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(54) **Device for filling gas cylinders with gas under pressure and filling station**

(57) The present invention pertains to a device (1) for filling a gas cylinder (30) with gas under pressure, the device (1) comprising a supply connection (2) to be connected to a supply of filling gas and a cylinder fitting (3) to be connected to the gas cylinder (30) to be filled, wherein a cyclonic filter (4) between the supply connection (2) and the cylinder fitting (3).

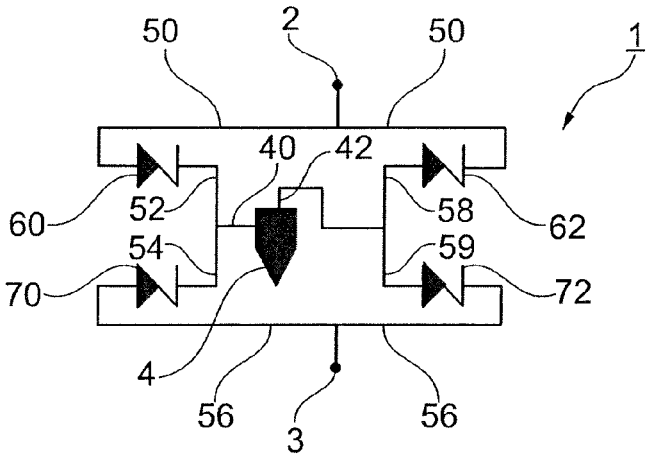

Fig. 1

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Description

Technical field

[0001] The present invention pertains to a device for filling gas cylinders with gas under pressure, as well as to a filling station.

Technological background

[0002] Industrial and medical gases are usually filled into gas cylinders for their distribution. The industrial and medical gases which are typically distributed in gas cylinders include nitrogen, helium, oxygen, nitrogenous oxide and other gases. Filling these gas cylinders is typically carried out in a filling station which comprises a filling rack in which several gas cylinders are received, for example ten gas cylinders. The gas cylinders are connected via filling lines to a centralized gas supply which contains the filling gas. The filling gas is filled into the gas cylinders under pressure, typically resulting in gas cylinders pressurized between 100 bar and 300 bar, typically around 200 bar.

[0003] The filling process is typically carried out such that the empty gas cylinders which have been returned from the customers are first connected to the respective filling lines and then the valves of the gas cylinders are opened manually. Next, the gas supply is opened and all gas cylinders are filled simultaneously at the filling station via the filling lines up to the predetermined filling pressure.

[0004] It happens frequently that the gas cylinders returned from customers are not completely empty but still contain some residual gas. Accordingly, when the valve of the respective gas cylinder is opened after it has been connected to the filling line, the residual gas contained in the gas cylinder flows into the filling line. From the filling line it may spread into all other filling lines and gas cylinders connected thereto. However, the residual gas of the cylinder returned from the customer may include contaminations. Furthermore, the valve, fittings and connections may carry contaminations such as lubricants and dust which may be flushed into the filling lines and supply network by means of the residual gas flow.

[0005] Accordingly, as all gas cylinders are connected together by means of the filling lines and the supply network, and as the valves are opened one by one, the residual pressure inside the returned cylinders may spread the contamination from one gas cylinder into the supply lines, into the supply network and/or into other gas cylinders which have a lower residual pressure and/or to purged gas cylinders.

[0006] When the filling process is started, the contamination may further spread within the supply network, the filling lines and the other gas cylinders with the risk of contamination of all gas cylinders.

Summary of the invention

[0007] Accordingly, it is an objective of the present invention to provide a device which reduces or even avoids cross contamination of gas cylinders when they are being filled in a filling station.

[0008] This objective is solved by means of a device for filling gas cylinders with gas under pressure with the features of claim 1. Advantageous embodiments can be taken from the dependent claims.

[0009] Accordingly, a device for filling a gas cylinder with gas under pressure is provided, wherein the device comprises a supply connection to be connected to a supply of filling gas and a cylinder fitting to be connected to the gas cylinder to be filled. According to the invention, a cyclonic filter is arranged between the supply connection and the cylinder fitting.

[0010] By using the cyclonic filter it is possible to remove liquid contaminations such as lubricants and other liquid particles from the gas flow. The cyclonic filter also removes solid particles from the gas flow such that by using the cyclonic filter the majority of the contaminations can be filtered out. Accordingly, the contamination of the filling line, the supply network or other gas cylinders can be reduced or even avoided.

