

DEVICE FOR PRODUCING AND DISTRIBUTING NITROGEN, IN PARTICULAR FOR A LIQUEFIED GAS CARRIER

TECHNICAL FIELD

5 The invention relates to a device and a method for producing and distributing nitrogen, in particular for a liquid gas transport ship.

PRIOR ART

 A transport ship for liquid gas, such as liquid natural gas, is in general equipped with a device for producing and distributing nitrogen, this nitrogen
10 being able to be used by a plurality of consumers.

 In the present application, a “consumer”, in particular of nitrogen, means a system which uses nitrogen in order to operate, or a system which is designed to be supplied with nitrogen.

 A transport ship is for example equipped with three types of nitrogen
15 consumers.

 A first type (type I) of nitrogen consumer comprises means for supplying nitrogen to seals, for example of bearings of compressors of the ship. Compressors of the ship, for example in order to pump evaporation gas, are equipped with plain bearings for guiding of rotary parts. These bearings are
20 accommodated in enclosures, seals of which, of the labyrinth type, are supplied with nitrogen in order to prevent exterior air from polluting the enclosure and disrupting the operation of the bearings.

 A second type (type II) of nitrogen consumer comprises means for purging fluid circulation lines, such as a liquid gas circulation line of the ship. In
25 order to clean a line of this type, and prevent liquid gas from remaining in it, it is known to purge the line with nitrogen.

 A third type (type III) of nitrogen consumer comprises means for supplying nitrogen to insulation spaces, for example liquid gas storage tanks of

the ship. Tanks of this type are in fact equipped with a double wall defining an insulation space which is supplied with nitrogen.

The requirement for nitrogen differs according to the type of consumer. A consumer of type I is supplied with nitrogen continuously with a flow rate which is in general contained between 25 and 70 Nm³/h, and a relatively high pressure of approximately 5 barg. The continuous supply is due to the fact that the seals must be supplied with nitrogen continuously.

A consumer of type II is supplied with nitrogen with a flow rate which can be substantial, but which is in general intermittent, at a relatively high pressure of approximately 5 barg.

A consumer of type III is supplied with nitrogen with a substantial flow rate, which in general is contained between 100 and 200 Nm³/h, and at a relatively low pressure of approximately a few mbarg. The supply takes place during short and infrequent periods, in particular during operations of cooling of the tanks, preceding their filling with liquid gas.

In the prior art, a device for producing and generating nitrogen comprises two nitrogen generators, each comprising an air inlet and an air outlet, a nitrogen storage buffer tank, and nitrogen distribution means which are designed to supply consumers with nitrogen.

The generators are disposed in parallel, and are configured to operate in all-or-nothing mode (also known as start and stop). There are two of them, i.e. a main generator and a relay generator, in order to ensure redundancy, and guarantee filling of the buffer tank with nitrogen during high requirements for nitrogen by the consumers. The generators are oversized, i.e. they are each configured to be able to provide a flow of nitrogen which is sufficient to supply the largest nitrogen consumer in terms of output, i.e. the consumer of type III.

The buffer tank is designed to store the nitrogen produced, and to supply it to the consumers in accordance with the requirements. The generators are in general controlled such that the nitrogen pressure in the buffer tank reaches a maximal value. When nitrogen is consumed, and the nitrogen pressure in the buffer tank decreases, at least one of the generators is

commanded to produce nitrogen and increase the pressure in the buffer tank up to the maximal pressure value.

However, this technology has disadvantages.

5 The consumption profile of the consumer of type I is stable and constant, as previously stated, and is not suited for the cyclical operation of the buffer tank and of the nitrogen generators.

This operation imposes a very high number of start and stop operating cycles on the generators (approximately 2000 per year for a ship), which reduces the service life of the generators, and imposes frequent maintenance
10 operations.

The present invention proposes an improvement to the prior art, which is simple, efficient and economical.

SUMMARY OF THE INVENTION

According to a first aspect, the invention proposes a device for
15 producing and distributing nitrogen, in particular for a liquid gas transport ship, comprising:

- nitrogen generators each comprising an air inlet and an air outlet;
- a nitrogen storage buffer tank; and
- nitrogen distribution means which are designed to supply at least two
20 distinct consumers with nitrogen,

characterized in that it comprises:

- first nitrogen distribution means exiting from said buffer tank for the supply to at least one of said consumers; and
- second nitrogen distribution means exiting from at least one of said
25 generators, without passing via said buffer tank, for the supply to at least one other of said consumers.

The invention thus proposes that nitrogen produced by one or more generators reaches the second distribution means directly, without passing via the tank. The first distribution means, for their part, are supplied with nitrogen by

the tank. There are therefore two ways of supplying to the distribution means, with or without the buffer tank. This tank is thus used differently compared with the prior art. The generators are not necessarily oversized, on the contrary, and they can be less in demand, which reduces the number of start and stop cycles and increases their service life.

In the present application, "nitrogen" means air enriched with nitrogen. At sea level, atmospheric air comprises almost 78% (by volume) of nitrogen, 21% (by volume) of oxygen, and traces of other gases. In the present application, "nitrogen" thus means air comprising more than 78% by volume of nitrogen, and for example more than 80 or 90% by volume. This level is preferably at least 97%.

In the present application, "some" generators comprise at least two, and for example three generators. At least certain of the generators can have elements in common, such as a separator and/or a heater.

The device according to the invention can comprise one or a plurality of the following characteristics, taken in isolation from one another or in combination with one another:

- said second nitrogen distribution means are connected directly to said outlets of at least one of said generators; in the present application, "direct" connection means connection only by means of a duct, optionally equipped with a valve;
- said outlets of said generators are connected together by a manifold comprising a first outlet which is connected to an inlet of said buffer tank, and a second outlet which is connected to said second distribution means;
- said outlet of at least one of said generators is connected to an inlet of said buffer tank, and said outlet of at least one other of said generators is connected to said second distribution means; in this case, there is no fluid communication between the outlets of all the generators;
- said first distribution means are connected to said second distribution means, such that the nitrogen stored in said buffer tank can supply said at least one other said consumer;

- said outlet of at least one of said generators is connected to an inlet of said buffer tank by a valve;
- said valve is configured to be always a through valve, and to have a variable flow rate which is controlled according to a pressure P1 in the interior of said buffer tank, and/or according to a pressure P2 at the outlet of at least one of said generators, and/or according to a pressure P3 for supply to said first and/or second distribution means;
- at least certain of said inlets of said generators are connected together and to a single air supply port, and/or at least certain of said outlets of said generators are connected together and to a single nitrogen outlet port;
- said consumers comprise means for supplying nitrogen to seals, in particular of compressors of said ship, means for supplying to insulation spaces, in particular of tanks of said ship, and means for purging, in particular of supply lines of said ship;
- said generators are configured to operate in all-or-nothing mode; and
- said generators are identical, and have dimensions such as each to be able to supply alone one of said consumers, the consumption of which in terms of flow rate is designed to be stable and continuous.

The present invention also relates to a method for producing and distributing nitrogen by means of a device as described above, comprising the steps of:

- a) production of nitrogen by said generators; and
- b) distribution of nitrogen to one of the consumers, without passing via the buffer tank.

