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(54) **Title:** DEVICE FOR DRYING COMPRESSED GAS AND COMPRESSOR INSTALLATION PROVIDED WITH SUCH DEVICE.

(57) **Abstract:** Device for drying compressed gas, with a dryer inlet (2) and a dryer outlet (3), wherein said device (1) comprises at least two vessels (4a, 4b) with therein contained a regenerable drying agent (5) and a controllable valve system (8) consisting of a first valve block (9a) connecting the dryer inlet (2) to an inlet (6) of said vessels (4a, 4b) and a second valve block (9b) connecting the dryer outlet (3) to an outlet (7) of the vessels (4a, 4b), wherein the valve system (8) is such that always at least one vessel (4b) is being regenerated, while the other vessels (4a) dry the compressed gas, wherein by controlling the valve system (8), the vessels (4a, 4b) are successively regenerated, characterized in that each vessel (4a, 4b) is provided with an input (11) for a regeneration gas, wherein the device (1) is provided with a blower (23) for supplying ambient air as regeneration gas.

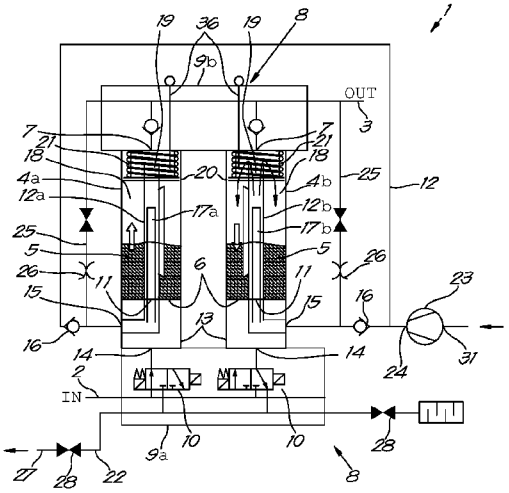

Fig. 1

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Device for drying compressed gas and compressor installation provided with such device.

The present invention relates to a device for drying compressed gas.

More specifically, the invention is intended for drying compressed gas originating from a compressor.

Such devices, also called dryers, are already known, which comprise two or more separate vessels, each containing a quantity of a regenerable drying agent or desiccant, wherein the vessels each alternatively and alternately operate to dry compressed gas by passing the compressed gas to be dried therethrough and to be regenerated, wherein the drying agent is regenerated by contacting it with a warm gas, also called regeneration gas.

Regeneration here means the process wherein drying agent, saturated or nearly-saturated with moisture, is stripped of the absorbed or adsorbed moisture by contacting it with a regeneration gas that will remove the moisture from the drying agent. The drying agent can then be used again for drying.

By means of a suitable system of lines and valves, it is possible to switch between the two vessels.

Devices are already known wherein part of the dried, compressed gas is branched-off via a regeneration line and used as regeneration gas.

A heater is often placed in this regeneration line to heat up the regeneration gas.

Although by heating up the regeneration gas, less regeneration gas is needed and thus there is less loss of dried, compressed gas, such an arrangement has a number of drawbacks.

First of all, the heater will not only heat up the regeneration gas, but also, because of losses, the ambient air and thus, indirectly, also the vessels, which is, of course, undesirable for the vessels that are not regenerating.

Due to said losses, the heater must also operate at a higher temperature in order to obtain a sufficiently high temperature of the regeneration gas or more regeneration gas will have to be branched-off to ensure that the drying agent can be sufficiently regenerated in an acceptable period of time.

In addition, this regeneration gas is vented after passing through the vessel, which means a loss of dried compressed gas.

Dryers are also known wherein said heater is placed in the vessels instead of in the regeneration line.

An advantage is that the heat losses from said heater will end up in the vessel that is regenerating, i.e. exactly at the location where this heat is desired and useful.

A disadvantage of these dryers remains that dried compressed gas is used as regeneration gas.

Hence, part of the efficiency to regenerate the drying agent is lost.

Although such type of dryer succeeds in drying the compressed gas in a satisfactory manner, the consumption of dried compressed gas as regeneration gas is too high for such a dryer to be considered efficient.

The present invention aims to provide a solution to said and other disadvantages.

The present invention relates to a device for drying compressed gas, with a dryer inlet for compressed gas to be dried and a dryer outlet for dried compressed gas, wherein said device comprises at least two vessels with therein contained a regenerable drying agent and a controllable valve system consisting of two valve blocks, namely a first valve block, connecting said dryer inlet to an inlet of said vessels, and a second valve block, connecting said dryer outlet to an outlet of said vessels, wherein said valve system is such that always at least one vessel is being regenerated, while the other vessels dry the compressed gas, wherein, by controlling the valve system, the vessels are each in turn successively regenerated, characterized in that each vessel

is provided with an input, physically different from said inlet and outlet, for a regeneration gas with a regeneration line connected thereto for supplying the regeneration gas to the vessel that is being regenerated, wherein the regeneration line extends via the regeneration gas input at least partially into the vessels, wherein a heater is provided in the vessels which is located in the regeneration line for heating up the regeneration gas before the regeneration gas is passed through the drying agent in the vessel that is being regenerated, wherein the device is also provided with a discharge line for discharging the regeneration gas after it has passed through the vessel that is being regenerated, wherein said discharge line is connected via the valve system to the inlet of said vessels, wherein the device is provided with a blower for supplying ambient air as regeneration gas.

An advantage is that, for the regeneration, compressed dried gas is not branched-off and then vented.

This means that all of the compressed gas to be dried is effectively dried and that all of the dried compressed gas can be supplied to the end user.

An additional advantage is that, by using the blower, it is possible to draw in ambient air as the regeneration gas.

Moreover, by means of the blower, the flow rate of the regeneration gas can be controlled by simply controlling the flow rate of the blower.

This allows to control the rate of regeneration of the drying agent by increasing the flow rate of the blower if better regeneration of the drying agent is required.

Since the vessels are provided with a separate outlet for dried compressed gas, an inlet for gas to be dried, and an input for regeneration gas and a cooling gas, this has the advantage that there is more freedom to select the position of the inlet and input in the vessels. This is important because the heater for the regeneration gas is located in the vessels.

A smart choice of this position ensures that both the gas to be dried and the regeneration gas and cooling gas are always passed through the entire drying agent, which increases the efficiency of the drying process, regeneration process and cooling process.

Preferably, an intermediate block is arranged between each vessel and the first valve block with a first passage for gas to be dried, which connects to the inlet of the respective vessel and to the first valve block, and a second passage for regeneration gas, which connects to said input for regeneration gas in the vessels, wherein said passage for regeneration gas is part of the regeneration line.

An advantage of such an intermediate block is that it increases the modularity of the dryer, such that one or more extra vessels can easily be added, because in such intermediate blocks the necessary connections can be provided for

gas to be dried, regeneration gas and optionally cooling gas.

According to a preferred feature of the invention, the vessels are formed by extruded profiles.

This has the advantage that the vessels can be produced in a simpler and cheaper manner compared to boilers, which may or may not be provided with insulation along an inside and/or outside of the extruded profiles.

Obviously, the invention is not limited to this, and the vessels can also be manufactured in a different manner.

The provision of insulation on the inside and/or outside of the extruded profiles will significantly improve efficiency as less heat exchange with the environment will occur.

In a first practical embodiment, the regeneration lines converge into a common regeneration line to which the blower outlet is connected.

In this case, the blower will blow the ambient air through the vessel that is being regenerated.

In a second practical embodiment, the blower inlet is connected to the discharge line.

In this case, the blower will draw in ambient air, which will first flow through the vessel that is being regenerated before passing through the blower.

The invention also relates to a compressor installation, provided with a compressor with an inlet for gas to be compressed and an outlet with a pressure line for compressed gas, characterized in that the compressor installation is provided with a device according to one of the preceding claims for drying the flow rate of compressed gas supplied by the compressor, which is passed through the device for the supply of dried gas to a user network via the dryer outlet of the device, wherein for this purpose the pressure line connects to the dryer inlet of the device.

The advantages of such a compressor device are similar to the advantages of the device according to the invention.

With the intention of better demonstrating the features of the invention, some preferred embodiments of a device for drying compressed gas and compressor installation provided with such a device according to the invention are described hereafter, by way of example, without any limiting character, with reference to the accompanying drawings, wherein:

Figure 1 schematically shows a device according to the invention for drying a compressed gas according to the principle of dry air cooling, and pressure regeneration;

Figure 2 shows a variant of Figure 1, according to the principle of dry air cooling, and vacuum regeneration;

Figure 3 shows an alternative embodiment of a device according to the invention for drying a compressed gas

according to the principle of blower air open-loop cooling, and pressure regeneration;

Figure 4 shows the embodiment of Figure 3, but in a different position;

Figure 5 shows a variant of Figure 3, according to the same principle;

Figure 6 shows a second variant of Figure 3, according to the principle of blower air open-loop cooling, and vacuum regeneration;

Figure 7 shows a second alternative embodiment of a device according to the invention for drying a compressed gas according to the principle of blower air closed-loop cooling, and vacuum regeneration;

Figure 8 shows a variant of Figure 7 according to the principle of blower air closed-loop cooling, and pressure regeneration;

Figure 9 shows a third alternative embodiment of a device according to the invention for drying a compressed gas, according to the principle of dry air pressure cooling, and dry air pressure regeneration;

Figure 10 shows a variant of Figure 9, according to the principle of dry air vacuum cooling, and dry air vacuum regeneration;

Figure 11 shows a second variant of Figure 9, according to the principle of dry air pressure cooling, and dry air vacuum regeneration.

The device 1 for drying compressed gas shown schematically in Figure 1 comprises a dryer inlet 2 for compressed gas to be dried and a dryer outlet 3 for dried compressed gas.

The device 1 is provided with two vessels 4a, 4b containing a regenerable drying agent 5 therein.

However, it is not excluded for the invention that the device 1 comprises more than two vessels 4a, 4b. For instance, the device 1 may also comprise four, six, eight or ten vessels.

Each vessel 4a, 4b is provided with an inlet 6 for gas and an outlet 7 for gas.

Furthermore, the device 1 is provided with a valve system 8.

In this case, this valve system 8 consists of two valve blocks 9a, 9b, namely a first valve block 9a that connects said dryer inlet 2 to the inlet 6 of said vessels 4a, 4b and a second valve block 9b that connects said dryer outlet 3 to the outlet 7 of said vessels 4a, 4b.

