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(54) **AIR SEPARATION UNIT**

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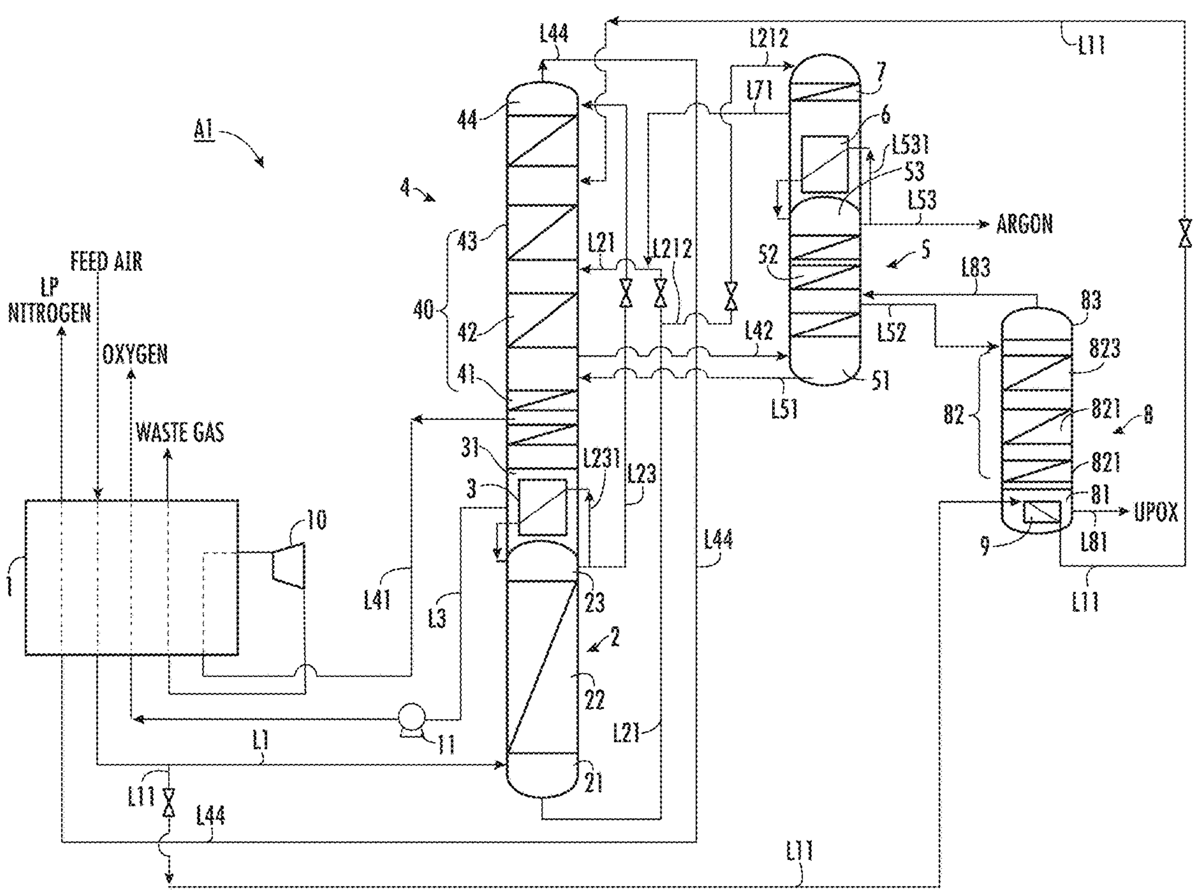
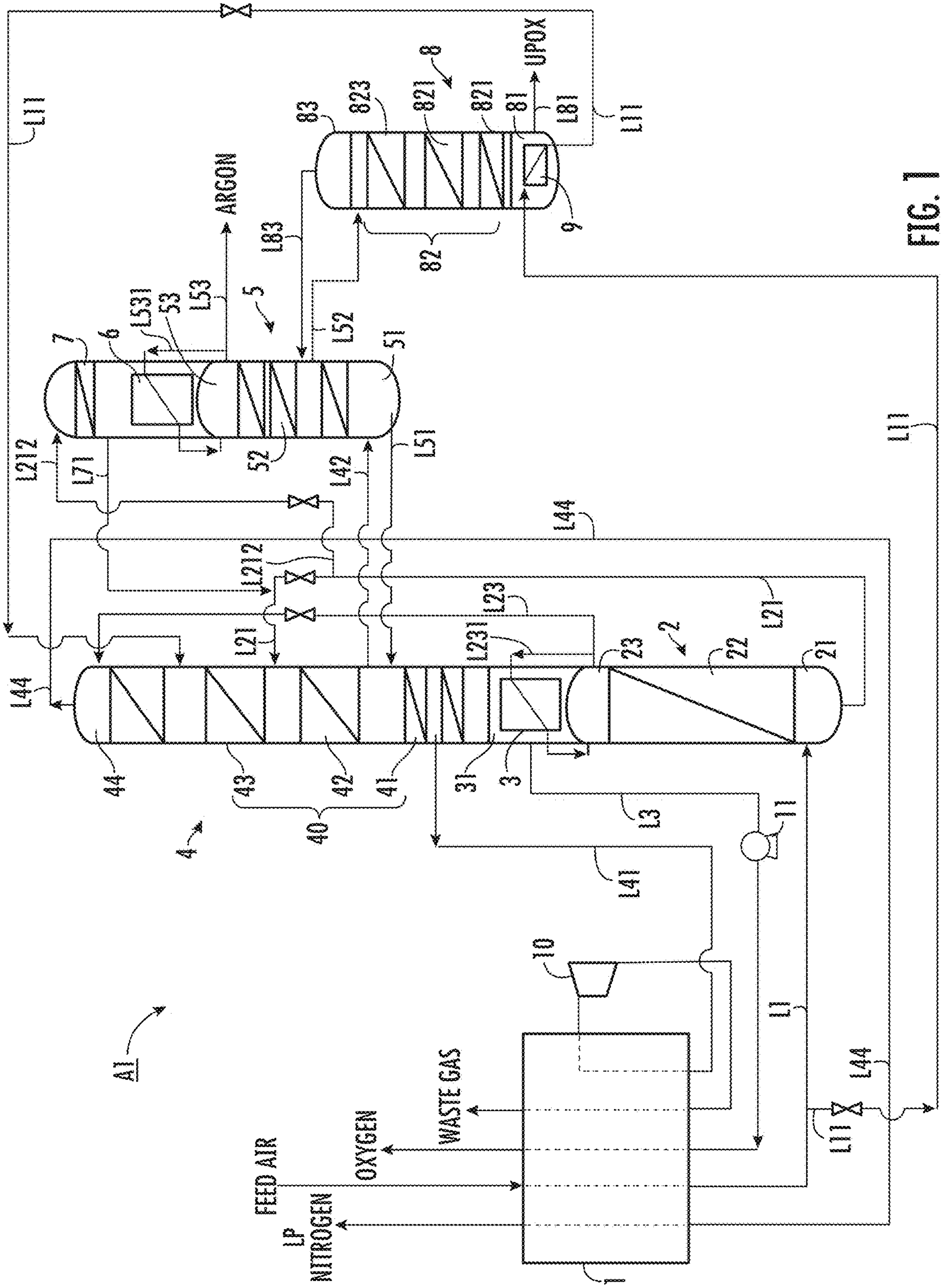
(57) **ABSTRACT**