The method according to the invention can comprise one or a plurality of the following characteristics or steps, taken in isolation from one another, or in combination with one another:

- the buffer tank is supplied with nitrogen during steps a) and b);

- the buffer tank is supplied with nitrogen via a valve, the flow rate of which is regulated according to a pressure P1 in the interior of said buffer tank, and/or according to a pressure P2 at the outlet from at least one of said generators, and/or according to a pressure P3 for supply to said first and/or second distribution means;
- the pressure in said buffer tank decreases during steps a) and b).

According to a second aspect, the invention proposes a device for producing and distributing nitrogen, in particular for a liquid gas transport ship, comprising:

- nitrogen generators each comprising an air inlet and an nitrogen outlet;
- a nitrogen storage buffer tank; and
- nitrogen distribution means which are designed to supply at least two distinct consumers with nitrogen,

characterized in that it comprises at least one nitrogen recirculation line, an inlet of which is connected to an nitrogen outlet of said buffer tank, and an outlet of which is connected to said inlet of at least one of said generators.

The recirculation of nitrogen has a plurality of advantages. Firstly, it makes it possible not to waste the excess nitrogen produced, which is thus reused. It also makes it possible to optimize the nitrogen production performance by increasing the level of enrichment with nitrogen of the gas produced. In fact, in addition to the ambient air, the air inlets of the generators receive air already charged with nitrogen. The recirculation also makes it possible not to stop a generator, and therefore to limit the number of start and stop cycles, if the flow rate of nitrogen produced by this generator is not very excessive. In other words, it is possible to prefer to make a generator operate in order to produce nitrogen and fulfill a need of a consumer, whilst producing an excess of nitrogen with this same generator, which nitrogen will be recirculated and thus recycled, rather than stopping this generator and supplying the consumer with nitrogen stored in the tank for example.

The device according to the invention can comprise one or a plurality of the following characteristics, taken in isolation from one another or in combination with one another:

- 5 - the device is configured to recirculate nitrogen stored in the buffer tank, when the pressure therein exceeds a certain threshold;
- said recirculation line comprises at least one first valve configured to have a variable flow rate which is controlled according to a pressure P1 in the interior of said buffer tank;
- said recirculation line comprises at least one non-return valve;
- 10 - said recirculation line comprises at least one flow meter;
- the device comprises a control system which is configured to receive information from said flow meter and from a pressure sensor of said buffer tank, and to control accordingly said first valve as well as said generators;
- said outlet of at least one of said generators is connected to an inlet of said buffer tank via a valve;
- 15 - said second valve is configured to be always a through valve, and to have a variable flow rate which is controlled according to a pressure P1 in the interior of said buffer tank, and/or according to a pressure P2 at the outlet of at least one of said generators, and/or according to a supply pressure P3 of said distribution means;
- 20 - said control system is also configured to control said second valve;
- at least certain of said inlets of said generators are connected together and to a single air supply port which is connected to said outlet of said circulation line; and/or at least certain of said outlets of said generators are connected together and to a single nitrogen outlet port;
- 25 - said consumers comprise means for supplying nitrogen to seals, in particular of compressors of said ship, means for supplying to insulation spaces, in particular of tanks of said ship, and means for venting, in particular of supply lines of said ship;

- said generators are configured to operate in all-or-nothing mode;
- said generators are identical, and have dimensions such as each to be able to supply alone one of said consumers, the consumption of which in terms of flow rate is designed to be stable and continuous.

5 The present invention also relates to a method for producing and distributing nitrogen by means of a device as described above, comprising the steps of:

- a) production of nitrogen by said generators; and
- b) recirculation of nitrogen via said recirculation line.

10 The method according to the invention can comprise one or a plurality of the following characteristics or steps, taken in isolation from one another, or in combination with one another:

- said distribution means are supplied with nitrogen during steps a) and b);
- the flow rate of recirculation of nitrogen via said recirculation line is monitored,
- 15 and at least one of said generators is stopped when the value of this flow rate exceeds a predetermined threshold.

 According to a third aspect, the invention proposes a device for producing and distributing nitrogen, in particular for a liquid gas transport ship, comprising:

- 20 - nitrogen generators each comprising an air inlet and an nitrogen outlet, at least one of these generators comprising a compressor comprising an air compression rotor;
- a nitrogen storage buffer tank; and
- nitrogen distribution means which are designed to supply at least two
- 25 distinct consumers with nitrogen,

characterized in that it comprises at least one system for variation of frequency or speed of said rotor.

 The nitrogen production of a generator depends in particular on the frequency or speed of the rotor of the compressor of this generator, and it can

therefore be regulated according to the needs of the consumers. In order to limit the number of start and stop cycles, the frequency of the rotor of the generator can be decreased, for example if the need for nitrogen is not substantial, rather than resorting to complete stoppage of the generator.

5 The device according to the invention can comprise one or a plurality of the following characteristics, taken in isolation from one another or in combination with one another:

- said system is configured to be controlled according to a pressure P1 in the interior of said buffer tank;
- 10 - at least certain of said generators comprise, from upstream to downstream, from the inlet to the outlet for nitrogen, said compressor, a separator of air from fluid(s), such as water and/or oil, an air heater, and a filtration membrane which is configured to separate the nitrogen from the remainder of the air; in practice, membrane separation technologies operate by retaining the nitrogen and
- 15 - permitting the permeation of the remainder of the components of the air;
- said outlet of at least one of said generators is connected to an inlet of said buffer tank;
- at least certain of said inlets of said generators are connected together and to a single air supply port, and/or at least certain of said outlets of said generators
- 20 - are connected together and to a single nitrogen outlet port;
- the device comprises first means for distribution of nitrogen exiting from said buffer tank for the supply of at least one of said consumers, and second means for distribution of nitrogen exiting from at least one of said generators, without passing via said buffer tank, for supply to at least one other of said consumers;
- 25 - said variation system is configured to vary the frequency or the speed of said rotor of said at least one generator which is designed to supply said second distribution means;
- said consumers comprise means for supplying nitrogen to seals, in particular of compressors of said ship, means for supplying to insulation spaces, in

particular of tanks of said ship, and means for purging, in particular of supply lines of said ship;

- said generators are configured to function in all-or-nothing mode; and

- said generators are identical and have dimensions such as each to be able to supply alone one of said consumers, the consumption of which in terms of flow rate is designed to be stable and continuous.

The present invention also relates to a method for producing and distributing nitrogen by means of a device as described above, comprising the steps of:

- a) production of nitrogen by said generators; and
- b) variation of the frequency or speed of the rotor of at least one of said generators.

The method according to the invention can comprise one or a plurality of the following characteristics or steps, taken in isolation from one another or in combination with one another:

- said buffer tank and said means for distribution are supplied simultaneously with nitrogen during steps a) and b);

- nitrogen is taken from said buffer tank and used to supply said distribution means of all of the consumers.

