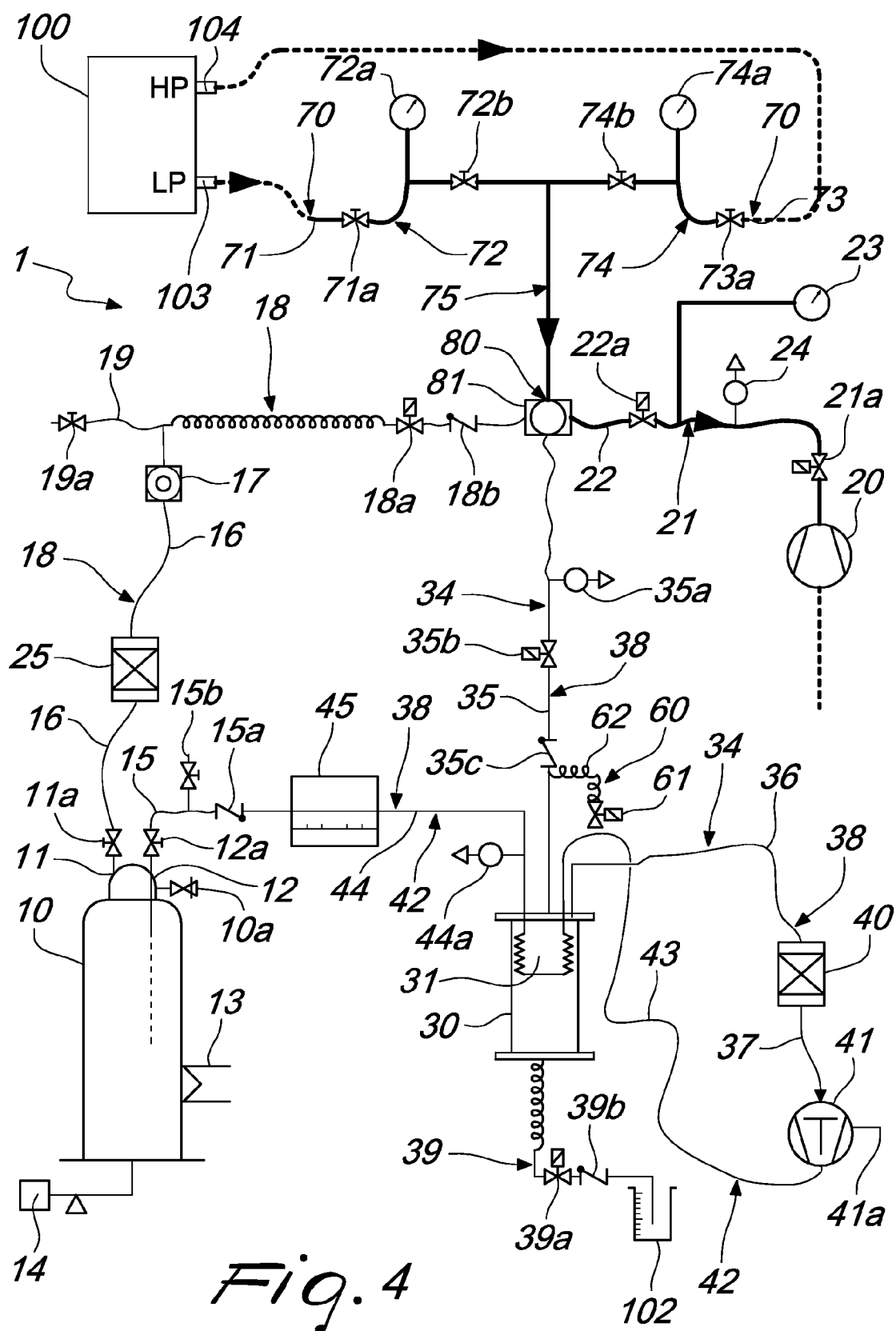
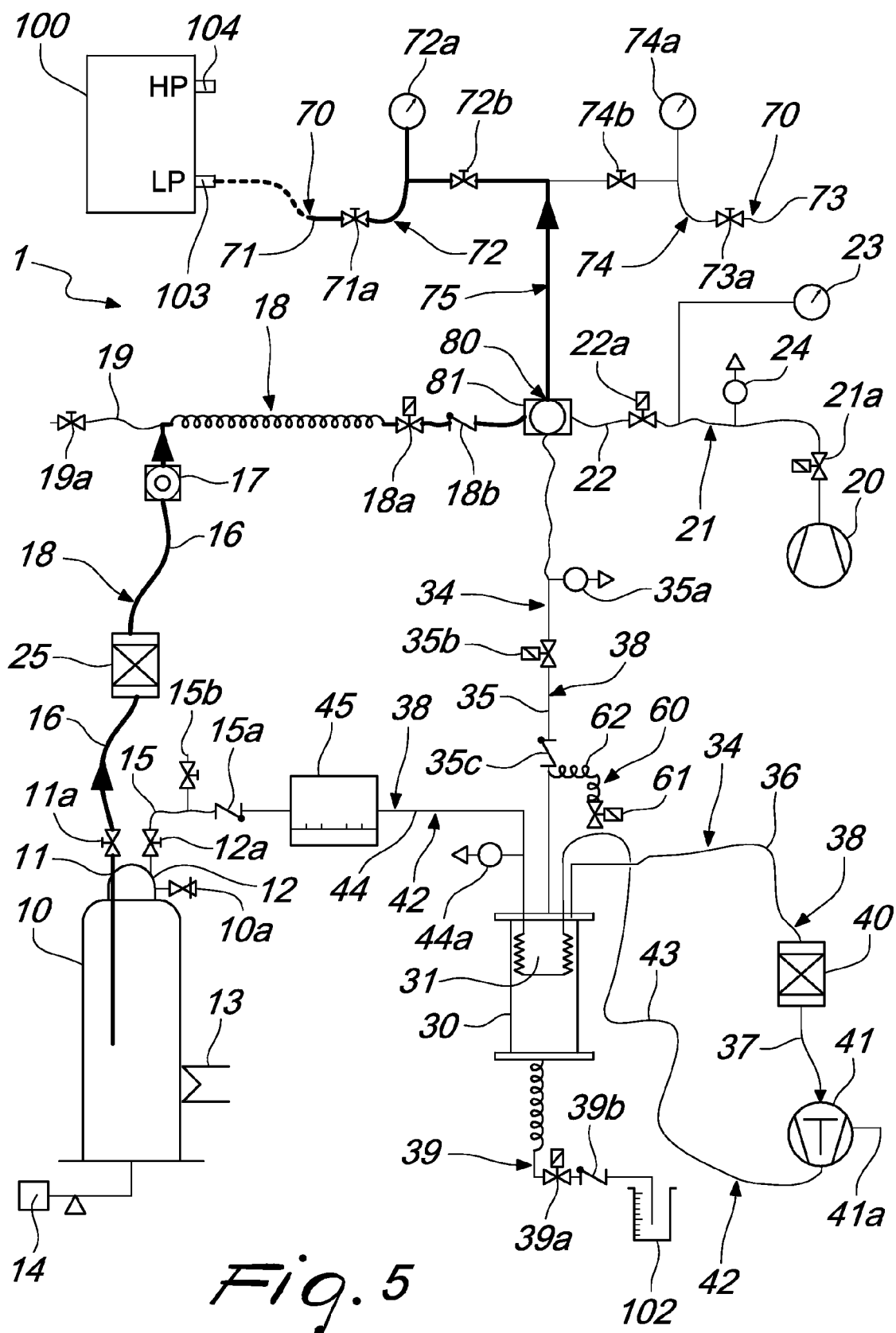
