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(54) **PROCESS AND APPARATUS FOR CRYOGENIC AIR SEPARATION HAVING A SPLIT HIGH-PRESSURE COLUMN**

(57) The invention regards a process for cryogenic air separation and a respective apparatus. The distillation system has a high-pressure column (12, 13), a low-pressure column (24, 25) and a main condenser (26) operating as condenser-evaporator. In a nitrogen recycle, a nitrogen-enriched gas (27) is withdrawn from the low-pressure column and used as a recycle fraction which is compressed in a recycle compressor and introduced (34) into the high-pressure column (13) at a first intermediate height (H1). A nitrogen fraction (17) from a second intermediate height (H2) being higher than the first intermediate height (H1) is withdrawn from the high-pressure column and recovered as medium pressure nitrogen product (18). The high-pressure column is split into a first part (12) and a second part (13) placed in two tightly separated vessels. The compressed recycle fraction (34) is introduced into the second part (13), the medium pressure nitrogen product (17, 18) is withdrawn from the second part (13). A gaseous nitrogen transfer fraction (15) is withdrawn from the top of the first part (12) and introduced into the second part (13) at a third intermediate height (H3) above the second intermediate height (H2). A liquid nitrogen transfer fraction (39) is withdrawn from a fourth intermediate height of the second section (H4), whereby the fourth intermediate height (H4) is equal to the third intermediate height (H3) or slightly above. The liquid nitrogen transfer fraction is introduced into the first section at its top. A gaseous portion is separated from a

two-phase fraction produced by the partial condensation of the nitrogen-rich top gas in the main condenser and used as a He-Ne preconcentrate intermediate product.

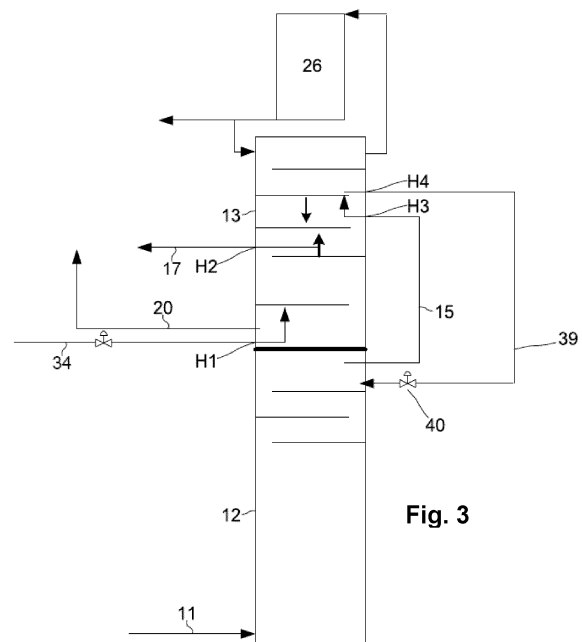


Fig. 3

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Description

[0001] The invention concerns a process for cryogenic air separation according to the first part of patent claim 1 as well as a respective apparatus.

[0002] WO 2021204424 A2 shows such a process according to the first part of the independent claims. Such type of plant is particularly used for electronic industries, e.g. wafer production (so called fabs). Recently some product specifications there became even stricter, e.g. a requirement for high purity for the gaseous nitrogen (GAN) product. In an example, the oxygen content to be guaranteed is equal or less than 10 ppb oxygen in the high-pressure nitrogen (HP-GAN) product. That means that direct GAN product compression shall normally not be applied because of the risk to contaminate the HP-GAN product with impurities. Instead an additional nitrogen purification section has been introduced into the high-pressure column as shown in WO 2021204424 A2.

[0003] On the other hand, the current worldwide demand on neon is extremely high so that there is a need for recovering a He-Ne concentrate with high recovery of neon.

[0004] The additional nitrogen purification section according to WO 2021204424 A2, however, does not allow to have a high neon recovery.

[0005] Therefore, it is the object of the invention to have a process for the production of pressurized HP-GAN with a high neon recovery.

[0006] Such problem is solved by the features of the characterizing portion of claim 1.

[0007] In prior art, neon recovery is restricted by a mixing of two gas streams:

- the gas rising up inside the high pressure column (from the bottom to above) and
- a nitrogen stream coming from the recycle compressor and being introduced into the column in its upper part.

[0008] Such mixing of both streams results in relatively large loss on helium and neon via a stream of product nitrogen taken from the high-pressure column. The Ne recovery turns out to be very low, e.g. lower than 40 %.

[0009] In the invention, the high-pressure column is physically divided into two parts: a first part comprising a main section and a second part comprising the additional nitrogen purification section and the He-Ne retention trays at its top. (Those "retention trays" may be realized by any type of mass exchange elements like structured or nonstructured packing, but more often, classical practical trays like sieve trays will be used in the additional nitrogen purification section.) "Physically divided" means there is no gas or liquid stream directly flowing from one part to the other; all connections are via pipes; the two parts are arranged in two tightly separated vessels. If e.g. the two parts of the high-pressure column are arranged above each other, there is a gas-tight interme-

diated seal between those parts. Even if the vessels of both parts have a common cylindrical shell, they are then "two tightly separated vessels" in the meaning of this application.

[0010] The arrangement in two tightly separated vessels means that there is no free flow between the vessels. That does not exclude that there are flow connections between the two vessels via conduits, which guide a gaseous or liquid fluid from one vessel to the other and/or backwards. Those conduits may or may not comprise a valve.