According to a fourth aspect, the invention proposes a device for producing and distributing nitrogen, in particular for a liquid gas transport ship, comprising:

- nitrogen generators each comprising an air inlet and an nitrogen outlet, at least one of these generators comprising a compressor comprising an air compression rotor; and

- a nitrogen storage buffer tank,

characterized in that it comprises at least one system for variation of frequency or speed of the rotor of said at least one generator with a compressor, and in that it also comprises main means for distribution of nitrogen exiting from said at

least one generator with a compressor, without passing via said buffer tank for the supply of nitrogen to at least two distinct consumers.

The inventors have found that, at a given pressure of nitrogen supplied, the purity of dinitrogen increases when the flow rate decreases. Thus, for a
5 purity specified at 97% of dinitrogen with a nominal flow rate, a reduction of the flow rate leads to production of an excess quality of nitrogen, with an excess supply of air upstream. The variation of the frequency or the speed of the rotor of the compressor of the nitrogen generator makes it possible to guarantee sufficient production of nitrogen with sufficient purity, whilst optimizing the air
10 consumption of the generators.

In this case, the buffer tank is used as an additional source of nitrogen, with the generators being connected directly to the consumers, and thus configured to supply the consumers directly.

In the present application, “main” means for distribution of nitrogen
15 indicates means which are designed to convey most or all of the flow of nitrogen produced by the generator(s) which is/are operating. On the other hand, “secondary” means for distribution of nitrogen are designed to convey only a minority part of the flow of nitrogen produced.

The device according to the invention can comprise one or a plurality of
20 the following characteristics, taken in isolation from one another or in combination with one another:

- said at least one generator with a compressor comprises, from upstream to downstream, from the inlet to the nitrogen outlet, said compressor, a separator of air from fluid(s), such as water and/or oil, a heater, and a filtration membrane
25 configured to separate the nitrogen from the remainder of the air; in practice, membrane separation technologies operate by retaining the nitrogen and permitting the permeation of the remainder of the components of the air;
- at least certain of said inlets of said generators are connected together and to a single air supply port, and/or at least certain of said outlets of said generators
30 are connected together and to a single nitrogen outlet port;

- said single nitrogen outlet port is connected, preferably by means of the valve, to an inlet of said buffer tank and to said main means for distribution of nitrogen;
 - the device comprises secondary means for distribution of nitrogen exiting from said buffer tank for the supply to at least certain of said consumers;
 - 5 - the main means for distribution are connected to the secondary means for distribution by a valve;
 - said consumers comprise means for supply of nitrogen to seals, in particular of compressors of said ship, means for supply to insulation spaces, in particular of tanks of said ship, and means for purging, in particular of supply lines of said ship;
 - 10 -said main means for distribution of nitrogen supply directly at least said means for supply of nitrogen to seals, and said means for supply to insulation spaces;
 - said main means for distribution of nitrogen comprise at least one pressure and/or flow rate sensor, this sensor being connected to a control system of said system for variation of frequency or speed;
 - 15 - said generators are identical and oversized, such as each to be able to supply alone at least one of said consumers, the consumption of which in terms of flow rate is designed to be stable and continuous, when this generator is regulated to a charge lower than 100% by means of said variation system.
- 20 The present invention also relates to a method for producing and distributing nitrogen by means of a device according to one of the preceding claims, comprising the steps of:
- a) production of nitrogen by said generators;
 - b) variation of the frequency or speed of the rotor of said at least one generator with a compressor; and
 - 25 c) supply to at least certain of said consumers without passing via said buffer tank.

The method according to the invention can comprise one or a plurality of the following characteristics or steps, taken in isolation from one another or in combination with one another:

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- the frequency or speed of the rotor of said at least one generator with a compressor is controlled such that the pressure or the flow rate is greater than, or equal to, a threshold value in said main means for distribution of nitrogen;

- the pressure threshold value in said main means for distribution of nitrogen is 5 barg; and

- said buffer tank is supplied with nitrogen if, and only if, the pressure measured in said main distribution means is greater than said pressure threshold value, and if the pressure measured in said buffer tank is lower than a lower limit value.

10 A single one of the generators can be used to produce nitrogen when the flow rate of nitrogen required by said consumers is lower than the maximum flow rate of nitrogen which this generator can produce alone.

15 At least two of the generators, or all the generators, can be used to produce nitrogen when the flow rate of nitrogen required by said consumers is higher than the maximum flow rate of nitrogen which each of these generators can produce, but this flow rate of nitrogen required is lower than the maximum cumulative flow rates of nitrogen which these generators can produce when they are operating simultaneously.

20 At least two of the generators, or all the generators, can be used to produce nitrogen when the flow rate of nitrogen required by said consumers is greater than the maximum cumulative flow rates of nitrogen which these generators can produce when they are operating simultaneously. The buffer tank can be used to provide a supplementary flow rate of nitrogen which is sufficient to fulfill the requirements of the consumers, in particular during cooling
25 of the tank to which these consumers are connected.

Advantageously, a maximum flow rate of nitrogen is required by said consumers, and in particular by a single one of said consumers, for the cooling of a liquid gas storage tank.

30 The flow rate of nitrogen can be required by said consumer(s) for the cooling of the tank, without the tank previously having been subjected to

inerting, the tank being able to be brought to a temperature higher than -40°C thanks to its supply with nitrogen.

The flow rate of nitrogen can be required by said consumer(s) in order to cool the tank after the tank has been subjected to inerting, and the tank can
5 be brought to a temperature higher than -10°C or 0°C thanks to its supply with nitrogen.

The characteristics of the different aspects of the invention can be combined with one another even if these combinations are not necessarily described in detail in the embodiments described hereinafter.

10 BRIEF DESCRIPTION OF THE FIGURES

The invention will be better understood, and other details, characteristics and advantages of the present invention will become more clearly apparent by reading the following description, provided by way of non-limiting example, and with reference to the appended drawings, in which:

- 15 - figure 1 is a schematic view of a device for producing and distributing nitrogen;
- figure 2 is a schematic view of an embodiment of a device for producing and distributing nitrogen according to the invention;
- figures 3 to 5 are schematic views corresponding to figure 1 and illustrating steps of a method according to the invention;
- 20 - figure 6 is a schematic view of a variant embodiment of a device for producing and distributing nitrogen according to the invention;
- figure 7 is a schematic view of another variant embodiment of a device for producing and distributing nitrogen according to the invention;
- figure 8 is a schematic view of another variant embodiment of a device for
25 producing and distributing nitrogen according to the invention;
- figures 9 to 14 are schematic views corresponding to figure 8, and illustrating steps of a method according to the invention;

- figure 15 is a diagram showing highly schematically the production of nitrogen by the generators of a device according to the prior art, relative to the requirement for nitrogen of a major consumer of nitrogen;
- figure 16 is a diagram showing highly schematically the production of nitrogen by the generators of another device, relative to the requirement for nitrogen of a major consumer of nitrogen, the generators in this case each having a fixed flow rate;
- figure 17 is a diagram showing highly schematically the production of nitrogen by the generators of the device according to the invention, relative to the requirement for nitrogen of a major consumer of nitrogen, the generators in this case each having a variable flow rate; and
- figure 18 is a diagram summarizing and comparing the devices in figures 15 to 17.