In this case, the first valve block 9a is provided with two 3/2 valves 10.

Said valve system 8 is such that one vessel 4b is always being regenerated, while the other vessel 4a dries the compressed gas. With more than two vessels 4a, 4b, at least one vessel will always be regenerated while the other vessels are drying.

By controlling the valve system 8, the vessels 4a, 4b are each in turn successively regenerated.

Moreover, in this case, it will be the case that said valve system 8 is such that at least one vessel 4b is always being regenerated and subsequently cooled, while the other vessels 4a dry the compressed gas, wherein by controlling the valve system 8 the vessels 4a, 4b are each in turn sequentially being regenerated and cooled. However, this cooling step is not necessary for the invention.

According to the invention, each vessel 4a, 4b is provided with an input 11 for a regeneration gas with a regeneration line 12 connected thereto for supplying the regeneration gas to the vessel 4a, 4b that is being regenerated.

In this case, between each vessel 4a, 4b and the first valve block 9a, an intermediate block 13 is arranged with a first passage 14 for gas to be dried, which connects to the inlet 6 of the respective vessel 4a, 4b and to the first valve block 9a, and a second passage 15 for regeneration gas, which connects to said input 11 for regeneration gas in the vessels 4a, 4b, wherein said second passage 15 for regeneration gas is part of the regeneration line 12.

For each vessel 4a, 4b, a separate regeneration line 12 is provided.

In this case, a controllable valve or check valve 16 is provided in the regeneration lines 12. This check valve 16 allows a gas to flow through the input 11 into the vessels 4a, 4b and prevents a gas from escaping from the vessels 4a, 4b through the input 11.

The regeneration lines 12 extend via the input 11 for regeneration gas, at least with the portion 12a, into the vessels 4a, 4b.

A heater 17a, 17b is provided in the vessels 4a, 4b, which is located in the regeneration line 12, more specifically in the portion 12a of the regeneration line 12, for heating the regeneration gas before the regeneration gas is sent through the drying agent 5 into the vessel 4b, which is being regenerated.

As is clear from the figures, the vessels 4a, 4b are provided, along one of their ends, with a free space 18 in which no drying agent 5 is contained. The free end 19 of the regeneration lines 12 is situated in this free space 18.

This ensures that the regeneration air can flow freely and without obstacles in the vessel 4b.

In this case, this free space 18 is realized by means of a grid 20, held by a spring 21 at a distance from the end of the vessel 4a, 4b. This grid 20 is permeable to gas but not to drying agent 5.

The device 1 is also provided with a discharge line 22 for discharging the regeneration gas after it has passed through the vessel 4b that is being regenerated.

This discharge line 22 is connected via the valve system 8 and more specifically the first valve block 9a to the inlet 6 of said vessels 4a, 4b.

The device 1 is also provided with a blower 23 for supplying ambient air as regeneration gas.

In this case, the regeneration lines 12 converge in a common regeneration line 12 to which the blower outlet 24 is connected.

Furthermore, in this case, the device 1 is provided with a branch line 25. In this case, two such branch lines 25 are provided.

By means of the branch line 25, part of the compressed dried gas can be branched-off at the dryer outlet 3. This branched-off gas is used as a cooling gas, as will be explained later.

The branch line 25 connects with one end to said dryer outlet 3 and with its other end, the branch line 25 connects to the respective regeneration line 12 at a point located between said input 11 and said controllable valve or check valve 16.

Expansion means 26 are provided in the branch lines 25 for expanding the dried compressed gas before it enters via the input 11 the vessel 4b, that is being cooled at that moment.

Since the vessels 4a, 4b are provided with a separate outlet 7, inlet 6 for gas to be dried and an input 11 for regeneration gas and cooling gas, this has the advantage that there is more freedom to determine the position of inlet 6 and input 11 in the vessels 4a, 4b.

A smart choice of this position ensures that both the gas to be dried and the regeneration gas and cooling gas are always passed through the entire drying agent, as shown in Figure 1, which increases the efficiency of the drying process, regeneration process and cooling process.

The operation of the device 1 as shown in Figure 1 is very simple and as follows.

During the operation of the device 1, compressed gas to be dried will be supplied via the dryer inlet 2. This gas is passed via the first valve block 9a and the first passage 14 of the intermediate block 13 to the vessel 4a which will perform the drying, in Figure 1 the left vessel 4a.

When passing through this vessel 4a, the gas will be dried, whereby the drying agent 5 in this vessel 4a will adsorb the moisture from the gas.

The dried compressed gas can exit the device 1 through the second valve block 9b and the dryer outlet 3 and can be delivered to the end user.

At the same time, the other vessel 4b, in Figure 1 the straight vessel 4b, will be regenerated in a first phase, wherein the drying agent 5 is dried by means of a regeneration gas.

To this end, the blower 23 will draw-in ambient air and pass it via the regeneration line 12 to the vessel 4b that is being regenerated.

The drawn-in ambient air cannot flow to the vessel 4a that is being dried because either the pressure of the drawn-in ambient air is too low to open the check valve 16 against the pressure of the vessel 4a that is being dried or because the adjustable valve 16 in the regeneration line 12 is closed.

When the drawn-in ambient air enters the portion 12a of the regeneration line 12 which extends into the vessel 4b, it will be heated by the heater 17b which is currently switched on.

This heated ambient air will flow through the vessel 4b as regeneration gas and thereby remove moisture from the drying agent 5.

Subsequently, this regeneration gas exits the device 1 via the discharge line 22 via the first passage 14 of the intermediate block 13 and the first valve block 9a.

After this first phase, the vessel 4b is cooled. To this end, a small portion of the dried compressed gas is branched-off via the respective branch line 25 and expanded, whereby it is cooled.

Via the regeneration line 12, this cool or cold cooling gas ends up in the vessel 4b where it will extract heat from the drying agent 5. The heater 17b is hereby switched off.

Subsequently, this cooling gas also exits the device 1 via the discharge line 22 via the first passage 14 of the intermediate block 13 and the first valve block 9a.

Figure 2 shows a variant of Figure 1, wherein, in this case, the blower inlet 31 is connected to the discharge line 22. The device 1 is also provided with a venting opening 27 for the cooling gas, wherein said venting opening 27 is connected via the first valve block 9a to the inlet 6 of the vessels 4a, 4b.

The operation of the device 1 from Figure 2 is very analogous to the operation of the device 1 from Figure 1.

In this case, the regeneration gas will be drawn-in via the blower 23, wherein the ambient air enters the device 1 by the aspiration action of the blower 23 via the regeneration line 12, and is then drawn-in via the vessel 4b and the first valve block 9a to the discharge line 22 and the blower 23.

This regeneration principle is also called vacuum regeneration. The regeneration principle from Figure 1 is called pressure regeneration.

Note that, for the embodiment of Figure 1, it is possible to realize a vacuum regeneration by simply reversing the blower 23, wherein the blower inlet 31 is connected to the regeneration line 12. Similarly, in the embodiment of Figure 2, a pressure regeneration can be realized by reversing the blower 23, wherein the blower outlet 23 is connected to the discharge line 22.

Returning to the embodiment of Figure 2, in this case, for the cooling of the vessel 4b, the cooling gas after passing through the entire device 1, will exit it via said venting opening 27 instead of via the discharge line 22.

To realize this, a closable valve 28 is provided in the discharge line 22 between the blower 23 and the first valve block 9a, which valve is closed during the cooling phase such that the cooling gas escapes via the venting opening 27.

The alternative embodiment shown in Figure 3 differs from Figure 1 in that the branch line 25 is absent. Furthermore, the check valves 16 in the regeneration lines 12 have been replaced by closable valve 28.

The big difference of this embodiment is that ambient air will now be used as cooling gas instead of branched-off dried compressed gas. This is clarified below. The cooling principle of this embodiment is according to the blower air principle, wherein ambient air, supplied by the blower, is used for cooling, while the cooling principle of the previous two embodiments follows the dry air cooling principle, wherein dried compressed gas is used for cooling.

To this end, the device 1 is provided with a valve device 29 which allows to connect said blower 23 to the device 1 in various ways. Figures 3 and 4 show the two positions of this valve device 29.

Figure 3 shows the position of the valve device 29 wherein the blower outlet 24 is connected to the regeneration lines 12 for supplying a regeneration gas to the vessel 4b that is being regenerated, and at the same time the discharge line 22 is connected to a venting opening 27 for the regeneration gas.

In this position, the right vessel 4b will be regenerated, wherein the regeneration gas is drawn-in by the blower 23 via the regeneration line 12 and the opened closable valve 28 and is entering the vessel 4b. As in the previous embodiment of Figures 1 and 2, the heater 17b will be switched on to heat the regeneration gas.

After passing through this vessel 4b, the regeneration gas will exit the device 1 via the first passage 14 of the intermediate block 13, the first valve block 9a, the discharge line 22 and the valve device 29 via said venting opening 27.

Figure 4 shows the position of the valve device 29 wherein the blower outlet 24 is connected to the discharge line 22 for supplying a cooling gas to the vessel 4b that is being cooled, and at the same time the regeneration lines 12 are connected to said venting opening 27 for the cooling gas.

In this position, the right vessel 4b will be cooled, wherein the cooling gas is being drawn-in by the blower 23 and ending up in the vessel 4b via the discharge line 22 and the first valve block 9a. As in the previous embodiment of Figures 1 and 2, the heater 17b will be switched off.

After passing through this vessel 4b, this cooling gas will exit the device 1 via the regeneration line 12 and the opened respective closable valve 28 or the valve device 29 along said venting opening 27.

In Figures 3 and 4, the valve device 29 is provided with a four-way valve 30. It will be clear that the invention is not limited thereto, however, and that the valve device 29 can be realized in many different ways, as long as it fulfills the functions described above.

By way of example and without any limiting character, Figure 5 shows a variant of Figure 3, in which case the valve system 8 comprises a number of closable valves 28.

Note that in the embodiments of Figures 3, 4 and 5, it is possible to apply the principle of vacuum regeneration by reversing the blower 23, connecting the blower inlet 31 to the regeneration lines 12 or the discharge line 22. Note that reversing the blower 23 is also possible in the embodiments discussed below.