[0011] Between the different "intermediate heights", there is at least one theoretical or practical tray respectively. The "height" does not directly refer to a geometrical height, but to the number of practical trays, theoretical trays or "separation stages" in a distillation column, normally denominating the bottom tray as 1 and the top tray as n, if n is the total number of (practical or theoretical) trays of that column. Such counting works in split columns as well, disregarding whether or not the parts of the column are arranged one above the other. The term "separation stages" has a different meaning depending on the usage of practical trays on the one or structured or nonstructured packing on the other side. In case of practical trays, it means the practical tray count, in case of packing the theoretical tray count.

[0012] The vapour stream from top of the main section ("gaseous nitrogen transfer fraction") is introduced into the second part above the additional nitrogen section below the He-Ne retention trays (at the "third intermediate height"). Such stream contains the full amount of neon (and helium) available from the feed air. The recycle stream from the compressor has a purity level of 45 to 100 ppb oxygen and is introduced at the bottom of the additional nitrogen section ("first intermediate height"), normally the bottom of the second part of the high-pressure column. The purified nitrogen fraction used as product stream with 5 to 10 ppb oxygen is withdrawn from the column (at the "second intermediate height") slightly below (e.g. just one tray below) the introduction of the stream from the main column section (the "third intermediate height"), so that no mixing occurs between the gas coming from the first part and the recycle gas to be withdrawn from the distillation as a product. The remainder of the gas rising in the column and not withdrawn with the product stream (such remainder being a part of the recycle stream from compressor) is mixed at the following tray with the gaseous nitrogen transfer fraction withdrawn from the top of the first part. The liquid reflux stream for the main column section ("liquid nitrogen transfer fraction") is introduced into the main section, preferably by means of hydrostatic pressure and a control valve.

[0013] The decisive tray preventing the undesired mixing in the second part of the high-pressure column is arranged between second and the third intermediate heights and preferably realized as slotted bubble cup tray (Schlitzglockenboden) to cope with relatively high liquid-to-vapour ratio in the respective column section.

[0014] A further aspect of the invention concerns the operation and mechanical construction of a split high-pressure column as described above. There is a certain risk of backflow inside the second part in case of possible incident like a compressor trip, short time closure of a valve or other sudden pressure reductions. In such cases a backflow of gas inside the column directed from the top to the bottom may be induced. Structured or nonstructured packing is relatively resistant against such backflow. In high-pressure columns, however, classical trays are frequently used and they may undergo considerable damage by a sudden backflow. Therefore, there is a need for avoiding such backflow. In a special embodiment, the apparatus of the invention comprises a particular mechanical realization of the split high-pressure column. It solves the particular problem of such possible backflow in the second part of the high-pressure column. Such a problem may occur in other columns like distillation or adsorption columns of other applications inside and even outside air separation, and it may be solved by the same means as described here. The details are explained and claimed here in connection with the particular process and apparatus exemplified above.

[0015] According to this aspect of the invention, the backflow problem is solved using a vertical dynamic backflow valve in the second part of the high-pressure column between the second intermediate height and the fourth intermediate height. Such is configured to enable a gas bypass around the trays in this area in case of gas backflow.

[0016] Preferably, the dynamic backflow valve comprises a vertical pipe extending through the trays in the above area. The dynamic backflow valve may comprise a single pipe. Alternatively it may have multiple parallel pipes, e.g. 2 to 6 pipes, preferably 3 to 5 pipes. In a practical example, the dynamic backflow valve comprise four pipes arranged at the corners of a square.

[0017] In order to be a vertical dynamic backflow valve it must be configured to be closed during normal operation (in order not to open a gas bypass around the trays) and to automatically open, when a backflow occurs.

[0018] For this purposes, it is advantageous to apply a liquid seal, the liquid seal in particular comprising a cup enclosing the lower end of the pipe(s) of the dynamic backflow valve. The dynamic sealing is realized by an overlap of cup and gap into the cup. The overlap must be designed in a way that gas goes through the tray under normal operation but is pushed/sucked away with a pressure drop lower than the pressure drop able to destroy the trays.

[0019] The liquid seal is constantly filled, respectively kept filled by a filling element configured to fill the cup with liquid, such filling element preferably comprising a halfpipe having a diameter lower than the diameter of the pipe and being attached to side wall of the pipe, whereby the upper end of the halfpipe is configured to be filled with liquid from a tray and the lower end of the halfpipe dives into the interior of the cup. During normal operation

liquid from one of the bypassed trays flows into the half-pipe and down into the cup thereby building up and keeping the liquid seal.

[0020] The cup may have a liquid drain for emptying the cup during shutdown. It may, however, be dimensioned in a way that the cup constantly loses a small amount of liquid in order to avoid the enrichment of impurities with high boiling temperature.

[0021] In case of a sudden reduction of pressure at the lower end of the dynamic backflow valve, the liquid is sucked from the liquid seal and releases away through the pipe for the backflow gas.

[0022] As an alternative to the dynamic backflow valve, the respective section in the second part of the high-pressure column between the second and the fourth intermediate heights (H2, H3) can be filled with packing, i.e. the mass exchange elements in such area are constituted by structured or nonstructured packing. The remainder of the second part of the whole high-pressure column may be still filled by practical trays. In another variant of the invention, packing may be used in one or more additional sections of the high-pressure column or in the whole column.

[0023] The invention and further details to the invention are now described at an exemplary embodiment shown in the drawing.

Figure 1 presents a schematic drawing of a single-part high-pressure column according to prior art.

Figure 2 contains a process flow diagram of the overall process of an embodiment of the invention.

Figure 3 shows the details of the high-pressure column of the embodiment of Figure 2.