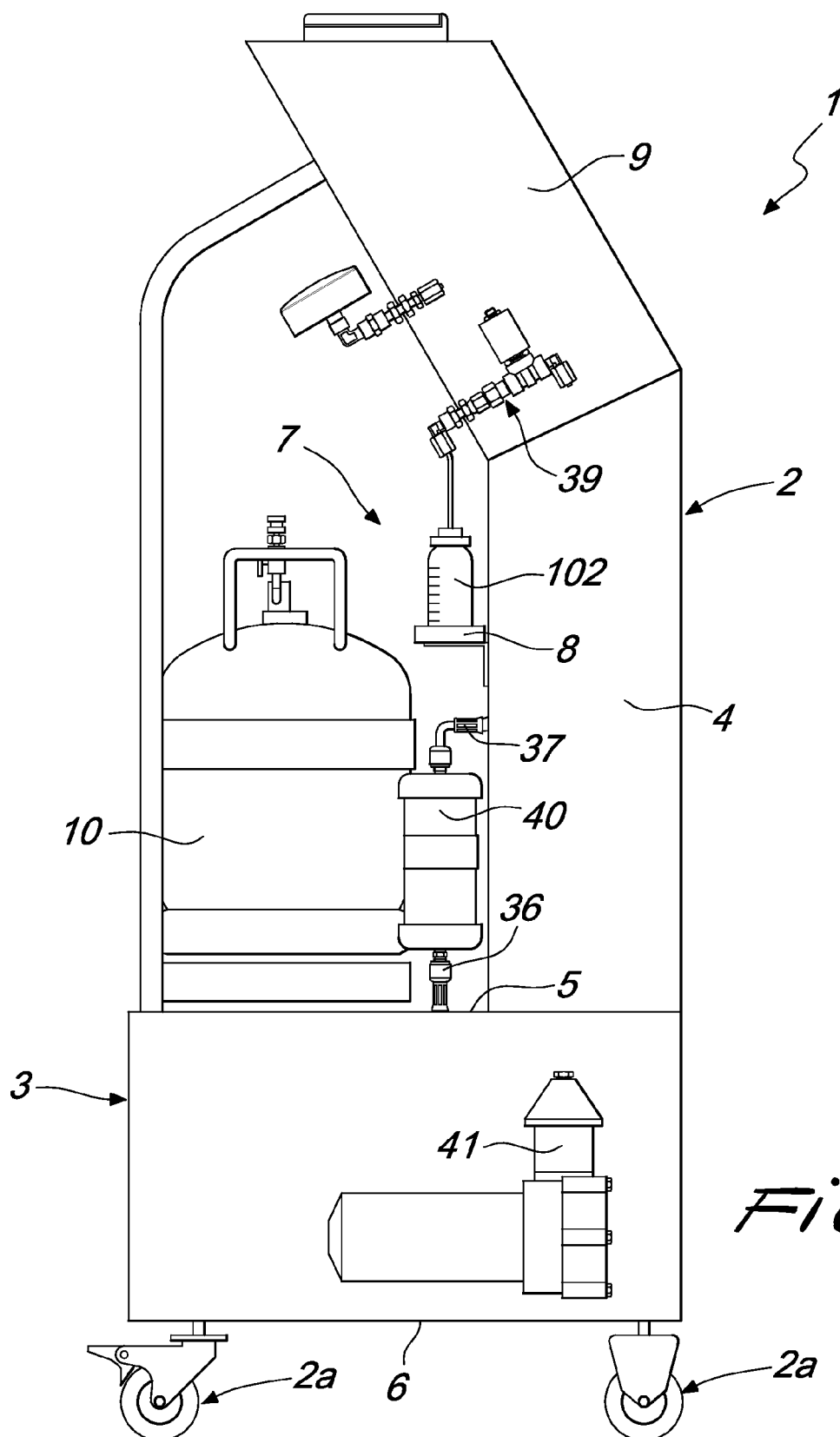


Fig. 4