DETAILED DESCRIPTION

In the following description, the terms “upstream” and “downstream” refer to the flow of a fluid, such as a gas or a liquid, in a duct or a circuit.

Figure 1 shows a device 10 for producing and distributing nitrogen, in particular for a liquid gas transport ship.

The device 10 substantially comprises nitrogen generators 12, each comprising an air inlet 12a and a nitrogen outlet 12b, a buffer tank 14 for storage of nitrogen, and means 16 for distribution of nitrogen which are designed to supply consumers 18, 20 and 22 with nitrogen.

There are two generators 12, which are fitted in parallel, their inlets 12a being connected together and connected to a single port 24 for supply of air to the generators. Their outlets 12b are connected together by a manifold, and are connected to an inlet 14a of the buffer tank 14.

From upstream to downstream, i.e. from the inlet 12a to the outlet 12b, each generator 12 comprises an air compressor 26, a separator 28 of air from fluid(s), such as water and/or oil, an air heater 30, and a filtration membrane 32 which is configured to separate the nitrogen from the remainder of the air. The

compressor 26 of each generator is for example of the type with a compression rotor. The rotor has for example a piston, a screw or blades.

The buffer tank 14 is equipped with an excess pressure valve 34, which is configured to permit the release of nitrogen contained in the tank 14 to the exterior, when the pressure in the interior of the tank 14 exceeds a predetermined threshold value, for example 11 barg.

The buffer tank 14 is also equipped with a pressure sensor 36, which is configured to measure the nitrogen pressure, known as P1, in the interior of the tank 14.

The buffer tank 14 also comprises a nitrogen outlet 14b, which is connected by the distribution means 16 to the consumers 18, 20 and 22. In this case, the distribution means 16 comprise pressure-reducing valves 38, 38', an inlet of which is connected to the outlet 14b, and an outlet of which is connected to a consumer 18, 20, 22. Each pressure-reducing valve is configured to be supplied upstream with nitrogen at any pressure (via the tank 14), and to provide a constant pressure downstream to the corresponding consumer. The valves 38 which are connected to the consumers 20, 22 are configured to provide nitrogen at a known consumption pressure Pc1, which is for example 5 barg. The valve 38' which is connected to the consumer 18 is configured to provide nitrogen at a known consumption pressure Pc2, which is for example 0.5 barg.

In the example represented, the consumer 18 is of type III, and comprises for example means for supply of nitrogen to insulation spaces, for example of liquid gas storage tanks of the ship. The consumer 20 is of type II, and comprises for example means for purging fluid circulation lines of the ship. The consumer 22 is of type I, and comprises means for supply of nitrogen to seals of bearings of compressors of the ship. The types I, II and III have previously been presented.

The device 10 also comprises a system 40 for control of the generators 14, and in particular of the compressors 26 of the generators, depending in particular on signals emitted by the pressure sensor 36.

One of the generators 12 is considered to be a main generator, and the other one of the generators is considered to be a relay generator. Each generator is configured to operate in all-or-nothing mode, and is controlled by the system 40.

5 The main generator is configured to produce nitrogen when the pressure in the tank 14, measured by the sensor 36, is contained between 6 and 9 barg. The relay generator is configured to produce nitrogen when the pressure in the tank 14, measured by the sensor 36, is contained between 5 and 8 barg. The system 40 controls the generators 14 according to the requirements for nitrogen of the consumers, such that the pressure P1 in the buffer tank is at a maximum value of approximately 10 barg. Thus, when the nitrogen consumption is such that the pressure P1 decreases to below 9 bars, the system 40 actuates the main generator in order to produce nitrogen and fill the buffer tank 14. When the nitrogen consumption is such that the pressure P1
10 decreases to below 8 bars, the system 40 actuates the main and relay generators in order to produce nitrogen and fill the buffer tank 14. This start and stop operation makes it possible to guarantee a maximal quantity of nitrogen available in the buffer tank 14, but gives rise to accelerated wear of the generators, and thus to a reduction of their service life. These generators are also costly, since they are oversized (and identical) so that they can each be sufficient to supply the largest consumer of nitrogen, in terms of flow rate, i.e. the consumer 18 of type III. They each have for example a nitrogen production capacity of 150 Nm³/h at 10 barg.
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25 Figures 2 to 5 illustrate a first embodiment of a device 110 according to the invention, which substantially comprises the same elements as those of the device 10. The foregoing description provided in relation with the device 10 thus applies to the device 110, provided that it does not contradict the description which follows.

30 In the following description, elements already previously described are designated by the same reference figures increased by a hundred.

In this case, the device 110 comprises three generators 112, but it could comprise more of them. The generators 112 are fitted in parallel, their inlets 112a being connected together and connected to a single port 124, and their outlets 112b being connected together and connected to an inlet 114a of the buffer tank 114.

Contrary to the prior art, in this case the generators 112 are not oversized. They are identical, and configured such that they can supply alone the consumer 22 of type I which has a stable consumption. In practice, each generator preferably has dimensions such as to produce a flow rate of nitrogen which is slightly greater than the constant nitrogen consumption flow rate of a consumer of type I. For example, they each have a nitrogen production capacity of 50 Nm³/h at 6 barg.

Each generator 112 comprises, from upstream to downstream, i.e. from the inlet 112a to the outlet 112b, an air compressor 126, a separator 128 of air from fluid(s), such as water and/or oil, an air heater 130, and a filtration membrane 132 which is configured to separate the nitrogen from the remainder of the air.

Certain elements of the generators 112 can be communalized. This is the case for example for the separators 128 and the heaters 130 of the generators, as represented schematically by rectangles in broken lines in figure 2. Thus, the device 110 can comprise a separator 128 which is common to the three generators 112, or to only two of them. In the same way, the device 110 can comprise a heater 130 which is common to the three generators 112, or to only two of them.

The outlets 112b of the generators 112 are connected by a valve 142 to the inlet 14a of the buffer tank 114. A pressure sensor 114 is provided upstream from the valve 142, and makes it possible to measure the nitrogen pressure, known as P2, at the outlet of the generators 112. The buffer tank 114 is also equipped with two pressure sensors 136 and 146, which are configured to measure the pressure P1 in the interior of the tank. The sensors 136, 146 can be replaced by a single sensor. The signals which are emitted by the sensors

144 and 136 are designed to be received by the system 140 which controls the functioning of a means 148 for control of the valve 142. In the same way, the signals which are emitted by the sensor 146 are designed to be received by the system 140 which controls the functioning of a means 150 for control of a
5 nitrogen recirculation valve 152.

The device 110 comprises a nitrogen recirculation line 154, an upstream end of which is connected to the or a nitrogen outlet 114b of the tank 114, and an opposite, downstream end of which is connected to the inlets 112a of the generators 112.

10 The line 154 is equipped with the valve 152, as well as with a non-return valve 156. It can also be equipped with a flow meter 158, the signals of which are designed to be transmitted to the system 140. The flow meter 158 makes it possible to determine the quantity of nitrogen produced in excess. In the case when the flow rate of nitrogen produced in excess and circulating in
15 the line 154 is too great, the system 140 can command stoppage of one of the generators 112, when two generators are operating.