Figure 4 shows a dynamic backflow valve according to an aspect of the invention, and

Figures 5 and 6 details of such dynamic backflow valve.

[0024] In the embodiment of Figure 1, the rising vapor 85 inside the single-part high-pressure column is mixed with a recycle stream 34 comprising all the helium and neon from the feed air 11. By this way, the nitrogen product 17 withdrawn below the He-Ne retention section still contains considerable amounts of helium and neon which are lost for the (helium and neon) recovery. During the development of the invention, such fact has been discovered to be the reason for the limited neon recovery.

[0025] In the embodiment of the invention shown in Figure 2, atmospheric air 1 is filtered 2 and compressed in multi-stage main air compressor 3 with aftercooler 4 to a high air pressure of e.g. 12.5 bar.

[0026] Downstream a water separator 5, the compressed air 6 is fed to a purification unit 7 comprising two reversible adsorption vessels. The purified feed air 8 enters the main heat exchanger 9 to be cooled to distillation temperature. The cold feed air 10, 11 is fed to the first

part 12 of the high-pressure column comprising a second part 13 as well. The first and second parts 12, 13 are arranged in a common cylindrical vessel being divided by a gas-tight plate 14 in two tightly separated vessels. The first part contains the bulk of the trays (or, if packing is used, of the theoretical trays) of the high-pressure column, even though this fact is not clearly reflected in the drawings. In case that only classical trays are used as mass-exchange elements, about of the number of trays of both parts of the high-pressure column is placed in the first part 12.

[0027] The top gas of the first part 12 is withdrawn as a gaseous nitrogen transfer fraction 15 and introduced into the second part at the "third intermediate height" H3. (References beginning with H are shown in Figures 3 and 4 only.) The trays above are the He-Ne retention section forcing most of the helium and neon from the feed air into the top gas 16 of the second part and keeping it out of the nitrogen fraction 17 withdrawn from the high-pressure column (second part 13) at a "second intermediate height" H2 and recovered, after warming in main heat exchanger 9, as medium pressure nitrogen product with high-purity 18 (PGAN) with an oxygen content of e.g. 10 ppb and a pressure of e.g. 11.8 bar. A portion 19 may be withdrawn as seal gas.

[0028] From the bottom of the second part 13 of the high-pressure column, a liquid nitrogen reflux fraction 20 is withdrawn, optionally cooled in a subcooler 21 and fed as reflux to the low-pressure column. The cooled liquid nitrogen reflux fraction 22 is introduced via line 23 into the very top of the low-pressure column, being, in this particular embodiment, realized as split column comprising a first low-pressure column part 24 and a second low-pressure column part 25. The first part is arranged above the high-pressure column 12, 13 and contains a main condenser 26 in its bottom. The second part 25 is at least partially arranged side-by-side to the first part 24.

[0029] In the invention, the high-pressure column (12, 13) is generally operated at a pressure of 9 to 14.5 bar, in particular about 11,6 bar and the low-pressure column (24, 25) at 2.0 to 5.2 bar, in particular about 3.5 bar both pressures measured at the top of the respective column.

[0030] Nitrogen-enriched gas 27 is withdrawn from the top of the low-pressure column at a pressure of e.g. 3.7 bar and comprises e.g. 100 ppb oxygen. It is optionally warmed in the subcooler 21 and used as a recycle fraction, which is warmed in the main heat exchanger 9, compressed in a recycle compressor 31 with aftercooler, cooled again in the main heat exchanger 9 and introduced into the second part 13 of the high-pressure column at a first intermediate height H1 as the compressed recycle fraction 34. Another portion 82 of the top fraction may be sent to the atmosphere (ATM).

[0031] Main purpose of the main condenser 26 is to produce reflux liquid for both columns and rising vapor for the low-pressure column (first low-pressure column part 24). It works as a condenser-evaporator and, in the present case, as bath evaporator. The top gas 16, con-

taining nearly all He and Ne present in the feed air, is partially condensed in the main condenser 26, partially meaning here at least by 99 mol-%, i.e. nearly completely. It is still a two-phase fraction 35 which leaves the condensation space of the main condenser 26. A first part 80 of the liquid portion is fed to the second part of the high-pressure column as reflux; the second part 81 of the liquid portion is optionally cooled in subcooler 21 and the fed via line 23 to the second low-pressure column part as reflux. The gaseous portion 36 from the main condenser 26 is fed as a first He-Ne concentrate into a He-Ne-concentration column 37, which is operated in the usual manner and produces a second He-Ne concentrate 38 with Ne concentration of at least 57%. The Ne recovery is preferably more than 87 %, the He recovery is preferably more than 90%.

[0032] In order to provide reflux liquid for the first part 12 of the high-pressure column, a liquid nitrogen transfer fraction 39 is withdrawn from a fourth intermediate height H4 of the second section 13, and introduced into the top of the first part 12. The fourth intermediate height is equal to the third intermediate height or the distance between the fourth and third intermediate height is no more than five theoretical trays.

[0033] Liquid crude oxygen 41 from the bottom of the first part 12 is cooled in subcooler 21. The cooled crude oxygen 42 enters a argon section 43 for the production of liquid argon (LAR) and liquid ultra-high purity oxygen (UHPLOX), where it serves as heating and cooling medium for condensers and evaporators. It flows back to the main plant (second low-pressure column section 25) via the lines 44, 45, 46, 47. The internal operation of section 43 is the same as described in WO 2021204424 A2 and does not directly influence the He-Ne recovery according to the invention.