[0011] The cyclonic filter has the advantage of not being limited to a specific particle type but filters solid particles as well as liquid particles reliably. The cyclonic filter is specifically suitable for high velocity gas flows which occur in the filling process, especially at the beginning of the filling process. High velocity gas flows also occur when the valve of a gas cylinder is opened with a residual pressure inside, which relaxes through the supply network. Accordingly, the cyclonic filter is effective at least for the high velocity gas flows in the filling network which might be harmful because, due to their impulse, may spread solid or liquid contamination throughout the supply network.

[0012] The cyclonic filter, furthermore, has the advantage that it can be operated at high pressures and is able to support adiabatic compression such that it may be used in combination with inflammable gases.

[0013] The term cyclonic filter is intended to refer to a filter which uses cyclonic separation as a means of removing particles from a gas flow through vortex separation. Rotational effects and gravity are used to separate mixtures of particles and gas. To this end, a high speed rotating gas flow is established within a cylindrical or conical container such that the air flows in a helical pattern, beginning at the top of the container and ending at its bottom before exiting in a straight stream through the center of the container. Larger particles in the rotating stream have too much inertia to follow the tight curve of the gas stream, strike the outside wall and fall to the bottom of the container where they can be removed.

[0014] Thus, the cyclonic filter has a dedicated gas inlet and a dedicated gas outlet and only filters if the gas flows through the inlet to the outlet. Accordingly, the device

preferably comprises means for directing the gas flow originating from the supply connection to the gas inlet of the cyclonic filter, as well as for directing a gas flow originating from the cylinder fitting to the gas inlet of the cyclonic filter. In other words, the means for directing the gas flow are arranged such that a gas flow from the supply connection to the cylinder fitting is fed in the same direction through the cyclonic filter as a gas flow from the cylinder fitting to the supply connection. On the basis of the means, the cyclonic filter filters the residual gas stemming from a returned gas cylinder before it enters the distribution network. It also filters the filling gas before it is filled into the gas cylinder.

[0015] The means for directing the gas flow always in one direction through the cyclonic filter is preferably provided by gas conduits and check valves such that a reliable guidance of the gas flows - irrespective of their origin - can be achieved.

[0016] Preferably, two pairs of oppositely aligned check valves are provided with the cyclonic filter arranged in between, wherein the first pair and the second pair of check valves are arranged mirror-inverted with respect to one another. By means of this arrangement it can be achieved that the flow from the supply connection to the cylinder fitting flows through one check valve of the first pair and the other check valve of the first pair blocks this gas flow. The gas flow is then directed through the cyclonic filter because the first check valve of the second pair also blocks the gas flow. At the downstream end of the cyclonic filter, a gas flow towards the first pair of check valves is prohibited due to the high pressure at the supply connection side of the gas such that the gas flows through the second check valve of the second pair towards the cylinder fitting. If a gas cylinder comprising residual gas is connected to the cylinder fitting and the valve of this gas cylinder is opened, the gas flows through the first check valve of the second pair because the other check valve of the second pair blocks the gas flow. The gas is then fed through the cyclonic filter in the correct direction because the first check valve of the first pair blocks the gas flow. At the gas outlet of the cyclonic filter, the gas flow is then prohibited to flow back through the second check valve of the second pair of check valves due to the pressure which is applied by the residual pressure in the gas cylinder such that the gas flows through the second check valve of the first pair of check valves towards the supply connection.

[0017] Accordingly, this arrangement allows a gas flow from the supply connection to the cylinder fitting to always flow from the gas inlet to the gas outlet of the cyclonic filter and also allows a residual gas flow from the cylinder fitting towards the supply connection to flow from the gas inlet to the gas outlet of the cyclonic filter. In other words, the gas always flows through the cyclonic filter from its gas inlet to its gas outlet such that the cyclonic filter is operated at its optimum.

[0018] In another preferred embodiment, a first check valve is provided in a conduit between the supply connection and a gas inlet of the cyclonic filter, wherein the first check valve opens towards the cyclonic filter. In this embodiment, a second check valve is provided in a conduit between the gas outlet of the cyclonic filter and the supply connection, wherein the second check valve opens towards the supply connection. A third check valve is provided in a conduit between the cylinder fitting and the gas inlet of the cyclonic filter, wherein the third check valve opens towards the gas inlet of the cyclonic filter. In this embodiment a fourth check valve s provided in a conduit between the gas outlet of the cyclonic filter and the cylinder fitting, wherein the fourth check valve opens towards the cylinder fitting.

[0019] The cyclonic filter filters debris stemming from the valve or the inside of the gas cylinder and also filters debris which might be present in the supply network and the gas supply before the gas is filled into the gas cylinder. Furthermore, debris which is produced on the basis of wear of the device or which is produced from O-rings can be filtered out by means of the cyclonic filter. Furthermore, solid and liquid contaminations can be removed by means of the cyclonic filter.