The means 150 is configured to actuate the valve 152 when the pressure in the tank 114, measured by the sensor 146, exceeds a certain threshold, for example of approximately 10 barg.

20 In the event of excess production of nitrogen, the line 154 makes it possible to reuse the nitrogen produced in excess, in order to avoid stopping the generators, and thus to limit the number of start and stop cycles.

The buffer tank 114 is equipped with an excess pressure valve 134, and its outlet 114b is connected by first distribution means 116a to the
25 consumers of type II and III, i.e. the consumers 118 and 120.

In this case, the distribution means 116a comprise pressure-reducing valves 138, 138', the inlet of which is connected to the outlet 114b, and an outlet of which is connected to a consumer 118, 120.

The device 110 also comprises second means 116b for direct
30 distribution of nitrogen to the consumer of type I, i.e. the consumer 122. In this

case, these distribution means 116b comprise a pressure-reducing valve 138, the inlet of which is connected to the outlets 112b of the generators 112, and an outlet of which is connected to the consumer 122.

5 The outlets 112b of the generators 112 are thus connected together in order to form a first branch of a connection in the form of a “Y”, a second branch of which is connected by the valve 142 to the inlet 114a of the tank, and a third branch of which is connected to the valve 138 and to the consumer 122. The direct supply to the consumer 122, which requires a constant flow rate of nitrogen over a relatively long period, makes it possible to avoid the numerous
10 start and stop cycles of operation of the generators, and thus to limit their wear. In addition, the tank 114 can adopt a function of storage of nitrogen, and have a storage pressure which varies between a minimal value and a maximum value, and not simply a buffer function, for which an operating pressure must be kept constant.

15 According to a variant not represented, the consumer which is supplied directly by the generators 112 could be the consumer 120 of type II.

Figures 3 to 5 illustrate steps of operation of the device 110, and in particular of a method for producing and distributing nitrogen.

The step represented in figure 3 represents the direct supply of nitrogen
20 to the consumer 122, as well as the recirculation of nitrogen, if necessary.

One of the generators 112 is actuated by the system 140, and produces nitrogen with a flow rate and a pressure which are sufficient to cover the needs of the consumer 122 of type I. The nitrogen pressure is equal to 5 barg downstream from the valve 138 of the means 116b, and is higher than 5 barg
25 upstream from this valve. The surplus nitrogen produced by the generator is conveyed to the buffer tank 114, through the valve 142 which remains permanently open.

In the case when the nitrogen pressure in the interior of the tank 114, measured by the sensor 146, exceeds a certain threshold, for example 10 barg,
30 the valve 152 is opened, and nitrogen is discharged from the tank in order to reduce its pressure and return the nitrogen to the inlets 112a of the generators.

This nitrogen will therefore be re-treated by the generators, in order to increase the nitrogen production output of the device, i.e. the enrichment with nitrogen of the gas at the outlet of the generators.

5 The step represented in figure 4 also represents the direct supply of nitrogen to the consumer 122, as well as the recirculation of nitrogen, if necessary.

Two of the generators 112 are actuated by the system 140, and produce nitrogen with a flow rate and pressure which are sufficient to cover the needs of the consumer 122 of type I, or of other consumers. The nitrogen
10 pressure is equal to 5 barg downstream from the valve 138 of the means 116a, and is higher than 5 barg upstream from this valve. The surplus nitrogen produced by the generator is conveyed to the buffer tank 114, through the valve 142 which is open.

In the case when the nitrogen pressure in the interior of the tank 114,
15 measured by the sensor 146, exceeds the aforementioned threshold, the valve 152 is opened, and nitrogen is discharged from the tank in order to decrease its pressure, and return the nitrogen to the inlets 112a of the generators.

When the consumers do not require nitrogen, or require a flow rate of nitrogen which is lower than the flow rate of nitrogen produced, the nitrogen
20 pressure in the tank 114 increases. Beyond the pressure threshold, the means 150 command the opening of the valve 152, and thus the recirculation of part of the nitrogen contained in the tank, such as to maintain its inner pressure at 10 barg. In the case when the flow rate of nitrogen which is recirculating is lower than a threshold value, the generators are kept operating. In the case when this
25 flow rate is greater than this threshold value, one of the generators could be stopped by the system 140.

When the consumers require a flow rate of nitrogen which is greater than the flow rate of nitrogen produced, the nitrogen pressure in the tank 114 decreases. The system can then command the activation of the third generator
30 112, in order to prevent the pressure in the tank from reaching a minimal value,

for example of 1 barg. The device is however configured such that the pressure in the tank can drop as low as that level, which was not the case in the prior art.

Before the activation of a generator, such as the third one, the system 140 can command the activation of the heater of this generator. This makes it possible to pre-heat the generator for the purpose of its imminent operation.

The step represented in figure 5 represents the supply of nitrogen to the consumers 118 and 122. The consumer 118 requires a relatively high flow rate of nitrogen. This is the case in particular during cooling and filling of a liquid gas tank, since the insulation space of this tank must be supplied with nitrogen with a high flow rate and a low pressure.

Two of the generators 112 are actuated by the system 140 and produce nitrogen, part of which supplies the consumer 122 directly and the other part of which supplies the buffer tank 114. In the distribution means 116b, the nitrogen pressure is equal to 5 barg downstream from the valve 138, and is higher than, or equal to, 5 barg upstream from this valve. In the distribution means 116a, the nitrogen pressure is equal to 0.5 barg downstream from the valve 138', and is higher than 0.5 barg upstream from this valve.

The valve 142 is controlled such as to ensure that the pressure upstream from the valve 138 of the distribution means 116b is always higher than 5 barg. For this purpose, the valve 138 can be almost closed, such that all, or almost all of the nitrogen produced by the generators supplies the consumer 122.

In general, irrespective of the operational conditions of the device 110, the valve 142 is preferably kept open. This allows the buffer tank 114 to be supplied with nitrogen at any time, and to rebalance the pressures upstream and downstream from the valve 142, i.e. in the nitrogen outlet manifold of the generators 112, and in the tank 114. If the flow rate of nitrogen consumed is high, and greater than the flow rate of nitrogen produced by the generators 112, the pressure in the tank will decrease. If the nitrogen consumption stops, or if the flow rate consumed is lower than the supply flow rate, then the pressure in the tank will increase until it reaches a maximum value.

In particular, the valve 142 is configured to be completely open when the pressure in the interior of the tank is higher than 5 barg, and to be partly open when the pressure in the interior of the tank is lower than 5 barg, such that the pressure upstream from the valve is higher than, or equal to, 5 barg.

5 As a variant, the valve 142 could be replaced by a valve with two states, i.e. all or nothing. An additional duct for connection of the outlets of the generators to the inlet of the buffer tank would then be necessary in parallel with the valve, such as to ensure fluid communication between the outlets of the generators and the inlet of the buffer tank, even when the valve is closed.

10 Figure 6 illustrates a second embodiment of a device 210 according to the invention, which substantially comprises the same elements as those of the device 110. The foregoing description provided in relation with the device 110 therefore applies to the device 210, provided that it does not contradict the description which follows.