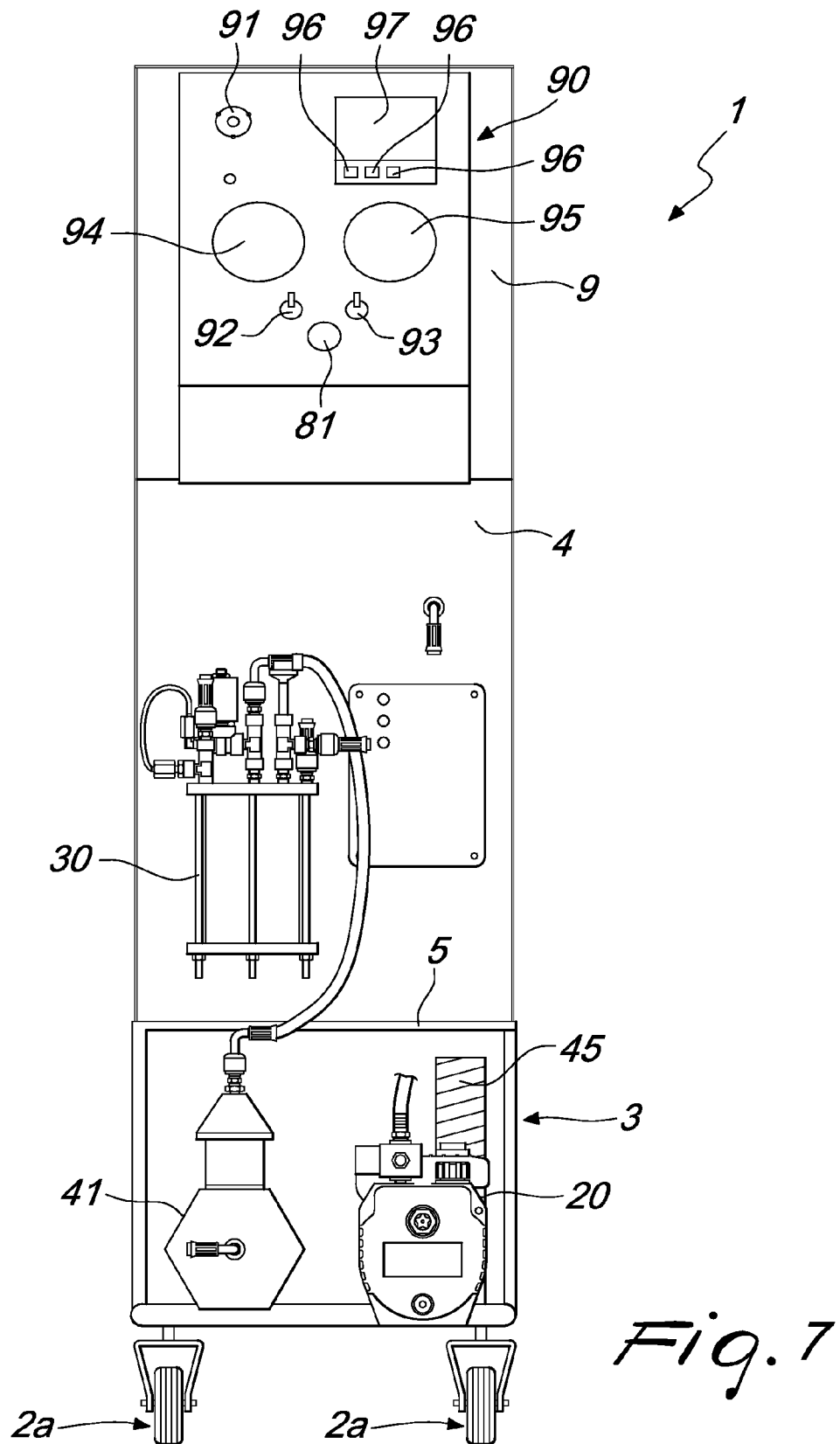


Fig. 7

REFERENCES CITED IN THE DESCRIPTION

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