[0034] Likewise, the krypton and xenon recovery according to the embodiment does not directly depend on the above He-Ne recovery. The bottom liquid (taken from below Kr-Xe retention section 48) is fed to a usual Kr-Xe unit comprising an adsorber 50 and a Kr-Xe concentration column 51 to produce a Kr-Xe concentrate (Crude KrXe).

[0035] An oxygen (waste) product 52 is taken from above the Kr-Xe retention section 48 and mixed with a dilution stream 53 which may come from any suitable source, e.g. from the top or an intermediate height of the second part 25 of the low-pressure column (in particular waste nitrogen) or from the evaporation space of the argon condenser on top of the crude argon column in argon section 43. The mixture 54 is partially warmed in the main heat exchanger 9. The intermediate-temperature mixture 56 withdrawn from the main heat exchanger 9 is work-expanded in a mixed gas turbine 57 and then fully warmed in the main heat exchanger 9. The warm waste gas 55 may be used for regeneration purposes in the purification unit 7.

[0036] Figure 3 illustrates the operation of the two parts of the high-pressure column in some more detail. Con-

cerning the apparatus features, it is still quite schematic. In the first part 12 nearly the complete nitrogen-oxygen separation takes place. The top gas of the first part 12 withdrawn as a gaseous nitrogen transfer fraction 15 contains, e.g. less than 1 ppb oxygen, but all of the helium and neon contained in the feed air 11.

[0037] The invention avoids the presence of meaningful amounts of helium and neon at the withdrawal of the final product at the "second intermediate height" in the second part of the high-pressure column. The product is not taken anymore from rising gas of the first part, but from He-Ne depleted recycle stream 34. Rising up from the bottom H1 of the second part to the second intermediate height H2, remaining oxygen is removed, so that at H2 a nearly oxygen-free and nearly Ne-free product 20 can be split from the rising vapor and removed from the column.

[0038] In this particular embodiment, there is just one single practical tray between the second and third heights H2, H3.

[0039] The tray counts in the high-pressure column are as follows:

First part 12... 70 to 99 theoretical trays	
H1 - H2 8 to 15 theoretical trays	25
H2 - H3 1 to 3 separation stages, normally a single practical tray is sufficient	
H3 - H4 1 to 3 separation stages, normally a single practical tray is sufficient	
H4 - top 1 to 5 separation stages	30

[0040] Figure 4 shows a further detailed view of the split high-pressure column of Figures 2 and 3. This view is only partial. It depicts the immediate upper part of the first part 12 below the separation plate 14 plus the upper and lower ends of the upper part 13. The reference numbers are the same as in Figure 3.

[0041] In this embodiment a dynamic backflow valve comprises four identical pipes arranged in a square, two of them (93.1 and 93.2) being visible on the schematic drawing. The pipes 93.1 and 93.2 are arranged between the second and fourth intermediate heights H2 and H4. They bypass the two trays 90, 91 arranged between those intermediate heights H2 and H4.

[0042] The details of a pipe of the dynamic backflow valve are shown in Figures 5 and 6. A cup around the lower end enables a liquid seal closing the lower end of main pipe 93.3a during normal operation. Between tray 90 and the lower end of main pipe 93.2a, an auxiliary pipe 93.2c being a halfpipe is tightly connected to the cylindrical shell of the main pipe 93.2a. During normal operation, liquid from the tray 90 flows through auxiliary pipe 93.2c into the cup 93.2b and builds up the indicated liquid levels in the pipes 93.2c and 93.2a by the pressure difference between the different column heights.

[0043] When the pressure rapidly falls below tray 90, the liquid is quickly sucked from the pipes through the cup into the space outside the dynamic backflow valve.

A gas flow from top to bottom bypassing the trays 90, 91 is established compensating the inverse pressure difference and protecting the mechanics of the column, in particular the trays.

[0044] For safety reasons, there is a drain hole 93.2d in the cup 93.2b.

Claims

1. Process for cryogenic air separation in a distillation system for oxygen-nitrogen separation comprising a high-pressure column (12, 13) and a low-pressure column (24, 25) being in heat-exchange relationship via a main condenser (26) operating as condenser-evaporator,

- at least a portion of a compressed feed air stream (11) is introduced into the high-pressure column (12),
- bottom liquid is withdrawn from the high-pressure column (12) and introduced into the low-pressure column (25),
- at least a portion of the nitrogen-rich top gas (16) of the high-pressure column is at least partially condensed in the main condenser (26) against evaporating liquid oxygen from the bottom of the low-pressure column (24),
- in a nitrogen recycle, a nitrogen-enriched gas (27) is withdrawn from the low-pressure column and used as a recycle fraction which is compressed in a recycle compressor and introduced (34) into the high-pressure column (13) at a first intermediate height (H1),
- a nitrogen fraction (17) from a second intermediate height (H2) being higher than the first intermediate height (H1) is withdrawn from the high-pressure column and recovered as medium pressure nitrogen product (18),

characterized in that

- the high-pressure column is split into a first part (12) and a second part (13) placed in two tightly separated vessels,
- the compressed feed air stream (11) is introduced into the first part (12),
- the nitrogen-rich top gas (16) is withdrawn from the second part (13),
- the compressed recycle fraction (34) is introduced into the second part (13),
- the nitrogen fraction (17) recovered as medium pressure nitrogen product (18) is withdrawn from the second part (13),
- a gaseous nitrogen transfer fraction (15) is withdrawn from the top of the first part (12) and introduced into the second part (13) at a third intermediate height (H3) above the second in-