15 In the following description, elements already previously described are designated by the same reference figures increased by at least a hundred.

 The embodiment in figure 6 differs from that in figures 2 to 5, in particular in that the first distribution means 216a are connected to the second distribution means 216b by a bypass line 260 which is equipped with a valve
20 262 and/or with a non-return valve.

 The bypass line 260 is configured to permit the passage of nitrogen from the distribution means 216a, and thus from the buffer tank 114, as far as the consumer 122. The line 260 can have an upstream end connected to the distribution means 216a, just upstream from the valves 138, 138', and a
25 downstream end connected to the distribution means 216b, just upstream from the valve 138.

 The outlets 212b of two of the generators 212 are in this case connected to the inlet 214a of the buffer tank 214 by a duct which is without a valve, in order to simplify the device 210. The device 210 is also without a
30 recirculation line, although it could comprise one.

In addition, the device 210 comprises at least one system 264 for variation of the frequency or speed of the rotor of a compressor 226 of at least one of the generators 212'. The system 264 can be controlled by the system 240. As a variant, it can be controlled manually, with the frequency or the speed
5 of the rotor being adjusted manually.

In the example represented, the system 264 is associated with a single one of the compressors, the outlet 212b' of which is connected directly to the distribution means 216b, and is not connected to the outlets 212b of the other generators. The outlets 212b of the two other generators are connected to the
10 inlet 214a of the tank, as previously described.

Figure 7 illustrates a third embodiment of a device 310 according to the invention, which substantially comprises the same elements as those of the device 210. The foregoing description provided in relation with the device 210 therefore applies to the device 310, provided that it does not contradict the
15 description which follows.

In the following description, elements already previously described are designated by the same reference figures increased by at least a hundred.

The embodiment in figure 7 differs from that in figure 6 in particular in that the device 310 comprises only first distribution means 316a, and thus does
20 not comprise second means for direct distribution of nitrogen from the outlets 312a of the generators 312. The distribution means 316a are thus connected to the outlet 314b of the buffer tank 314 and to all of the consumers 318, 320 and 322, by the pressure-reducing valves 338, 338'. The outlets 312b of the generators are all connected together and to the inlet 314a of the buffer tank.

In addition, the device 310 comprises a means 366 for controlling the system 364, in particular according to the pressure in the buffer tank 314 measured by the pressure sensor 346.
25

In the embodiment in figure 7, the generator with which the system 364 is associated can be undersized compared with the other generators. This
30 generator is for example similar to those 112, 212, 212 previously described,

whereas the other generators can be of the type used in the prior art (which are in general oversized).

In general, the invention proposes solutions in order to solve the technical problem of accelerated wear of the nitrogen generators as a result of their all-or-nothing or start and stop operating mode.

Figures 8 to 14 illustrate another variant embodiment of a device 410 according to the invention, which substantially comprises the same elements as those of the device 10. The foregoing description provided in relation with the device 10 therefore applies to the device 110, provided that it does not contradict the description which follows.

In the following description, elements already previously described with reference to figure 1 are designated by the same reference figures increased by four hundred.

In this case, the device 410 comprises two generators 412, but could comprise more of them. The generators 412 are fitted in parallel, their inlets 412a being connected together and connected to a single port 424, and their outlets 412b being connected together.

From upstream to downstream, i.e. from the inlet 412a to the outlet 412b, each generator 412 comprises an air compressor 426, a separator 428 of air from fluid(s) such as water and/or oil, an air heater 430 and a filtration membrane 432 which is configured to separate the nitrogen from the remainder of the air. In practice, membrane separation technologies operate by retaining the nitrogen and permitting the permeation of the remainder of the components of the air.

Certain elements of the generators 412 can be communalized, as previously described.

The outlets 412b of the generators 412 are connected by a valve 442 to the inlet 414a of a buffer tank 414. The outlets 421b are also connected to main means 416b for distribution of nitrogen to the consumers 418 and 422.

The direct supply to the consumers makes it possible to avoid the numerous start and stop operating cycles of the generators, and thus to limit their wear. In addition, the tank 414 can adopt a nitrogen storage function, and have a storage pressure which varies between a minimal value and a maximal value, and not simply a buffer function for which an operating pressure must be kept constant.

An outlet 414b of the buffer tank 414 is also connected by secondary means 416a for distribution of nitrogen to at least one of the consumers, in this case the consumer 418 of type III. The buffer tank 414 can comprise another outlet 414c which is connected to the consumer 420 of type II.

The main means 416b for distribution are equipped with pressure 444a, 444b and flow rate 445 sensors. A pressure sensor 444a and a flow rate sensor 445 are situated just at the outlet of the generators 412, and the other pressure sensor 444b is further downstream. The sensors 444a, 444b are configured to measure pressures P1 and P2 of the nitrogen in the means 416b.

The buffer tank 414 is also equipped with a pressure sensor 446a which is configured to measure a pressure P4 in the interior of the tank. The secondary distribution means 416a are equipped with a pressure sensor 446b which is configured to measure a pressure P3.

Downstream from each consumer 418, 420, 422, the distribution means 416a, 416b comprise a pressure-reducing valve 438, 438', 438".

In the example represented, the main distribution means 416b comprise two respective supply lines of the consumers 418, 420, 422. The first line 416b1 extends from the outlets 412b of the generators 412 as far as the consumer 422, and is equipped with the sensors 444a, 444b and 445, as well as with the valve 438. The second line 416b2 extends between the first line 416b1 and the consumer 418, and is equipped with the valve 438', as well as with another valve 462 which is disposed downstream from the valve 438'. The second line 416b2 is connected to the first line 416b1, downstream from the sensors 444a, 444b, 445 and upstream from the valve 438. A third line 416b3 extends between the first line 416b1 and the consumer 420, and is equipped with the

valve 438''. The line 416b3 is connected only to the outlet 414c of the buffer tank 414. The secondary distribution means 416a are connected to the second line 416b2 and downstream from the valve 462 and upstream from the valve 438'. These distribution means 416a are equipped with a valve 443.

5 The signals emitted by the sensors 446a, 444b are designed to be received by control means 448a, 448b, which control the valves 442 and 462 accordingly. In the same way, the signals which are emitted by the sensor 446b are designed to be received by a control means 448c which controls the valve 443 accordingly.

10 The signals which are emitted by the sensors 444a, 445 are designed to be received by a control system 440 of a system 464 for variation of frequency or speed of the rotor of the compressor 426 of each generator 412.

 It will thus be understood that the speed or the frequency of each compressor rotor is controlled according to the pressure and/or the flow rate of
15 nitrogen circulating in the main distribution means 416b.

 Unlike the device 110, where each (all-or-nothing) generator has a capacity slightly larger than the regular consumer 422, in this case the generators 412 of the device 410 have larger capacities, such that the variation system 464 can make a reduced charge ("low"-functioning) generator operate,
20 and fulfills the requirement of the regular consumer 422. It is when the requirement increases, for example as a result of an additional need of the consumer 418, that the system 464 makes it possible to increase the production of the generator.