In the embodiments of Figures 3 to 5, regeneration was realized by pressure regeneration. Figure 6 shows a variant of Figure 3 wherein the regeneration is realized by means of vacuum regeneration.

To this end, the device 1 is provided with a valve device 29 that allows either to connect the blower inlet 31 to the discharge line 22 for drawing-in a regeneration gas through

the vessel 4b that is being regenerated, or to connect the blower outlet 24 to the discharge line 22 for supplying a cooling gas for the vessel 4b that is being cooled.

As is clear from this figure, during regeneration the blower 23 will draw-in ambient air, which will be drawn-in via the regeneration line 12, the vessel 4b that is being regenerated, the first valve block 9a and the discharge line 22 up to the blower 23 and will exit the device 1 via the blower outlet 24. Here too, the heater 17b in the respective vessel 4b will be switched on.

In the other position of the valve device 29, not shown in the figures but very analogous to the embodiment of Figures 3 and 4, the blower 23 will be able to draw-in ambient air as cooling gas, which will flow via the discharge line 22 and the first valve block 9a into the vessel 4b that is being cooled before it exits the device 1 via the discharge line 22. In this case, the heater 17b will be switched off. This principle is called open-loop cooling.

Figure 7 shows a second alternative embodiment of a device 1 according to the invention, which differs from Figure 6 in that a feedback line 32 is provided which runs from the blower inlet 31 to a point on the regeneration line 12 such that a closed circuit for cooling gas is formed, consisting of the regeneration lines 12, the feedback line 32 and the discharge line 22 when the blower outlet 24 is connected to the discharge line 22 for supplying a cooling gas to the vessel 4b that is being cooled, wherein in this feedback

line 32, a closable valve 28 and a cooler 33 for cooling regeneration gas is provided.

In this case, during regeneration, the regeneration gas will follow the same path as described for Figure 6. The closable valve 28 in the feedback line 32 will then be closed and the heater 17b in the respective vessel 4b that is being regenerated will also be switched on.

With regard to the cooling of the vessel 4b, the cooling gas drawn-in by the blower 23 after regeneration will now pass through a closed path through the device 1, as described above.

Instead of constantly drawing-in new ambient air as cooling gas, as is the case in Figure 6, the cooling gas will now be reused or recycled, wherein, after passing through the vessel 4b, the cooling gas is cooled in the feedback line 32 before it is sent back by the blower 23 to this vessel 4b. This principle is called closed-loop cooling.

An advantage is that by not constantly drawing-in fresh or new ambient air, additional humidity, which is inevitably present in ambient air, is not constantly introduced into this vessel 4b.

Figure 8 is a variant of Figure 7, wherein, as in this case, the cooling gas passes through a closed path. The difference lies in the fact that, where in Figure 7 the regeneration took place by means of the principle of vacuum regeneration,

in Figure 8, this takes place by means of pressure regeneration, as in Figure 3.

For this purpose, the valve device 29, as shown in Figure 3, is adapted and provided with a check valve 16 which prevents gas from leaving the device 1 via the venting opening 27 when the valve device 29 connects the regeneration line 12 to said venting opening 27, and wherein the device 1 is provided with a feedback line 32 which extends from the blower inlet 31 to a point on the regeneration line 12 such that a closed circuit is formed for cooling gas, consisting of the regeneration lines 12, the feedback line 32 and the discharge line 22 when the blower outlet 24 is connected to the discharge line 22 for supplying a cooling gas to the vessel 4b that is being cooled, wherein a closable valve 28 and a cooler 33 for cooling regeneration gas are provided in this feedback line 32.

For the regeneration, the blower 23 will draw-in ambient air, which can end up through the check valve 16 into the regeneration line 12 and the vessel 4b that is being regenerated, as in the situation in Figure 3.

For cooling, the ambient air drawn-in by the blower 23 will be able to circulate through the device 1 due to the feedback line 32, as is the situation in Figure 7.

Figure 9 shows a third alternative embodiment, which is very similar to the embodiment of Figure 3 and wherein the device 1 is additionally provided with a boiler 34, filled with a regenerable drying agent 5, which is included between the

regeneration lines 12 and the valve device 29, such that, when the blower outlet 24 is connected by the valve device 29 to the regeneration lines 12, the regeneration gas, before being heated up, must pass through the boiler 34 and such that, when the regeneration lines 12 are connected to the venting opening 27, the cooling gas must pass through the boiler 34.

An advantage of this third alternative embodiment is that all of the moisture in the ambient air will be extracted by the drying agent 5 in the boiler 34 such that regeneration can be accomplished with completely dry ambient air. This ensures a more efficient regeneration.

An additional advantage thereof is that the ambient air has to be heated less strongly, such that the heater 17a, 17b can be set to a lower temperature and at least temporarily use less energy.

Typically, this temperature reduction will be, for example, 30°C to 40°C, compared to known devices.

Therefore, it is also possible to install a heater 17a, 17b with a lower connected power, since less heating capacity will be required.

Preferably, the internal volume of the boiler 34 is at most 1/3 or at most 1/4 of the internal volume of one of said at least two vessels 4a, 4b.

The preferred maximum dimensions of the boiler 34 will depend on the expected environmental parameters.

If the relative humidity is 100%, the internal volume of the boiler 34 is preferably 1/3 of the internal volume of said vessels 4a, 4b.

If the relative humidity is 70%, the internal volume of the boiler 34 is preferably 1/4 of the internal volume of said vessels 4a, 4b.

Such a volume of the boiler 34 provides sufficient drying agent 5 to properly carry out or realize the drying and regeneration process described below.

During regeneration, the regeneration gas, drawn-in by the blower 23, will pass through said boiler 34 and will thus be dried, as a result of which the regeneration of the vessel 4b will proceed optimally and efficiently. The regeneration of the vessel 4b is further as described in Figure 3.

In addition, during regeneration, the drying agent 5 from the boiler 34 will become saturated with moisture from the ambient air.

During the cooling of the vessel 4b, the ambient air, drawn-in by the blower 23, after passing through the vessel 4b that is being cooled, will exit the device 1 after passing through the boiler 34. The cooling of the vessel 4b is further as described for Figure 4.

After passing through the vessel 4b which is cooled, the cooling gas is heated up and will therefore regenerate the drying agent 5 in the boiler 34.

Heat will, as it were, be temporarily stored in the boiler 34, which means that the boiler 34 heats up.

When, in a subsequent phase, a vessel 4a,4b is regenerated, the ambient air, drawn-in by the blower 23, will not only be dried by the boiler 34, but will also be heated for a certain time.

This means that, in a subsequent phase, the boiler 34 can again dry regeneration gas.

Typically, this will amount to an increase of 10°C compared to the known devices.

Figure 10 is a variant of Figure 9. Where Figure 9 concerned pressure regeneration and also pressure cooling for cooling, since the blower 23 pushed drawn-in ambient air through the device 1, Figure 10 concerns a vacuum regeneration and also vacuum cooling, wherein the blower 23 draws-in ambient air via the device 1. In other words, the air, drawn-in by the blower 23, has passed through the device 1 before flowing through the blower 23.

To realize this, a number of changes have been made to the device 1 and more specifically to the orientation of the blower 23 and the valve device 29.

These changes essentially imply that the valve device 29 allows either to:

- connect the blower inlet 31 to the discharge line 22 for supplying a regeneration gas to the vessel 4b that is being regenerated, and at the same time connect the regeneration lines 12 to an aspiration opening 35 for the regeneration gas; or to:
- connect the blower inlet 31 to the regeneration lines 12 for supplying a cooling gas to the vessel 4b that is being cooled and at the same time connect the discharge line 22 to said aspiration opening 35 for the cooling gas.

Further, said modifications comprise that the boiler 34 is included between the regeneration lines 12 and the valve device 29, such that, when the blower inlet 31 is connected by the valve device 29 to the discharge line 22, the regeneration gas must pass through the boiler 34 before reaching the vessel 4a, 4b to be regenerated and such that, when the blower inlet 31 is connected by the valve device 29 to the regeneration lines 12, the cooling gas must pass through the boiler 34 before exiting the device 1.

The regeneration and cooling is done similarly to Figure 9.

Figure 11 shows a second variant of Figure 9, which is closely related to the embodiment of Figure 6. Basically, the boiler 34 from Figure 9 has been added to the variant of Figure 6.

To this end, the boiler 34 is connected to the regeneration lines 12, such that, when the blower inlet 31 is connected

to the discharge line 22, the supplied regeneration gas must pass through the boiler 34 and such that, when the blower outlet 24 is connected to the discharge line 22, the cooling gas must pass through the boiler 34 to exit the device 1.

In this case, the regeneration is based on the principle of vacuum regeneration and the cooling is based on the principle of pressure cooling.

The regeneration and the cooling are realized in a very similar way as in Figure 6. The principle of drying the ambient air of the boiler 34 and regenerating the drying agent 5 in the boiler 34 by the cooling gas is as described for Figures 9 and 10.

As can be seen in the figures, the vessels 4a and 4b are each equipped with a temperature sensor 36. These temperature sensors 36 will measure the temperature of the regeneration gas. During the regeneration of a vessel 4a or 4b, the respective heater 17a, 17b will be switched on in this vessel 4a or 4b. The heater 17a, 17b will be switched on or off until the temperature sensor 36 measures the desired temperature.

The present invention is by no means limited to the embodiments described by way of example and shown in the figures, but a device for drying compressed gas and a compressor installation provided with such a device according to the invention can be realized in all kinds of shapes and dimensions without departing from the scope of the invention.