- intermediate height (H2),
- a liquid nitrogen transfer fraction (39) is withdrawn from a fourth intermediate height of the second section (H4), whereby the fourth intermediate height (H4) is equal to the third intermediate height (H3) or no more than five separation stages above the third intermediate height (H3),
 - the liquid nitrogen transfer fraction is introduced into the first section at its top,
 - a gaseous portion is separated from a two-phase fraction produced by the partial condensation of the nitrogen-rich top gas in the main condenser and used as a He-Ne preconcentrate intermediate product.
2. Process according to claim 1, whereby the liquid nitrogen transfer fraction is transferred by means of hydrostatic pressure and a control valve from the second part to the first part of the high-pressure column.
 3. Process according to claim 1 or 2, whereby a single tray is arranged between the second and the third intermediate heights (H2, H3), such tray being a slotted cups tray.
 4. Process according to any of the preceding claims, a liquid nitrogen reflux fraction from the high-pressure column is fed as reflux to the low-pressure column, the liquid nitrogen reflux fraction preferably withdrawn from the bottom of the second part of the high-pressure column.
 5. Process according to any of the preceding claims, whereby the second part (13) of the high-pressure column comprises a vertical dynamic backflow valve between the second intermediate height (H2) and the fourth intermediate height (H4) configured to enable a gas bypass around the trays in this area in case of gas backflow.
 6. Process according to claim 5, the dynamic backflow valve comprising a vertical pipe extending through the trays.
 7. Process according to claim 6, the dynamic backflow valve comprising a liquid seal, the liquid seal in particular comprising a cup enclosing the lower end of the pipe.
 8. Process according to claim 7, the dynamic backflow valve comprising a filling element configured to fill the cup with liquid, such filling element preferably comprising a halfpipe having a diameter lower than the diameter of the pipe and being attached to the side wall of the pipe, whereby the upper end of the halfpipe is configured to be filled with liquid from a tray and the lower end of the halfpipe dives into the interior of the cup.
 9. Process according to any of claims 1 to 4 the section in the second part (13) of the high-pressure column between the second and the fourth intermediate heights (H2, H3) being filled with packing.
 10. Process according to any of the preceding claims, whereby the high-pressure column contains mass exchange elements in the following amount(s): 70 to 99 theoretical trays in the first part (12) and /or 8 to 15 theoretical trays in the section between first and second intermediate heights (H1, H2) and /or 1 to 53 separation stages in the section between first and second intermediate heights (H3, H4) and /or 1 to 3 separation stages in the section between third and fourth intermediate heights (H3, H4) and /or H4 - top 1 to 5 separation stages in the section above the fourth intermediate stage (H4) up to the column top.
 11. Apparatus for cryogenic air separation comprising a distillation system for oxygen-nitrogen separation having a high-pressure column (12, 13), a low-pressure column (24, 25) and main condenser (26), the main condenser (26) providing in heat-exchange relationship and being configured to operate as condenser-evaporator,
 - a feed air line for introducing at least a portion of a compressed feed air stream (11) into the high-pressure column (12),
 - means for introducing bottom liquid from the high-pressure column (12) into the low-pressure column (25),
 - means for introducing at least a portion of the nitrogen-rich top gas (16) of the high-pressure column into a condensation space of the main condenser (26) to be is at least partially condensed against evaporating liquid oxygen from the bottom of the low-pressure column (24),
 - a nitrogen recycle for withdrawing a nitrogen-enriched gas (27) from the low-pressure column as a recycle fraction, for compressing the recycle fraction in a recycle compressor and introducing (34) the compressed recycle fraction into the high-pressure column (13) at a first intermediate height (H1),
 - a product line for withdrawing a nitrogen fraction (17) from the high-pressure column at a second intermediate height (H2) being higher than the first intermediate height (H1) and for recovering it as medium pressure nitrogen product

(18),

characterized in that

- the high-pressure column is split into a first part (12) and a second part (13) placed in two tightly separated vessels, 5
 - a feed air line being configured to introduce the compressed feed air into the first part (12),
 - the means for introducing at least a portion of the nitrogen-rich top gas (16) into the main condenser (26) is connected to the second part (13), 10
 - the compressed recycle fraction (34) is introduced into the second part (13),
 - the product line being connected to the second part (13), 15
 - a gaseous nitrogen transfer line is configured to withdraw a gaseous nitrogen transfer fraction (15) from the top of the first part (12) and to introduce it into the second part (13) at a third intermediate height (H3) above the second intermediate height (H2), 20
 - a liquid nitrogen transfer line is configured to withdraw a liquid nitrogen transfer fraction (39) from a fourth intermediate height of the second section (H4), whereby the fourth intermediate height (H4) is equal to the third intermediate height (H3) or no more than five separation stages above the third intermediate height (H3), 25
 - the liquid nitrogen transfer line is further configured to introduce the liquid nitrogen transfer fraction into the first section at its top, 30
 - means for separating a gaseous portion from a two-phase fraction produced by the partial condensation of the nitrogen-rich top gas in the main condenser and for using as a He-Ne pre-concentrate intermediate product. 35
- 12.** Apparatus according to claim 11, whereby the second part (13) of the high-pressure column comprises a vertical dynamic backflow valve between the second intermediate height (H2) and the fourth intermediate height (H4) configured to enable a gas bypass around the trays in this area in case of gas backflow. 40
- 13.** Apparatus according to any of claims 1 to 4 the section in the second part (13) of the high-pressure column between the second and the fourth intermediate heights (H2, H3) being filled with packing. 45