 The "low"-functioning corresponds for example to an operating point of
25 50Nm³/h at 6 barg, which corresponds to approximately 30 to 50% of the nominal capacity of the generator. This "low"-functioning complies with the stable regular consumption, i.e. to the needs of the consumer 422.

 The maximal capacity of the generators is no longer correlated to the maximal requirement, which remains intermittent.

Figures 9 to 14 illustrate operating steps of the device 410, and in particular of a method for producing and distributing nitrogen.

The step represented in figure 9 represents the direct supply of nitrogen to the consumer 422, or optionally to the consumer 418.

5 One of the generators 412 is actuated by the system 440, and produces nitrogen with a flow rate and pressure which are sufficient to cover the needs of the consumer 422 of type I. The nitrogen pressure is equal to 5 barg downstream from the valve 438 of the means 416b, and is higher than 5 barg upstream from this valve. Unlike the device 110, there is no longer any surplus
10 production of nitrogen, since the generator is controlled so as to produce whatever is required. In the case of the operating rate in figure 9, there is substantially only the consumer 422 which is consuming. The consumer 418 can potentially consume a low flow rate or none, which flow rate then passes through the valves 462, 438' which are open.

15 The compressor of the generator 412 which is operating can be at a load of 30 to 50% of its nominal capacity. This load is regulated by the system 440 according to the flow rate consumed measured by the sensor 444a. The sensor 445 makes it possible to guarantee the operating rate, and that the valve 438 is actually being supplied with a pressure at least equal to 5 barg. The
20 valves 442 and 443 are closed. The valve 462 is completely open for the small requirements of nitrogen of the consumer 418. The valve 438' is thus open. Figure 9 therefore represents the stable normal consumption state of the device.

 The step in figure 10 represents an increase in the requirements for
25 nitrogen of the consumers 422 and 418. The pressure or the flow rate of nitrogen production is higher than in the preceding step.

 The increase in the flow rate consumed measured by the sensor 444a, as well as the pressure measured by the sensor 445, in this case show an increase in the flow rate. The system 440 increases the load of the compressor
30 in order to comply with the requirement. The valves 442 and 443 are closed.

The valve 462 is completely open for the small requirements of nitrogen of the consumer 418. The valve 438' is thus open.

5 A single generator 412 operates in step 10, compared with two in the following step illustrated in figure 11, which shows a state of the device corresponding to high consumption.

The two generators 412 are actuated by the system 440, and produce nitrogen with a flow rate and a pressure which are sufficient to cover the requirements of the consumers 422 and 418. In this case, the consumer 418 needs a relatively high flow rate of nitrogen. This is the case in particular during
10 cooling and filling of a liquid gas tank, with the insulation space of this tank having to be supplied with nitrogen with a high flow rate and a low-pressure.

After this increase in the consumption, which brings the compressor started first to approximately 80% of its charge, the compressor of the second generator thus starts. In order to have balanced outlet pressures, the global
15 charge is distributed to both compressors. For example, the two compressors can be regulated to a charge of approximately 40%. It is considered in the cases of "high consumption" that the flow rate required is lower than, or equal to, the total capacity of the two compressors ($2 \times 100\%$). The valves 442 and 443 are closed. The valve 462 is completely open for the small requirements of
20 nitrogen of the consumer 418. The valve 438' is thus open.

A consumption peak corresponds to the case where the flow rate required is greater than the total capacity of the two compressors ($2 \times 100\%$). When this consumption exceeds the capacity, the pressure supplied will drop. When the pressure approaches 5 barg, the buffer tank 414 is used in order to
25 complete the production of nitrogen and maintain the necessary pressure required by the consumers (figure 12). The nitrogen pressure in the tank 414 then decreases. The valve 443 opens and distributes the nitrogen stored, in order to maintain sufficient pressure upstream from the valve 438'. The valve 462 closes progressively, in order to maintain sufficient pressure upstream from
30 the valve 438. The valve 442 remains closed. It is considered that the

consumption peak has been passed when the pressure P2 measured by the sensor 444b rises to a sufficient value once more.

The case of a decrease in the flow rate or pressure of nitrogen required by the consumers (figure 13) is similar to the case of an increase in this flow rate or this pressure, as illustrated in figure 11.

The step represented in figure 14 represents the supply of nitrogen to the consumers and to the buffer tank 414. Two of the generators 412 are actuated by the system 440 and produce nitrogen, one part of which supplies the consumer 422 directly, and the other part of which supplies the buffer tank 414. In the distribution means 416b, the nitrogen pressure is equal to 5 barg downstream from this valve 438, and is higher than, or equal to, 5 barg upstream from this valve. In the distribution means 416a, the nitrogen pressure is equal to 0.5 barg downstream from the valve 438', and is higher than 0.5 barg upstream from this valve.

When the consumers do not require nitrogen, or require a flow rate of nitrogen lower than the flow rate of nitrogen produced, the nitrogen pressure in the tank 414 increases. Beyond the pressure threshold, the means 448c commands the opening of the valve 443.

At the normal operating rate, when there is no peak, the tank 414 must remain full, preferably at the highest pressure which can be produced by the generators 412, for example between 10 and 12 barg. If, and only if, the pressure P2 measured by the sensor 444b is greater than 5 barg, and the pressure P4 measured by the sensor 446a is lower than 8 barg (for example), then the valve 442 begins to open in order to allow the tank to be supplied with nitrogen, and thus increase its pressure. The two compressors can be used at 100% in order to obtain this maximal filling pressure of 10 to 12 barg.

The valve 442 is in any case controlled such as to ensure that the pressure upstream from the valve 438 of the distribution means 416b is always higher than 5 barg. For this purpose, the valve 438 can be almost closed, such that all or almost all of the nitrogen produced by the generators supplies the consumer 122.

Figure 15 illustrates the art prior to the present invention, and the fact that the generators are identical and oversized, such as to be suitable for providing a flow rate of nitrogen sufficient to supply the largest consumer, in terms of flow rate, with nitrogen, i.e. the consumer of type III. N1 and N2 are respectively low and high levels of requirements for nitrogen of the consumers. The levels L1 and L2 are respectively the nitrogen production capacities of the two generators G1 and G2. The capacity L1 of the first generator makes it possible to cover the level N1 but not the level N2. In order to cover the level N2, it is necessary to make the two generators operate simultaneously, which then produce a nitrogen flow rate greater than N2, and which corresponds to the nitrogen flow rate (MAX) of the largest consumer of nitrogen of type III.

Figure 16 illustrates a similar case with three generators (G1, G2 and G3) instead of two, as well as a buffer tank (RT). N1 and N2 are respectively low and high levels of requirements for nitrogen of the consumers. The levels L1, L2 and L3 are respectively the nitrogen production capacities of the three generators. The capacity L1 of the first generator makes it possible to cover the level N1. The cumulative capacities L1, L2 and L3 make it possible to cover the level N2. Beyond this level, in addition to the three generators, the buffer tank is used to supply more nitrogen and to complete the flow rate supplied up to the nitrogen flow rate (MAX) of the largest consumer of nitrogen of type III.