Claims

_____

1.- Device for drying compressed gas, with a dryer inlet (2) for compressed gas to be dried and a dryer outlet (3) for dried compressed gas, wherein said device (1) comprises at least two vessels (4a, 4b) with therein contained a regenerable drying agent (5) and a controllable valve system (8) consisting of two valve blocks (9a, 9b), namely a first valve block (9a), connecting said dryer inlet (2) to an inlet (6) of said vessels (4a, 4b), and a second valve block (9b), connecting said dryer outlet (3) to an outlet (7) of said vessels (4a, 4b), wherein said valve system (8) is such that always at least one vessel (4b) is being regenerated, while the other vessels (4a) dry the compressed gas, wherein, by controlling the valve system (8), the vessels (4a, 4b) are each in turn successively regenerated, **characterized in that** each vessel (4a, 4b) is provided with an input (11), physically different from the said inlet (6) and from said outlet (7), for a regeneration gas with a regeneration line (12) connected thereto for supplying the regeneration gas to the vessel (4b) that is being regenerated, wherein the regeneration line (12) extends via the regeneration gas input (11) at least partially into the vessels (4a, 4b), wherein a heater (17a, 17b) is provided in the vessels (4a, 4b), which is located in the regeneration line (12) for heating up the regeneration gas before the regeneration gas is passed through the drying agent (5) in the vessel (4b) that is being regenerated, wherein the device (1) is also provided with a discharge line (22) for discharging the regeneration gas after it has passed through the vessel (4b) that is being

regenerated, wherein said discharge line (22) is connected via the valve system (8) to the inlet (6) of said vessels (4a, 4b), wherein the device (1) is provided with a blower (23) for supplying ambient air as regeneration gas.

2.- Device according to claim 1, **characterized in that** between each vessel (4a, 4b) and the first valve block (9a) an intermediate block (13) is arranged with a first passage (14) for gas to be dried, which connects to the inlet (6) of the respective vessel (4a, 4b) and to the first valve block (9a), and a second passage (15) for regeneration gas, which connects to said input (11) for regeneration gas in the vessels (4a, 4b), wherein said passage (24) for regeneration gas is part of the regeneration line (12).

3.- Device according to any one of the preceding claims, **characterized in that** the vessels (4a, 4b) are formed by extruded profiles, which may or may not be provided with insulation along an inside and/or outside of the extruded profiles.

4.- Device according to any one of the preceding claims, **characterized in that** the regeneration lines (12) converge into a common regeneration line (12) to which the blower outlet (24) or blower inlet (31) is connected.

5.- Device according to any one of the preceding claims 1 to 3, **characterized in that** the blower inlet (31) or the blower outlet (24) is connected to the discharge line (22).

6.- Device according to any one of the preceding claims,

characterized in that a controllable valve or check valve (16) is provided in the regeneration lines (12).

7.- Device according to any one of the preceding claims, **characterized in that** said valve system (8) is such that always at least one vessel (4b) is regenerated and subsequently cooled, while the other vessels (4a) dry the compressed gas, wherein by controlling the valve system (8) the vessels (4a, 4b) are each in turn successively regenerated and cooled.

8.- Device according to claim 6 and 7, **characterized in that** the device (1) comprises a branch line (25) for branching-off compressed dried gas at said dryer outlet (3) of the device (1), wherein said branch line (25) connects to said regeneration lines (12) at a point located between the input (11) of the vessels (4a, 4b) and the controllable valve or the check valve (16) provided in the regeneration lines (12), wherein expansion means (26) are provided in the branch line (25) for expanding the dried compressed gas before it passes through the input (11) into the vessel (4b) that is being cooled as a cooling gas.

9.- Device according to claims 4 and 7, **characterized in that** the device (1) is provided with a valve device (29) that allows either to:

- connect the blower outlet (24) or the blower inlet (31), respectively, to the regeneration lines (12) for supplying a regeneration gas to the vessel (4b) that is being regenerated, and at the same time connect the discharge line (22) to a venting opening (27) for the regeneration gas; or

to:

- connect the blower outlet (24) or the blower inlet (31), respectively, to the discharge line (22) for supplying a cooling gas to the vessel (4b) that is being cooled, and at the same time connect the regeneration lines (12) to said venting opening (27) for the cooling gas.

10.- Device according to claims 5 and 7, **characterized in that** the device (1) is provided with a valve device (29) that allows either the blower inlet (31) to be connected to the discharge line (22) for drawing-in a regeneration gas through the vessel (4b) that is being regenerated or the blower outlet (24) to be connected to the discharge line (22) for supplying a cooling gas for the vessel (4b) that is being cooled.

11.- Device according to claim 9, **characterized in that** said valve device (29) is provided with a check valve (16) which prevents gas from leaving the device (1) via the venting opening (27) when the valve device (29) the regeneration line(12) connects to said venting opening (27), **and that** the device (1) is provided with a feedback line (32) running from the blower inlet (31) to a point on the regeneration line (12) such that a closed circuit is formed for cooling gas, consisting of the regeneration lines 12, the feedback line (32) and the discharge line (22) when the blower outlet (24) is connected to the discharge line (22) for supplying a cooling gas to the vessel (4b) that is being cooled, wherein a closable valve (28) and a cooler (33) for cooling regeneration gas are provided in this feedback line (32).

12.- Device according to claim 10, **characterized in that** said device (1) is provided with a feedback line (32) that runs from the blower inlet (31) to a point on the regeneration line (12) such that a closed circuit is formed for cooling gas, consisting of the regeneration lines (12), the feedback line (32) and the discharge line (22) when the blower outlet (24) is connected to the discharge line (22) for supplying a cooling gas to the vessel (4b) that is being cooled, wherein a closable valve (28) and a cooler (33) for cooling regeneration gas are provided in this feedback line (32).

13.- Device according to claim 9, **characterized in that** said device (1) is provided with a boiler (34), filled with a regenerable drying agent (5), which is included between the regeneration lines (12) and the valve device (29), such that, when the blower outlet (24) is connected by the valve device (29) to the regeneration lines (12), the regeneration gas must pass through the boiler (34), and such that, when the regeneration lines (12) are connected to the venting opening (27), the cooling gas must pass through the boiler (34).

14.- Device according to claim 10, **characterized in that** said device (1) is provided with a boiler (34), filled with a regenerable drying agent (5), which is connected to the regeneration lines (12), such that, when the blower inlet (31) is connected to the discharge line (22), the supplied regeneration gas must pass through the boiler (34) and such that, when the blower outlet (24) is connected to the discharge line (22), the cooling gas must pass through the boiler (34) to exit the device (1).

15.- Device according to claims 4 and 7, **characterized in that** said device (1) is provided with a valve device (29) that allows either to:

- connect the blower inlet (31) to the discharge line (22) for supplying a regeneration gas to the vessel (4b) that is being regenerated, and at the same time connect the regeneration lines (12) to an aspiration opening (35) for the regeneration gas; or to:
- connect the blower inlet (31) to the regeneration lines (12) for supplying a cooling gas to the vessel (4b) that is being cooled, and at the same time connect the discharge line (22) to said aspiration opening (35) for the cooling gas; wherein said device (1) is provided with a boiler (34), filled with a regenerable drying agent (5), which is included between the regeneration lines (12) and the valve device (29) such that, when the blower inlet (31) is connected to the discharge line (22) by the valve device (29), the regeneration gas must pass through the boiler (34) before being sent to the vessel (4b) that is being regenerated, and such that, when the blower inlet (31) is connected to the regeneration lines (12) by the valve device (29), the cooling gas must pass through the boiler (34) before it exits the device (1).

16.- Device according to any one of the preceding claims 9 to 15, **characterized in that** the valve device (29) comprises a four-way valve (30) and/or **that** the valve device (29) comprises a number of closable valves (28).

17.- Device according to any one of the preceding claims 13

to 15, **characterized in that** the internal volume of the boiler (34) is at most 1/3 or at most 1/4 of the internal volume of one of said at least two vessels (4a, 4b).

18.- Compressor installation, provided with a compressor with an inlet for gas to be compressed and an outlet (29) with a pressure line for compressed gas, **characterized in that** the compressor installation is provided with a device (1) according to one of the preceding claims for drying the flow rate of compressed gas supplied by the compressor, which is passed through the device (1) for supply of dried gas to a user network via the dryer outlet (3) of the device (1), wherein for this purpose the pressure line connects to the dryer inlet (2) of the device (1).

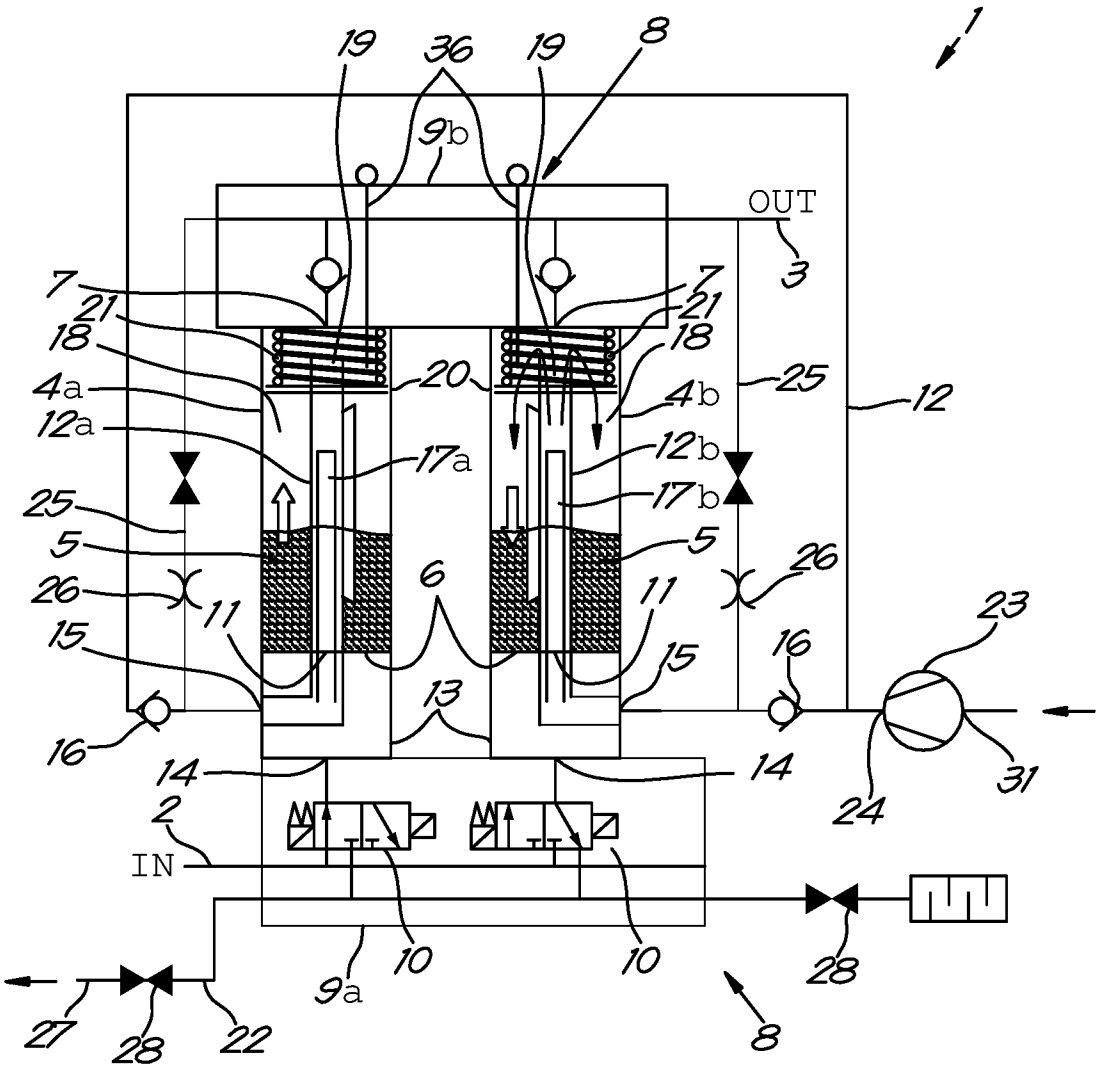
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Fig. 1