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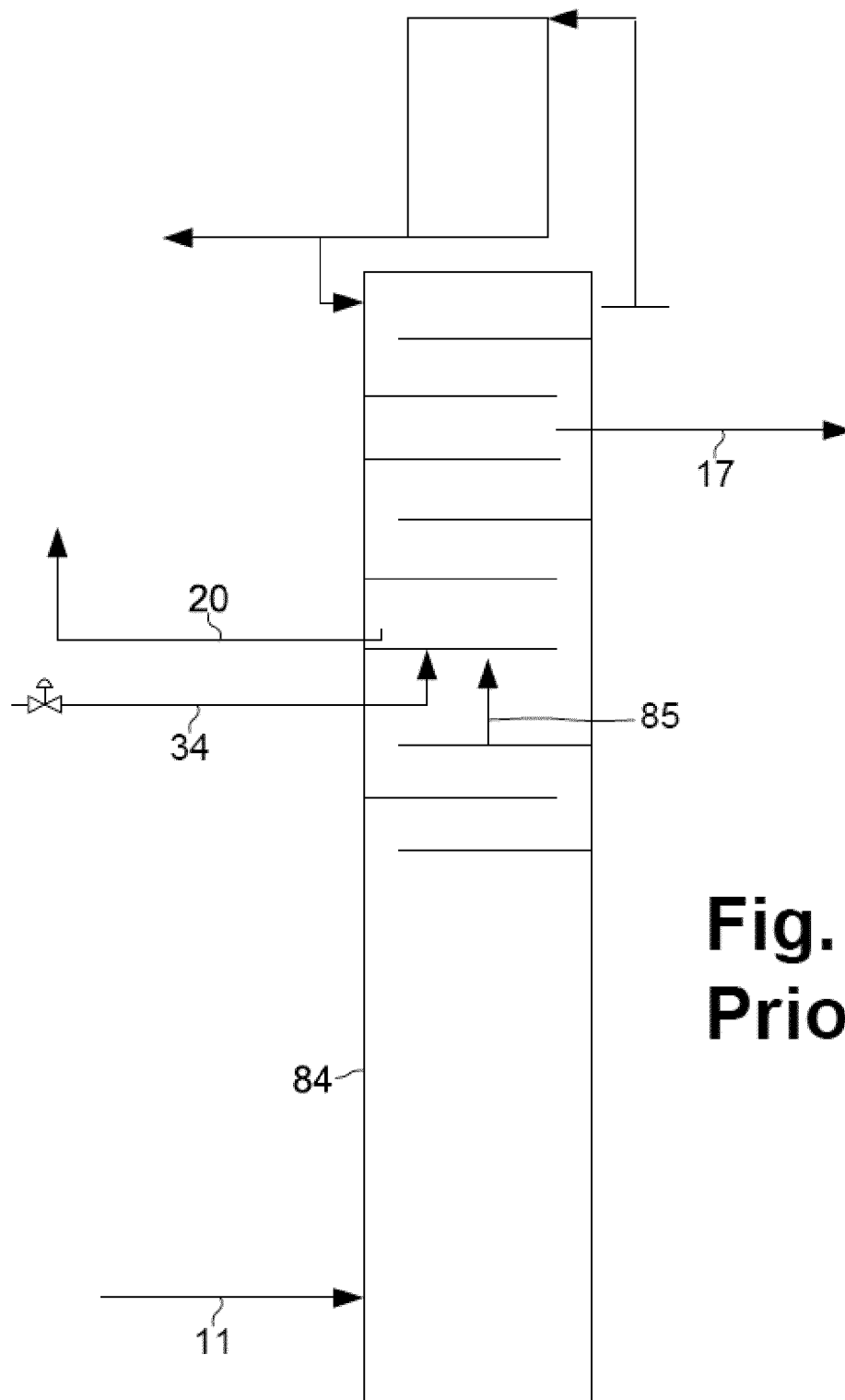
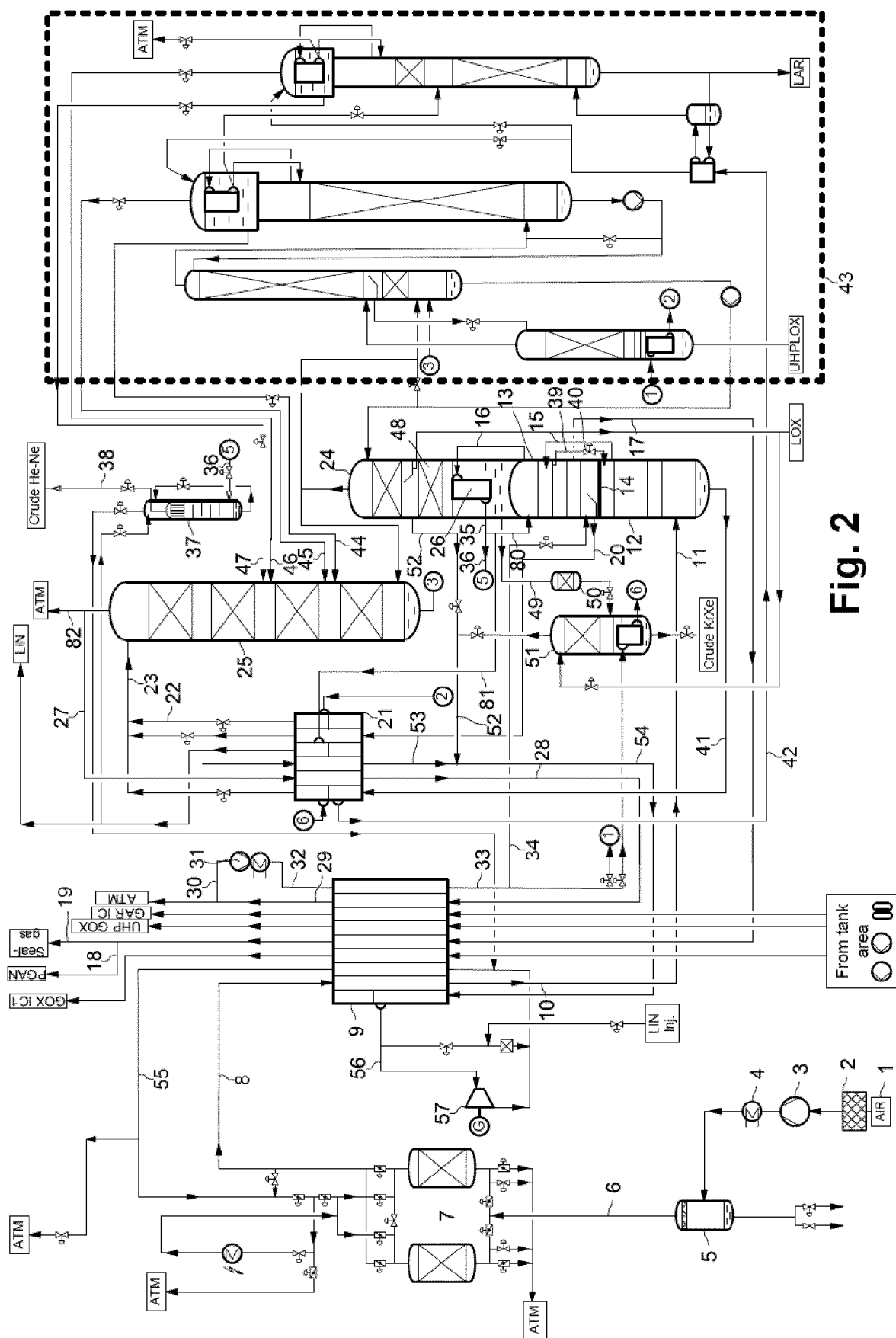