[0020] The device specified above can also be used in a filling station which is in compliance with pharmaceutical standards such that medical gases can be filled more reliably.

[0021] Due to the removal of any debris, liquid and solid contamination, the valve of the gas cylinder can be kept free of any contaminants such that the risk of ignition of the cylinder's valve can be reduced.

[0022] In a preferred embodiment, a conventional filter, preferably a paper filter or a sintered filter, is provided downstream of the cyclonic filter. The provision of the additional conventional filter is effective to remove at least solid contaminants at low gas velocities. At low gas velocities, the cyclonic filter is not as effective. The provision of the conventional filter thus aids in removing contaminants from the gas which is fed into the gas cylinder and/or residual gas which is fed from the gas cylinder into the supply network.

Brief description of the drawings

[0023] The present disclosure will be more readily appreciated by reference to the following detailed description when being considered in connection with the accompanying drawings in which:

Figure 1 shows schematically a preferred embodiment of the device for filling gas cylinders;

Figure 2 is another preferred embodiment of a device for filling gas cylinders which includes a conventional filter; and

Figure 3 is a schematic view of a filling station.

Detailed description of preferred embodiments

[0024] In the following, the invention will be explained in more detail with reference to the accompanying Figures. In the Figures, like elements are denoted by identical reference numerals and repeated description thereof may be omitted in order to avoid redundancies.

[0025] In Figure 1, a schematic diagram of a device 1 for filling gas cylinders with filling gas under pressure is shown. The device 1 is preferably used for filling gas under high pressure of between 100 bar and 300 bar into a gas cylinder. Typical gases are industrial and medical gases such as nitrogen, helium, oxygen or nitrous oxide.

[0026] The device 1 has a supply connection 2 which is to be connected to a gas supply of filling gas, for example to the gas production unit of a gas manufacturer, or to a gas supply tank.

[0027] The device 1 also comprises a cylinder fitting 3 which is intended to be connected to the gas cylinder to be filled with the filling gas. Fittings which can be used to connect gas cylinders to device 1 are commonly known.

[0028] The device 1 includes a cyclonic filter 4 which is arranged between the supply connection 2 and the cylinder fitting 3. The cyclonic filter 4 is effective at least for higher velocity gas flows and effectively filters solid and liquid particles from the gas stream. The cyclonic filter has a gas inlet 40 and a gas outlet 42 such that a gas flowing from gas inlet 40 towards gas outlet 42 is filtered in the cyclonic filter 4.

[0029] An arrangement of gas conduits 50-59 and two pairs of check valves 60, 62 and 70, 72 is provided which is arranged such that the gas flow through the cyclonic filter 4 is always directed from the gas inlet 40 towards the gas outlet 42 of cyclonic filter 4, irrespective of whether the gas flow originates at the supply connection 2 or at the cylinder fitting 3.

[0030] The two pairs of check valves 60, 62 and 70, 72 are arranged such that the first check valve 60 of the first pair is arranged opposite to the second check valve 62 of the first pair, and the first check valve 70 of the second pair is arranged opposite to the second check valve 72 of the second pair. Furthermore, the two pairs of check valves 60, 62 and 70, 72 are arranged in a mirror-inverted manner with respect to one another, leading to an arrangement such that the first check valve 60 of the first pair and the first check valve 70 of the second pair are opening towards one another. The second check valve 62 of the first pair and the second check valve 72 of the second pair are arranged such that they open in opposed directions to the outside.

[0031] Accordingly, a gas flow from the gas supply connection 2 towards the cylinder fitting 3 flows as follows:

[0032] The gas flow enters at the gas supply connection 2, flows into the first conduit 50 and is blocked by the second check valve 62 of the first pair but the gas flow is permitted through the first check valve 60 of the first pair. From the first check valve 60 of the first pair it flows through conduit 52 and cannot pass through the first check valve 70 of the second pair because it is in blocking arrangement. Accordingly, the gas flows to the gas inlet 40 of the cyclonic filter 4 and then to the gas outlet 42 of cyclonic filter 4. Here, it cannot flow through the second check vale 62 of the first pair, even if this check valve could open in this right direction, because the counter-pressure in conduit 50 behind check valve 62 would be too high for check valve 62 to open. Accordingly, the gas flows through conduit 59 towards check valve 72 and then into conduit 56 and out of cylinder fitting 3.