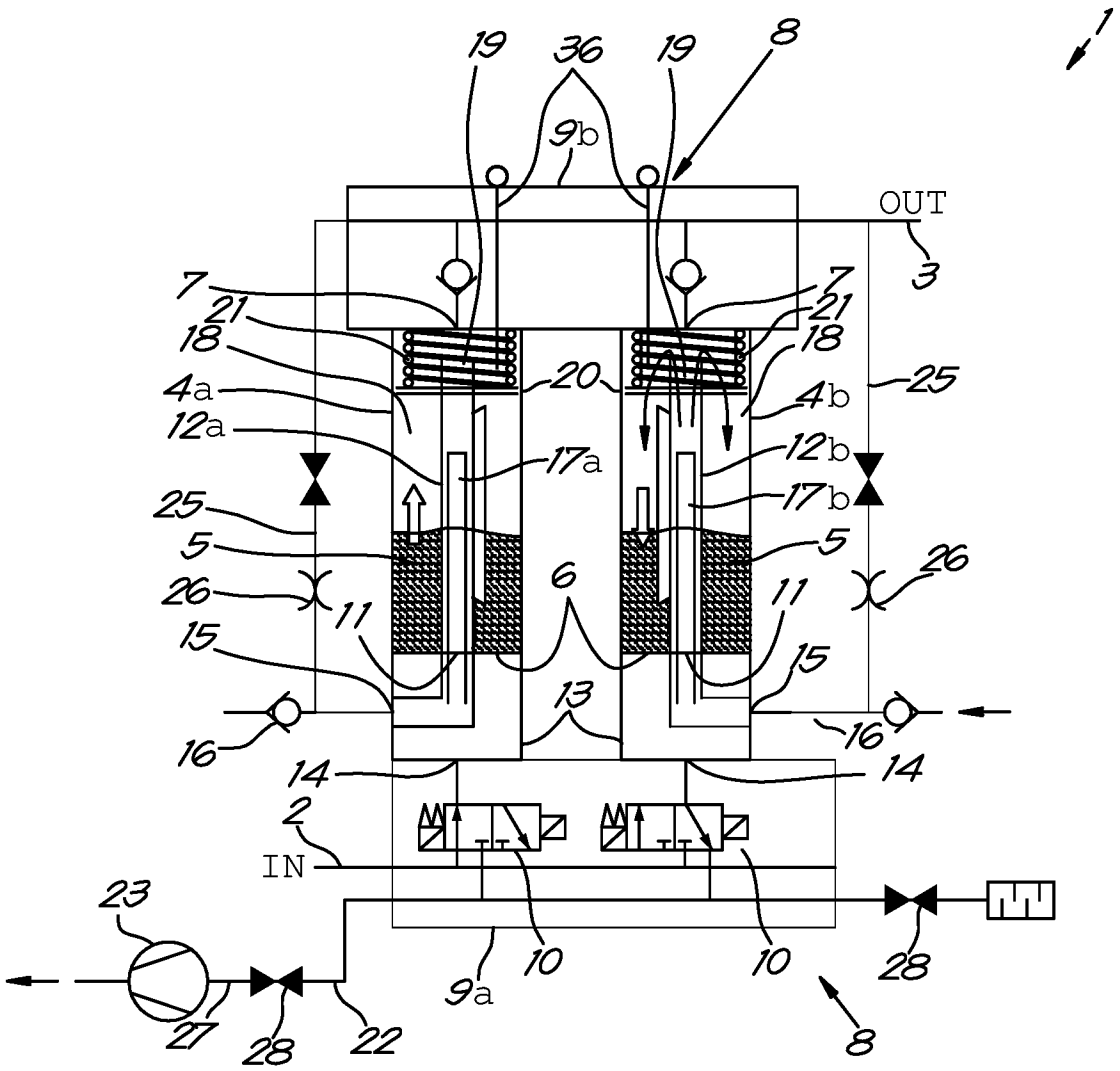
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Fig.2

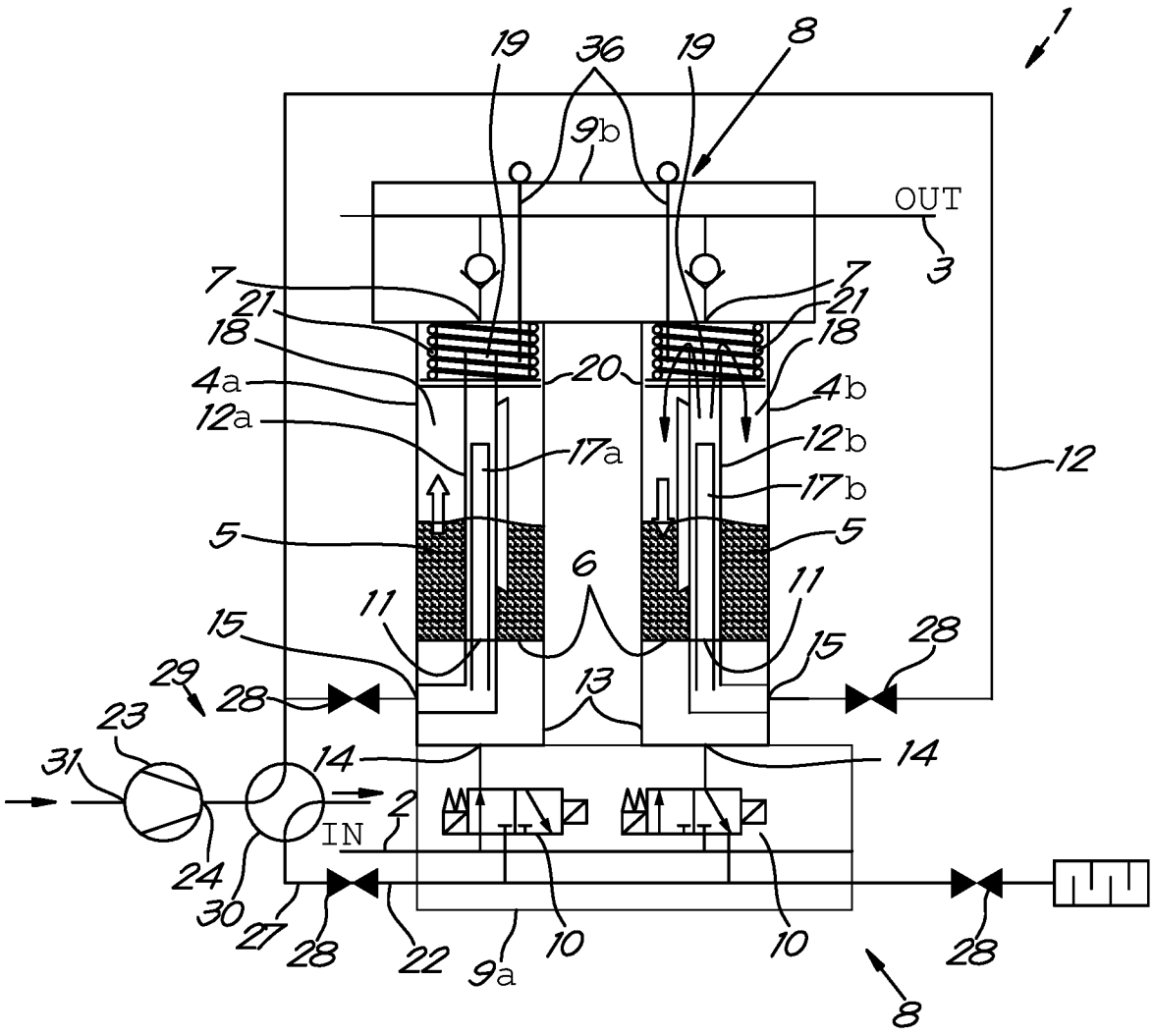
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Fig.3