Fig. 1
Prior Art



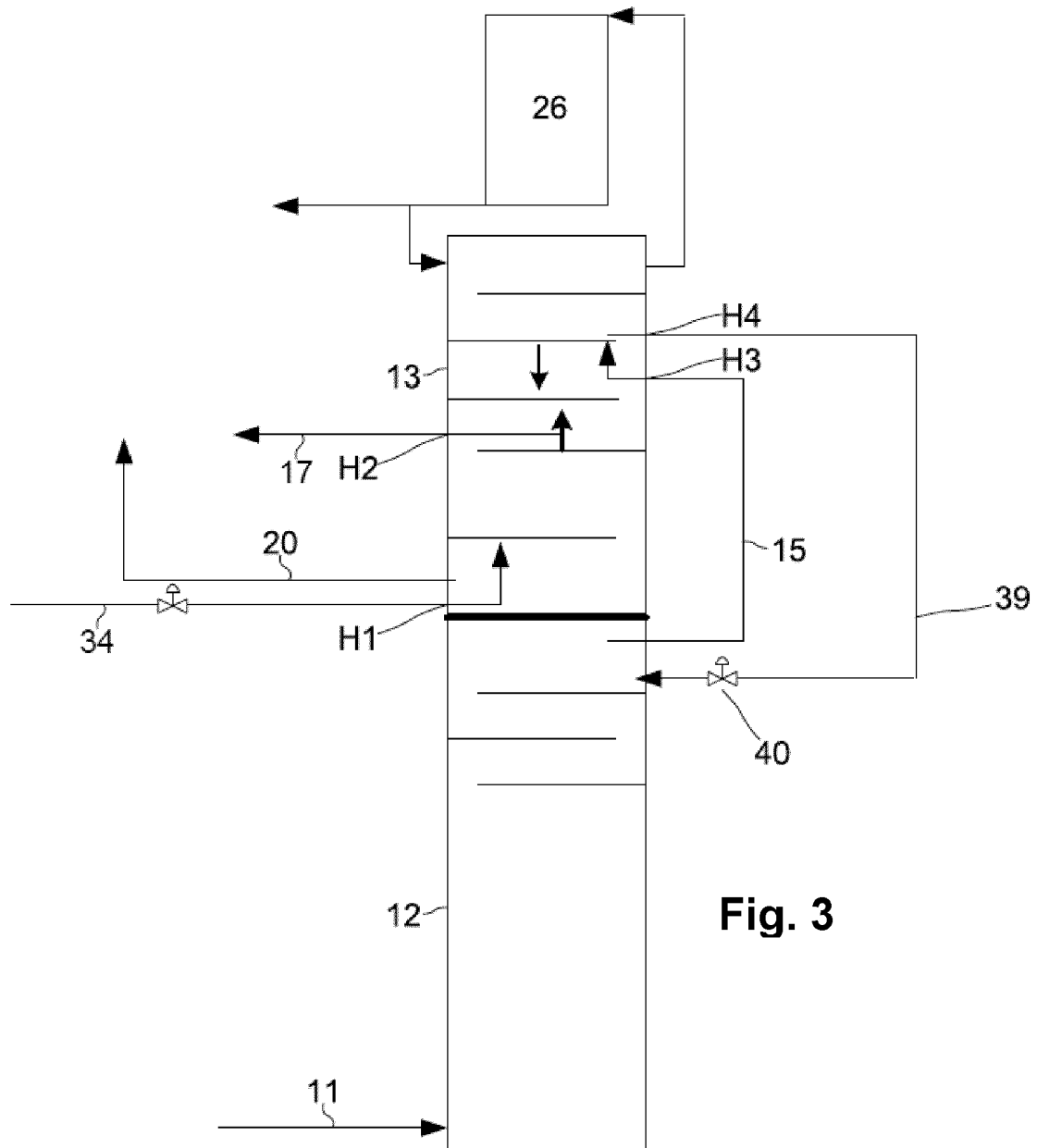
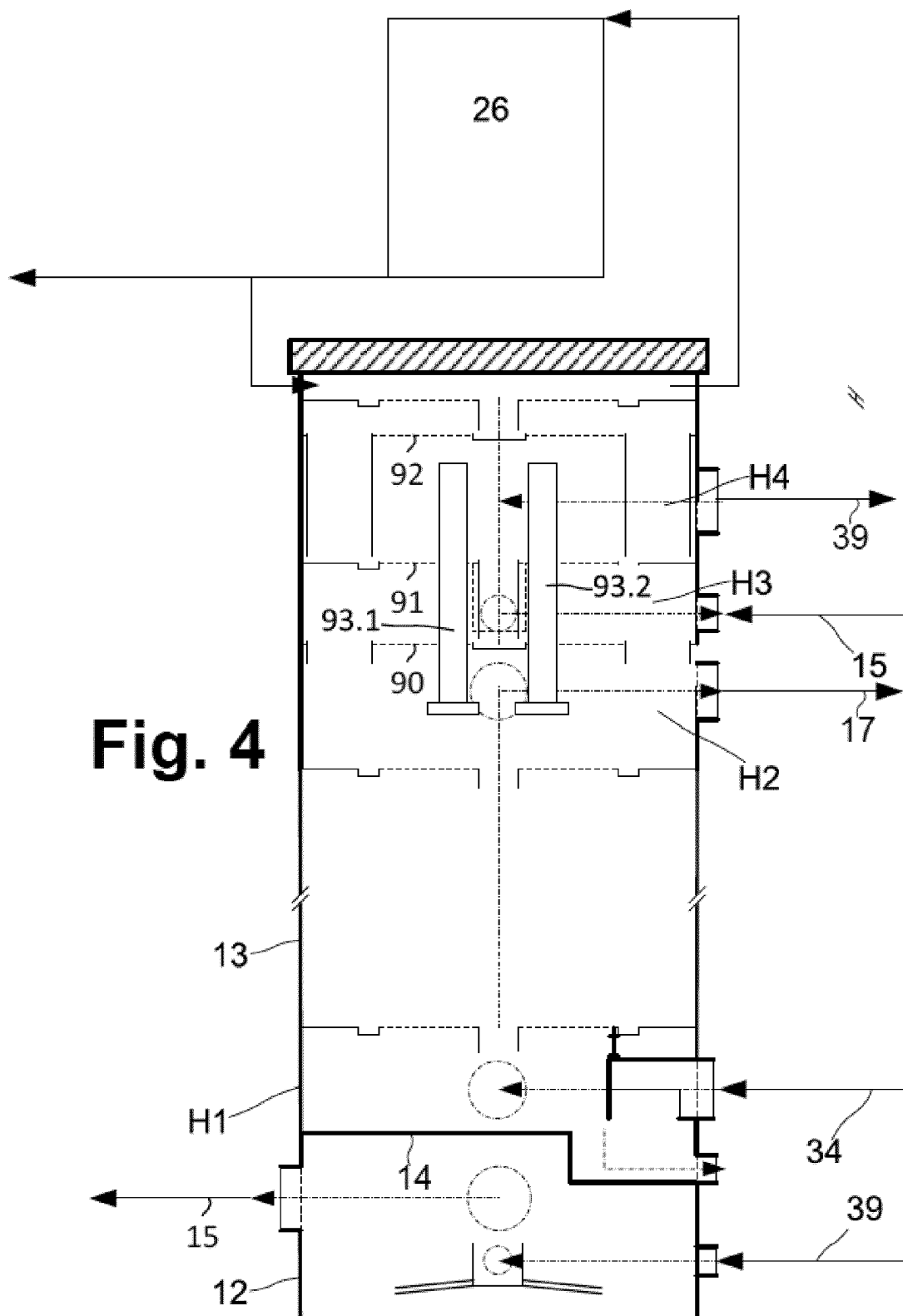


Fig. 3



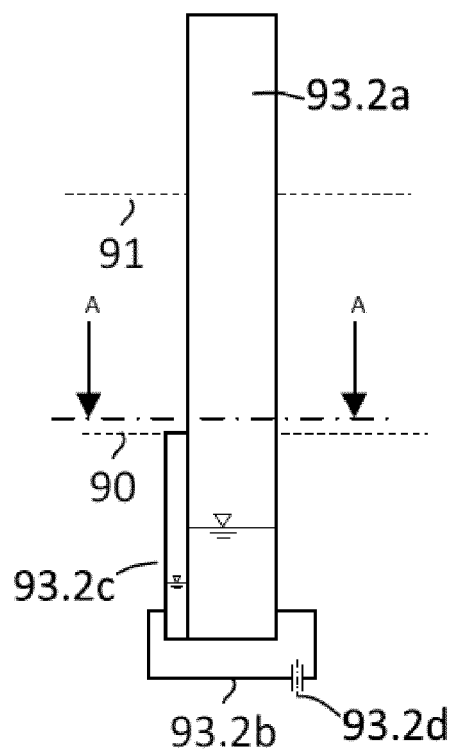


Fig. 5

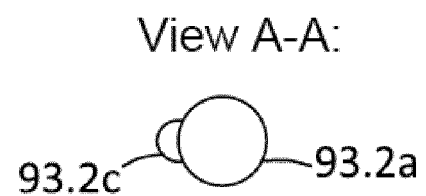


Fig. 6



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