[0033] For a gas flow from cylinder fitting 3 towards gas supply connection 2, e.g. if a residual pressure is present in a gas cylinder which is connected to the cylinder fitting 3, this gas flow would flow into conduit 56 and would be blocked by the second check valve 72 of the second pair of check valves but would flow through first check valve 70 of the second pair into conduit 54. From this conduit it could not flow through first check valve 60 of the first pair because it is in blocking position. Accordingly, the gas would flow through the gas inlet 40 of cyclonic filter 4 and out of the cyclonic filter 4 at through its gas outlet 42 and then into conduits 58 and 59. At conduit 59 it cannot pass through check valve 72 because of the counter-pressure present in conduit 56 such that the gas would then flow through the second check valve 62 of the first pair towards conduit 50 and out of the gas supply connection 2.

[0034] It becomes immediately apparent, that, irrespective of the flow direction of the gas, the gas always passes from the gas inlet 40 to the gas outlet 42 of cyclonic filter 4. Accordingly, cyclonic filter 4 can filter very effectively all solid and liquid particles out of the gas stream.

[0035] Accordingly, the device 1 as shown in Figure 1 and as described above is very effective in preventing contamination of the gas cylinders to be filled as well as contamination of the supply network by residual gas which might be present in a returned gas cylinder.

[0036] Figure 2 shows an alternative to the device 1 as shown in Figure 1. It includes, downstream of the gas outlet 42 of cyclonic filter 4, a conventional filter 7. The remainder of the arrangement is identical to the arrangement shown and described in Figure 1.

[0037] Accordingly, the gas always flows from the gas inlet 40 through cyclonic filter 4 towards the gas outlet 42 of cyclonic filter 4 and then through conventional filter 7. Provided the gas flow is high and, thus, the velocity of the gas flow is high, cyclonic filter 4 is very effective in removing solid and liquid particles and contaminations from the gas flow.

[0038] However, when the gas flow is low, for example at the end of a filling process or for low residual pressures, the cyclonic filter 4 is not as effective. However, in a case of low gas velocities the conventional filter 7 may remove at least the solid particles from the gas flow, such that contamination is also reduced or even prevented.

[0039] Furthermore, as the flow direction is always the same irrespective of whether the gas flows from the supply side to the cylinder side or from the cylinder side to the supply side, the gas flow through the filter 7 is also always in the same direction such that contaminations which are filtered in the filter, remain in the filter and are not flushed-out by a reverse flow of gas.

[0040] Accordingly, the arrangement shown in Figure 2 is very effective for preventing contamination of the gas cylinder to be filled as well as the supply network.

[0041] Figure 3 schematically shows a filling station 8. The filling station includes a gas supply line 80 which is connected to a gas manufacturing plant or to a supply tank from which the gas is to be filled into individual gas cylinder 30.

[0042] Filling lines 82 are provided through which the gas from the supply line 80 is provided towards each of the gas cylinder 30. In every filling line 82, a device 1 according to an embodiment discussed above with respect to Figures 1 or 2 is arranged.

[0043] Accordingly, if residual gas is present in the gas cylinder 30 and the cylinder valve 32 is opened, potential contamination from cylinder 30 can be filtered out by means of device 1 such that a contamination of the filling lines 82 is avoided. Furthermore, a gas flow from the supply line 80 into the gas cylinder 30 is also filtered by means of device 1 such that any contaminations of the filling line and the supply lines cannot flow into the gas cylinders to be filled.

Claims

1. Device (1) for filling a gas cylinder (30) with gas under pressure, the device (1) comprising a supply connection (2) to be connected to a supply of filling gas and a cylinder fitting (3) to be connected to the gas cylinder (30) to be filled,
characterized in that
a cyclonic filter (4) is arranged between the supply connection (2) and the cylinder fitting (3).

2. Device (1) according to claim 1, **characterized in that** the cyclonic filter (4) has a gas inlet (40) and a gas outlet (42), the device (1) comprising means (60, 62, 70, 72) for directing a gas flow originating from the supply connection to the gas inlet (40) of the cyclonic filter (4) as well as for directing a gas flow originating from the cylinder fitting to the gas inlet (40) of the cyclonic filter (4).

3. Device (1) according to claim 2, **characterized in that** the means for directing the gas flow is provided by an arrangement of gas conduits (50, 52, 54, 56, 58, 59) and check valves (60, 62, 70, 72).

4. Device (1) according to any one of the preceding claims, **characterized in that** two pairs of oppositely aligned check valves (60, 62 and 70, 72) are provided with the cyclonic filter (4) arranged in between, wherein the first pair (60, 62) and the second pair (70, 72) of check valves are arranged mirror-inverted with respect to one another.