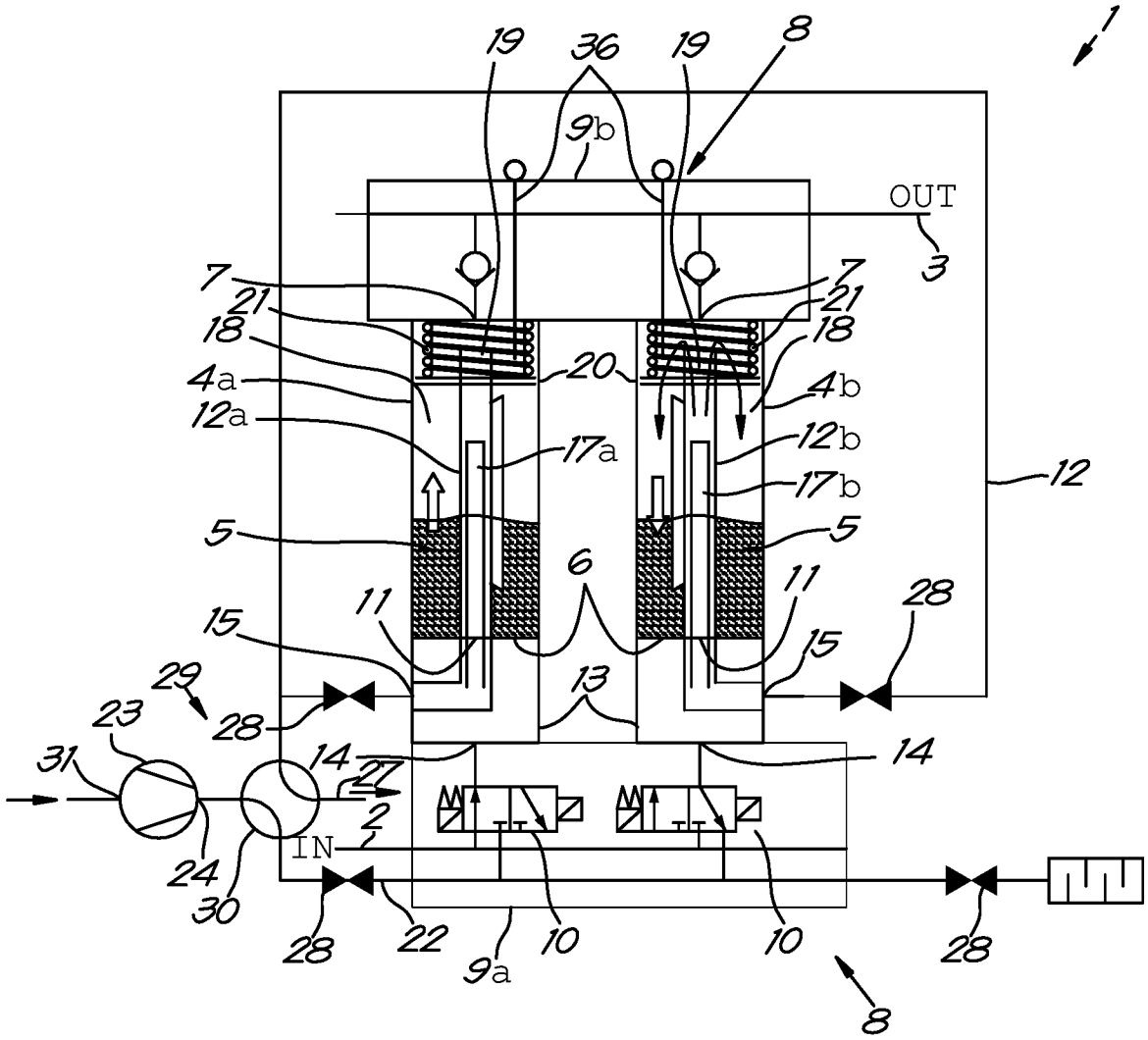
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Fig.4

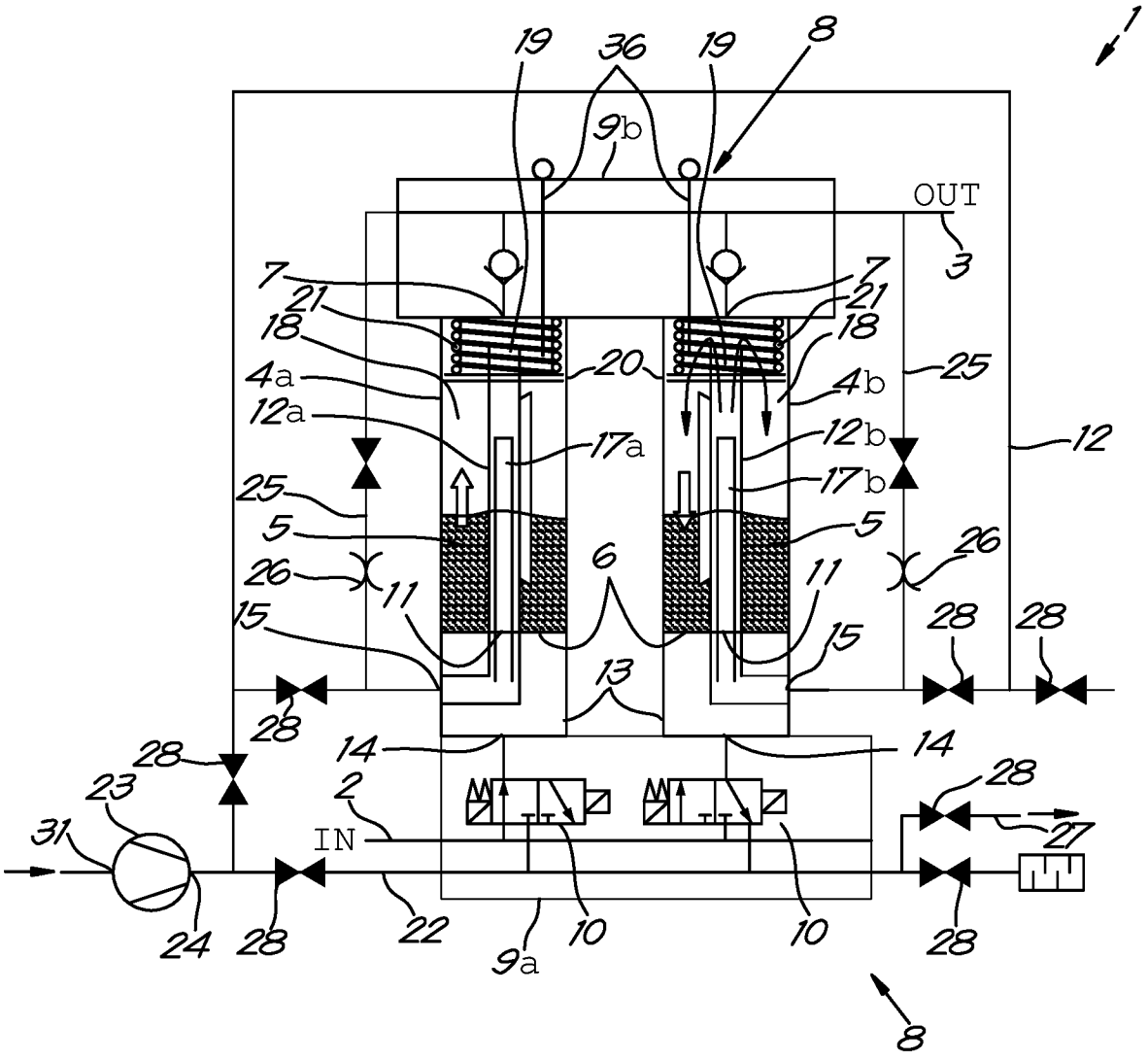
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Fig.5

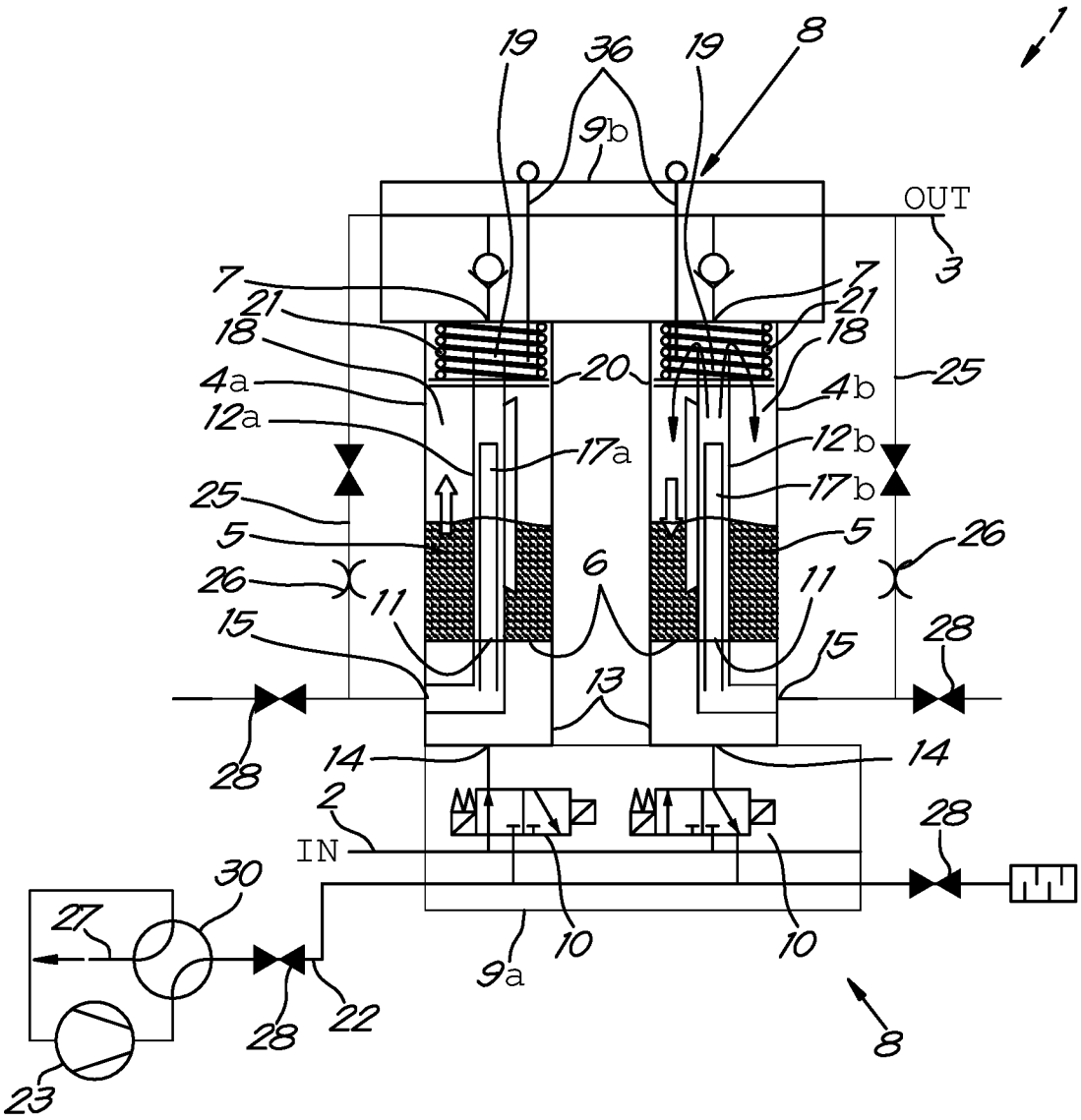
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Fig.6