Figure 17 illustrates one of the aspects of the invention, and the fact that the device comprises generators with a variable flow rate. According to the requirements, one or a plurality of the generators supply nitrogen. If the requirement for nitrogen is low, a single one of the generators is put into operation, and the speed or frequency of its rotor is controlled in order to supply the flow rate required. If the flow rate required is greater than the maximum flow rate which a single generator can produce, the two generators are put into operation. The cumulative capacities L1 and L2 of the generators are equal to N2. The buffer tank is used to supply intermittently a surplus of flow rate necessary in order to meet the requirements, and therefore the additional flow rate necessary to go from the level N2 to the level MAX.

According to an embodiment of the invention, the level N2 corresponds to the flow rate required by the consumer of type III during cooling of a tank. The tank can be emptied and brought to a temperature higher than -40°C . In the case when it is not subjected to a step of inerting consisting of injecting inert
 5 gas into the tank for the purpose of discharging the air, the tank can be filled again with liquid gas. Before this, it is however necessary to cool the tank thanks to the consumer of type III. The flow rate N2 thus corresponds to the flow rate necessary for the supply of this consumer.

The level MAX corresponds to the flow rate required by the same
 10 consumer during cooling of a tank which has previously been inerted. The tank can be emptied and brought to a temperature higher than -10°C or 0°C . It can be subjected to one or a plurality of steps of inerting, consisting of injecting inert gas into the tank for the purpose of discharging the air which is in it as a result of a maintenance operation for example carried out in the tank. The tank can be
 15 filled once more with liquid gas. Before this, it is however necessary to cool the tank thanks to the consumer of type III. The flow rate NMAX thus corresponds to the flow rate necessary for the supply of this consumer.

The level N1 can correspond to the flow rate required continuously by one or the other of the other consumers, for example the one of type I.

CLAIMS

1. A device (410) for producing and distributing nitrogen, in particular for a liquid gas transport ship, comprising:

- nitrogen generators (412) each comprising an air inlet (412a) and an air outlet (412b), at least one of these generators (412) comprising a compressor (426) comprising an air compression rotor; and
- a nitrogen storage buffer tank (414),

characterized in that it comprises at least one system (464) for variation of frequency or speed of the rotor of said at least one generator with a compressor, and in that it also comprises main means (416b) for distribution of nitrogen exiting from said at least one generator with a compressor, without passing via said buffer tank, for the supply of nitrogen to at least two distinct consumers (418, 420, 422).

2. The device (410) as claimed in the preceding claim, wherein said at least one compressor with a generator comprises, from upstream to downstream, from the inlet (412a) as far as the outlet (412b) for nitrogen, said compressor (426), a separator (428) of air from fluid(s), such as water and/or oil, a heater (430), and a filtration membrane (432) configured to separate the nitrogen from the remainder of the air.

3. The device (410) as claimed in one of the preceding claims, wherein at least certain of said inlets (412a) of said generators (412) are connected together and to a single air supply port, and/or at least certain of said outlets (412b) of said generators are connected together and to a single nitrogen outlet port.

4. The device (410) as claimed in the preceding claim, wherein said single nitrogen outlet port is connected, preferably via a valve (442), to an inlet (414a) of said buffer tank (114) and to said main nitrogen distribution means (416b).

5. The device (410) as claimed in one of the preceding claims, wherein it comprises secondary distribution means (416a) for distribution of nitrogen exiting from said buffer tank (414) for the supply of at least certain (418, 420, 422) of said consumers.

5 6. The device (410) as claimed in claim 5, wherein the main distribution means (416b) are connected to the secondary distribution means (416a) by a valve (462).

7. The device (410) as claimed in one of the preceding claims, wherein said consumers (418, 420, 422) comprise means (422) for supplying nitrogen
10 to seals, in particular of compressors of said ship, means (418) for supply to insulation spaces, in particular of tanks of said ship, and means (420) for purging, in particular of supply lines of said ship.

8. The device (410) as claimed in the claim 7, wherein said main means (416b) for distribution of nitrogen supply directly at least said means (422)
15 for supplying nitrogen to seals, and said means (418) for supply to insulation spaces.

9. The device (410) as claimed in one of the preceding claims, wherein said main means (416b) for distribution of nitrogen comprise at least one pressure and/or flow rate sensor (470, 472), this sensor being connected
20 to a system (440) for control of said system (464) for variation of frequency or of speed.

10. The device (410) as claimed in one of the preceding claims, wherein said generators (412) are identical and oversized, such as each to be able to supply alone at least one of said consumers, the consumption of which in
25 terms of flow rate is designed to be stable and continuous, when this generator is regulated to a load lower than 100% by means of said variation system.

11. A method for producing and distributing nitrogen by means of a device (410) as claimed in one of the preceding claims, comprising the steps of:

30 a) production of nitrogen by said generators (412);

- b) variation of the frequency or speed of the rotor of said at least one generator with a compressor (412); and
- c) supply to at least certain (418, 420, 422) of said consumers, without passing via said buffer tank (414).

- 5 12. The method as claimed in claim 11, wherein the frequency or speed of the rotor of said at least one generator with a compressor is controlled such that the pressure or the flow rate is higher than a threshold value in said main means (416b) for distribution of nitrogen.
- 10 13. The method as claimed in the preceding claim, wherein the pressure threshold value in said main means (416b) for distribution of nitrogen is 5 barg.
- 15 14. The method as claimed in one of claims 11 to 13, wherein said buffer tank (414) is supplied with nitrogen if, and only if, the pressure measured in said main distribution means (416b) is higher than said pressure threshold value, and if the pressure measured in said buffer tank (414) is lower than a lower limit value.
- 20 15. The method as claimed in one of claims 11 to 14 wherein:
- a single one of the generators is used to produce nitrogen, when the flow rate of nitrogen required by said consumers is less than the maximum flow rate of nitrogen which this generator can produce alone;
 - at least two of the generators, or all the generators, are used to produce nitrogen, when the flow rate of nitrogen required by said consumers is greater than the maximum flow rate of nitrogen which each of these generators can produce, but this flow rate of nitrogen required is lower than the maximum cumulative flow rates of nitrogen which these generators can produce when they are operating simultaneously; and
 - at least two of the generators, or all the generators, are used to produce nitrogen, when the flow rate of nitrogen required by said consumers is greater than the maximum cumulative flow rates of nitrogen which these generators can produce when they are operating simultaneously, with
- 25
- 30

the buffer tank being used to supply an additional flow rate of nitrogen which is sufficient to comply with the requirement from the consumers.

16. The method as claimed in claim 15, wherein a maximum flow rate of nitrogen is required by said consumers, and in particular by a single one of said consumers, in order to cool a liquid gas storage tank.

17. The method as claimed in claim 16, wherein the flow rate of nitrogen is required by said consumer(s) in order to cool the tank, without the tank previously having been subjected to inerting, with the tank being able to be brought to a temperature higher than -40°C thanks to its supply with nitrogen.

18. The method as claimed in claim 16, wherein the flow rate of nitrogen is required by said consumer(s) in order to cool the tank, after the tank has been subjected to inerting, with the tank being able to be brought to a temperature higher than -10°C or 0°C thanks to its supply with nitrogen.