5. Device (1) according to any one of the preceding claims, **characterized in that**

   - a first check valve (60) is provided in a conduit (50, 52) between the supply connection (2) and a gas inlet (40) of the cyclonic filter (4), wherein the first check valve (60) opens towards the cyclonic filter (4);
   - a second check valve (62) is provided in a conduit (50, 58) between the gas outlet (42) of the cyclonic filter (4) and the supply connection (2), wherein the second check valve (62) opens towards the supply connection (2);
   - a third check valve (70) is provided in a conduit (54, 56) between the cylinder fitting (3) and the gas inlet (40) of the cyclonic filter (4), wherein the third check valve (70) opens towards the gas inlet (40) of the cyclonic filter (4); and
   - a fourth check valve (72) is provided in a conduit (56, 59) between the gas outlet (42) of the cyclonic filter (4) and the cylinder fitting (3), wherein the fourth check valve (72) opens towards the cylinder fitting (3).

6. Device (1) according to any of the preceding claims, **characterized in that** a conventional filter (7) is arranged downstream of the gas outlet (42) of the cyclonic filter (4), wherein the conventional filter (7) preferably is a sintered filter or a paper filter.

7. Filling station (8) for filling at least two gas cylinders with gas under pressure, wherein the filling station (8) includes at least two filling lines (82) for simultaneously supplying filling gas to the at least two gas cylinders (30) to be filled,
characterized in that
each fill line (82) includes a device (1) according to any of the preceding claims.

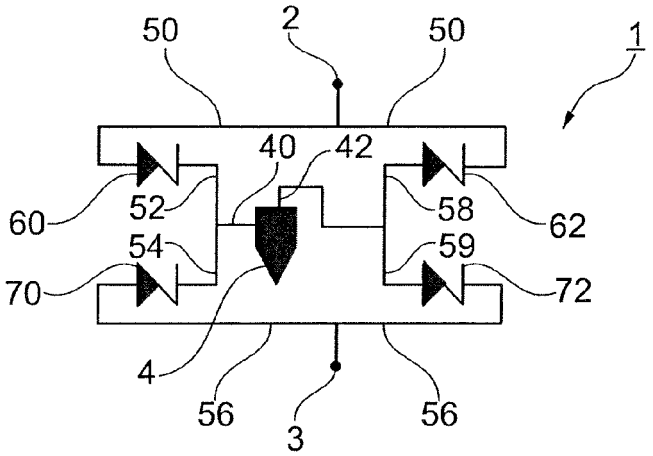

Fig. 1

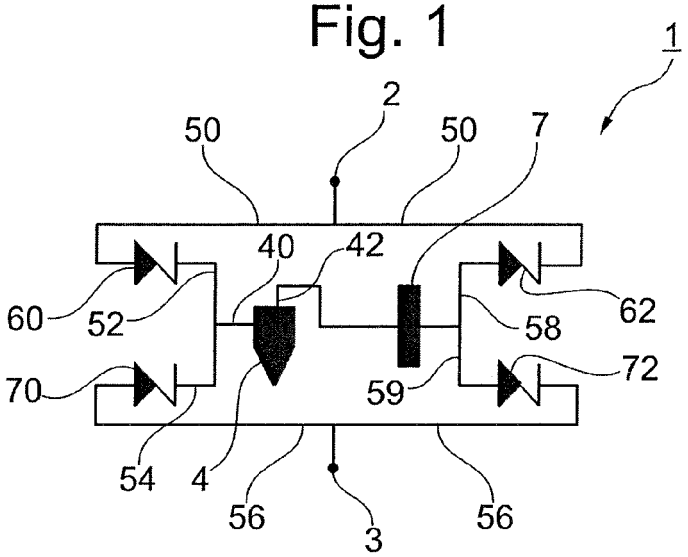

Fig. 2

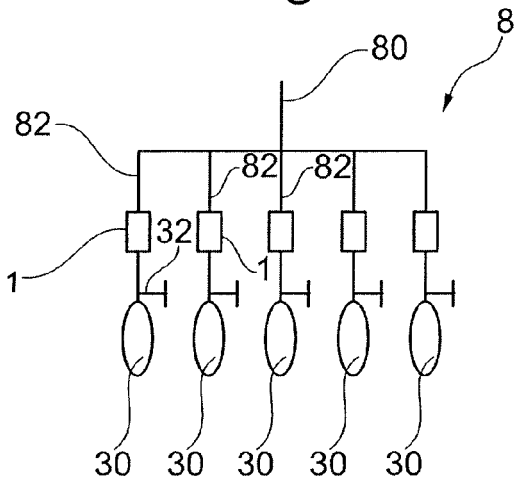

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 12 16 8126

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F17C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	30 January 2013	Stängl, Gerhard

CATEGORY OF CITED DOCUMENTS

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