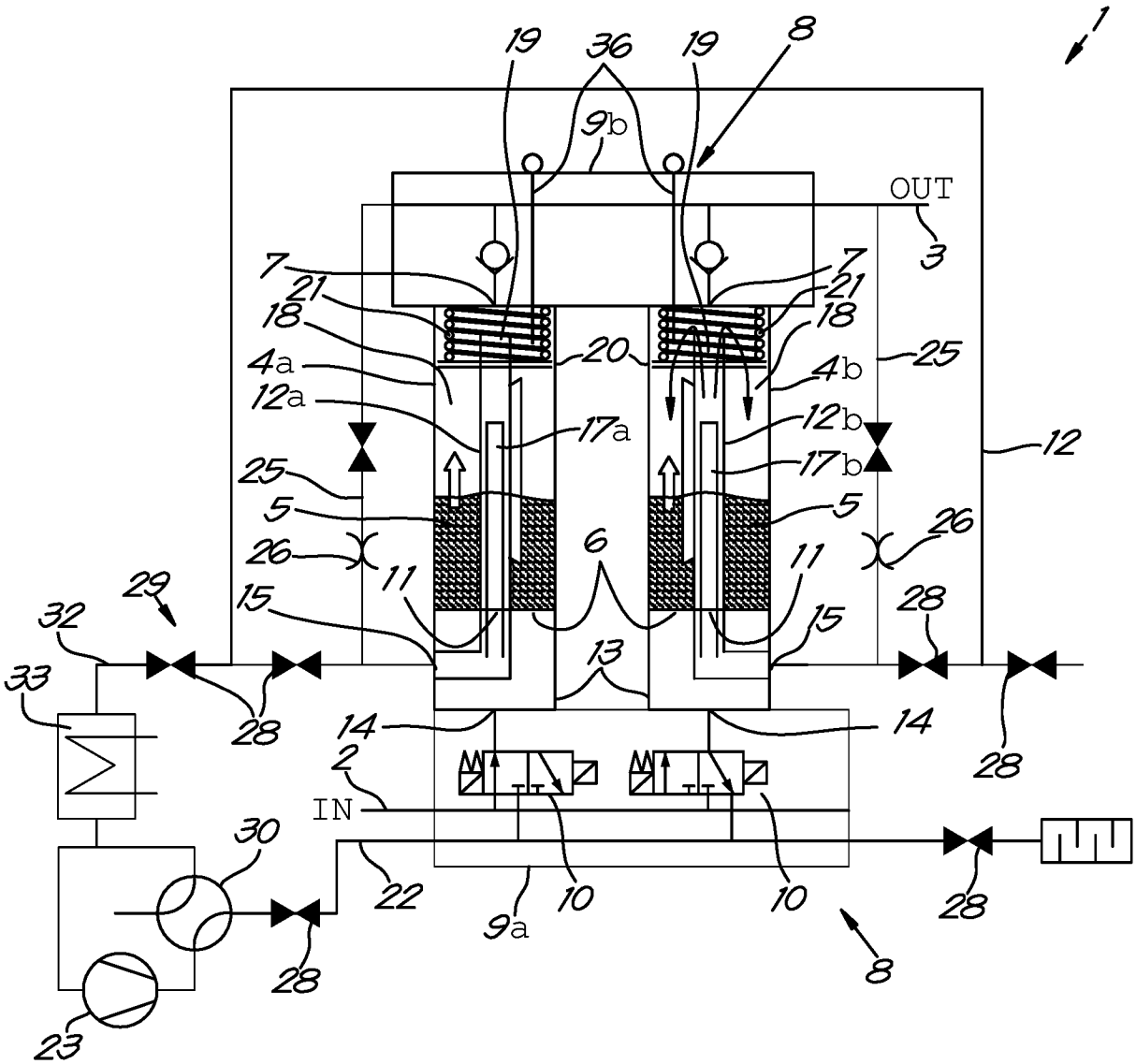
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Fig.7

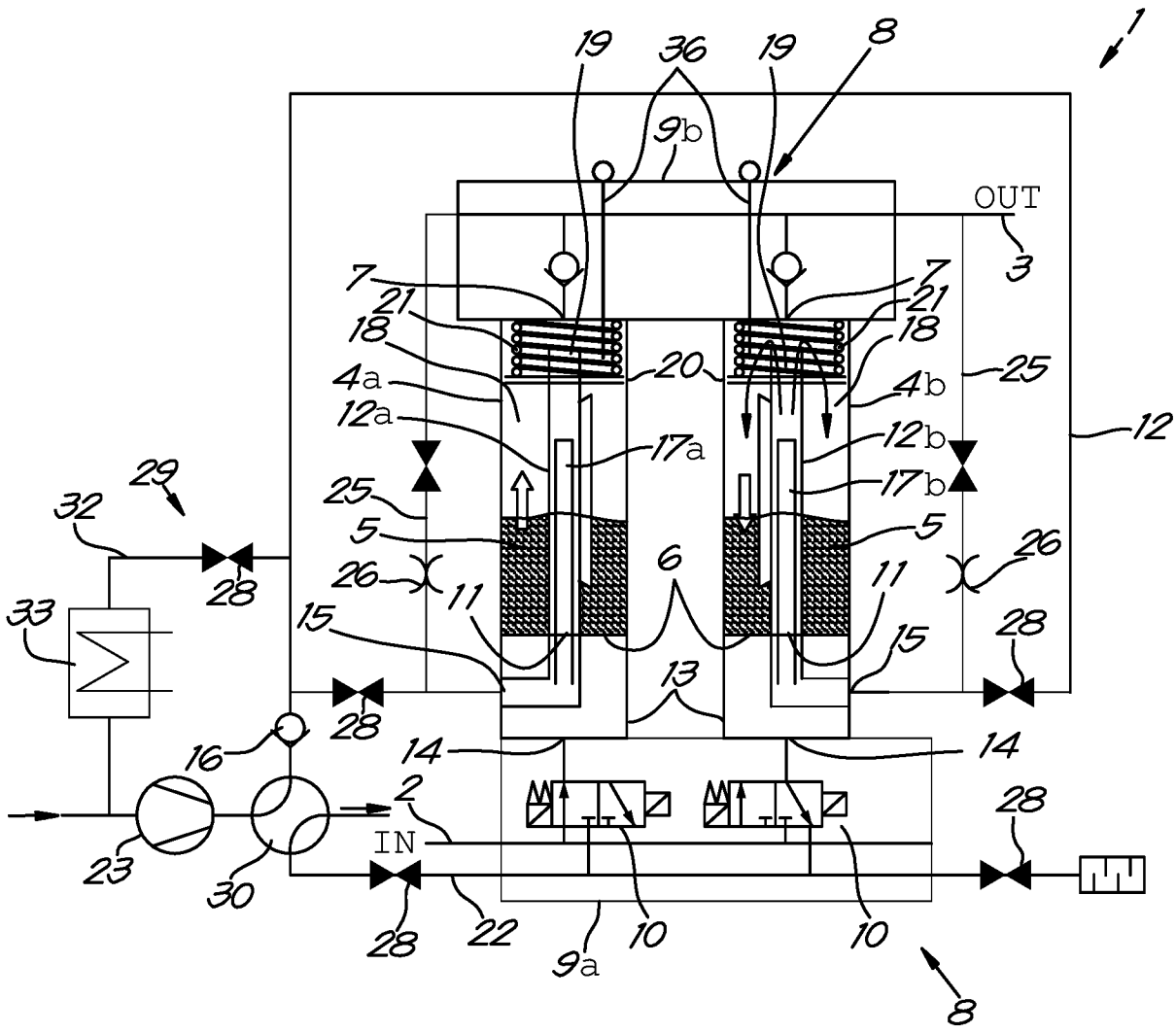
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Fig.8

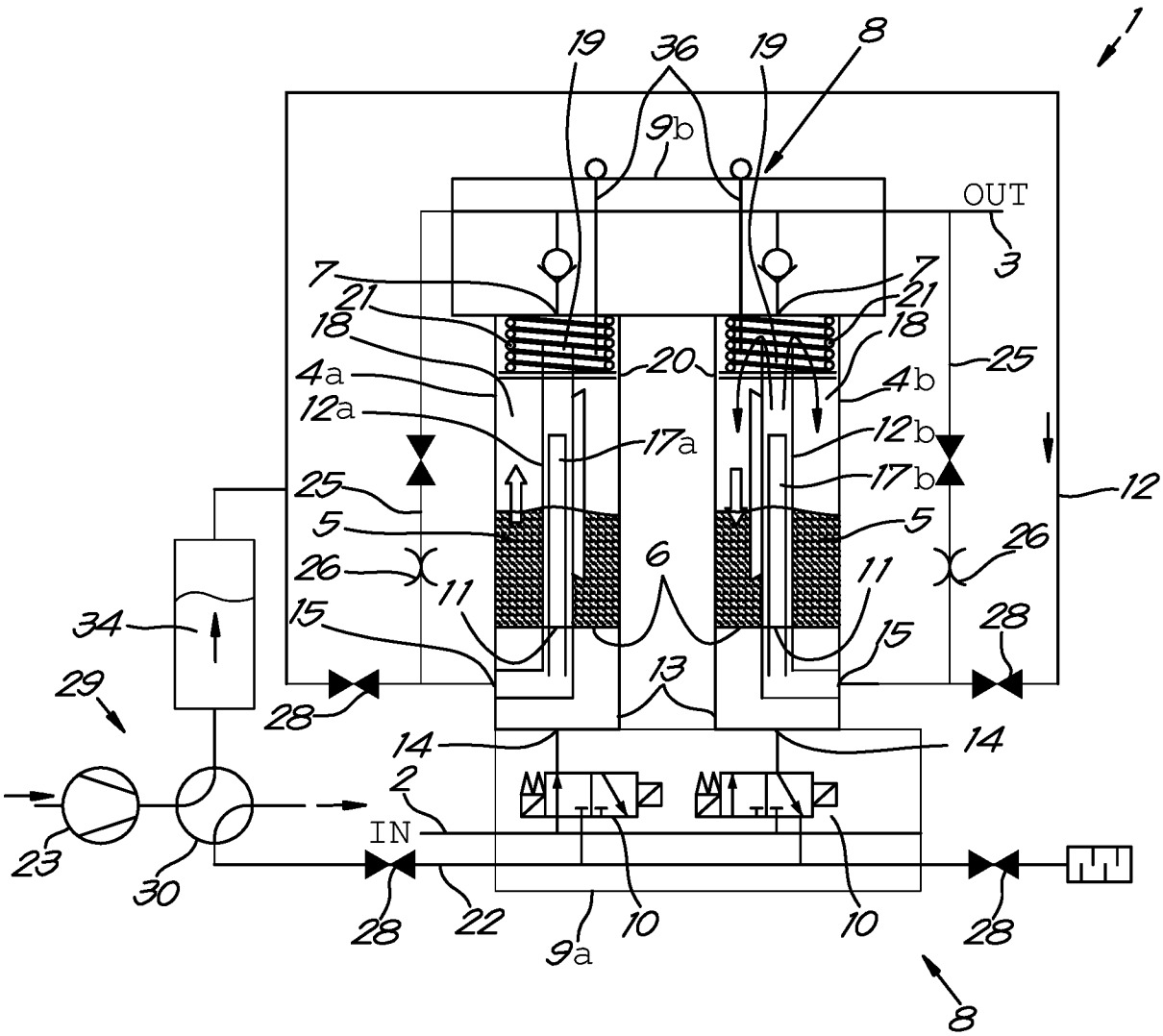
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Fig.9

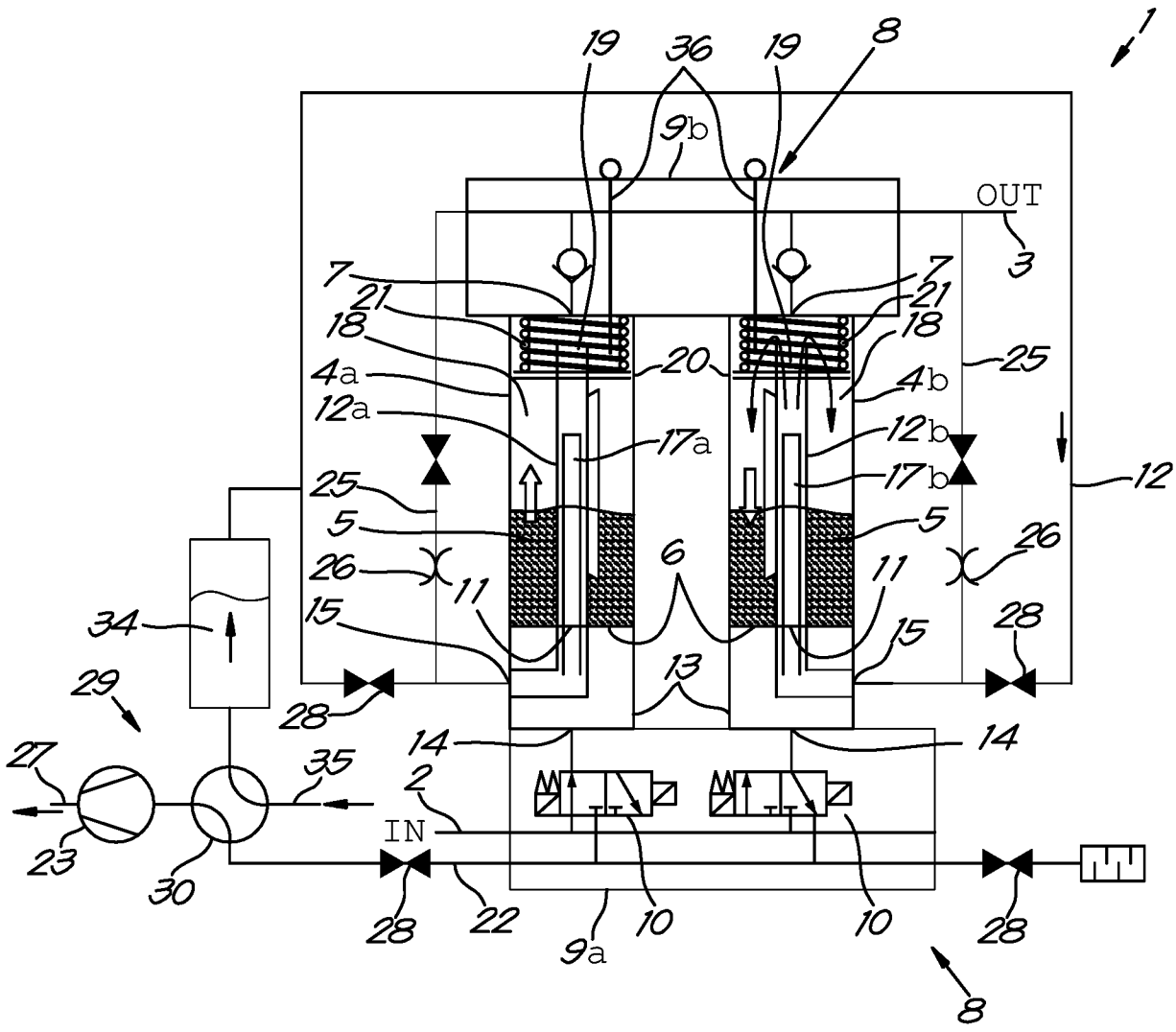
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Fig.10

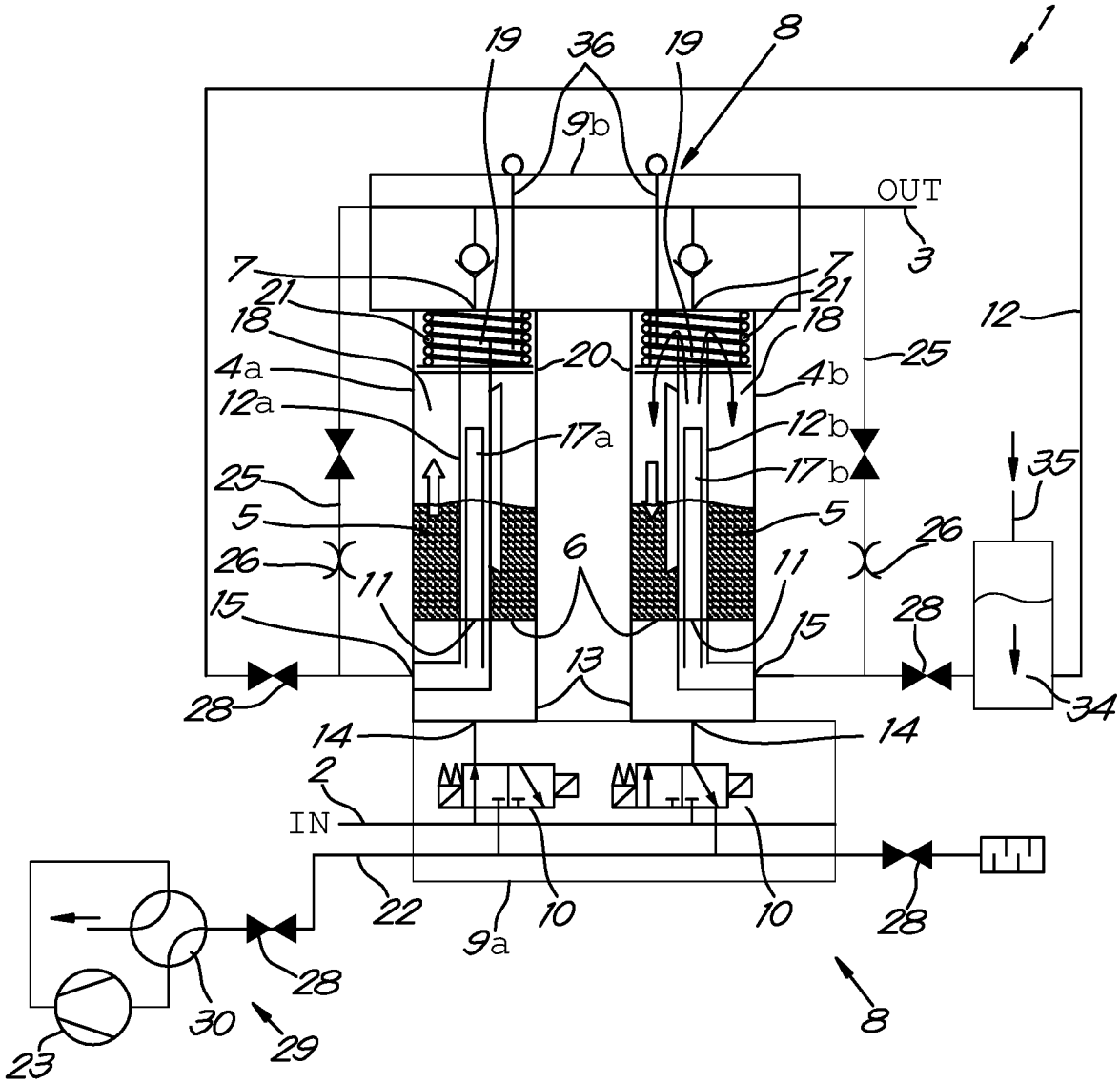
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Fig.11

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2023/056180

A. CLASSIFICATION OF SUBJECT MATTER
INV. B01D53/04 B01D53/26 F04B39/16
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B01D F04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2021/137126 A1 (ATLAS COPCO AIRPOWER NV [BE]) 8 July 2021 (2021-07-08) claims 1-14; figures 1-2	1-18
Y	EP 2 205 340 A1 (ATLAS COPCO AIRPOWER NV [BE]) 14 July 2010 (2010-07-14) paragraphs [0038] - [0054]; claims 1-9; figures 1-2	1-18
A	WO 2022/074507 A1 (ATLAS COPCO AIRPOWER NV [BE]) 14 April 2022 (2022-04-14) claims 1-16; figures 1-2	1-18
A	US 9 744 496 B1 (CHRIVIA CULLEN GUY [US] ET AL) 29 August 2017 (2017-08-29) column 11, line 10 - column 12, line 47; claims 1-15; figure 1	1,18

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[x] Further documents are listed in the continuation of Box C.

[x] See patent family annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search	Date of mailing of the international search report
26 September 2023	04/10/2023

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Ruiz Martinez, Maria

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INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2023/056180

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 3 075 433 A1 (INGERSOLL RAND CO [US]) 5 October 2016 (2016-10-05) paragraphs [0009] - [0013]; figures 1-10	1-18

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2023/056180

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