An air separation unit may include: a main heat exchanger **1**, a first rectification column **2**, a nitrogen condenser **3**, a second rectification column **4**, a third rectification column **5**, a crude argon condenser **6**, a high-purity oxygen rectification column **8**, and a high-purity oxygen reboiler **9**. The air separation unit uses a portion of the feed air that has passed through the main heat exchanger **1** as a heat source in the high-purity oxygen reboiler **9**.




FEED AIR
LP NITROGEN
OXYGEN
WASTE GAS
ARGON
UPOX
A1
L1
L3
L11
L21
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L51
L52
L53
L531
L71
L81
L83
L212

FIG. 1

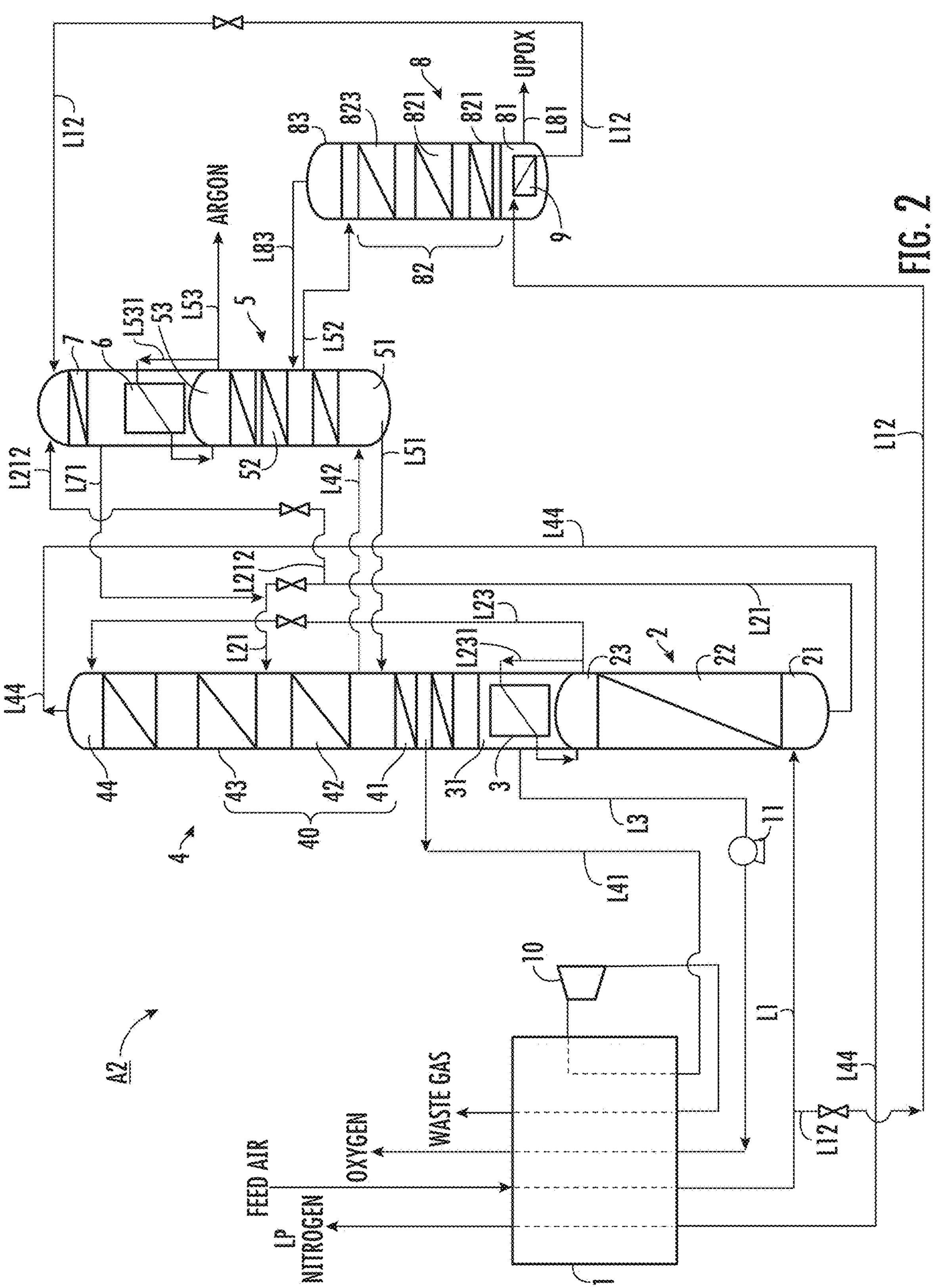


FIG. 2

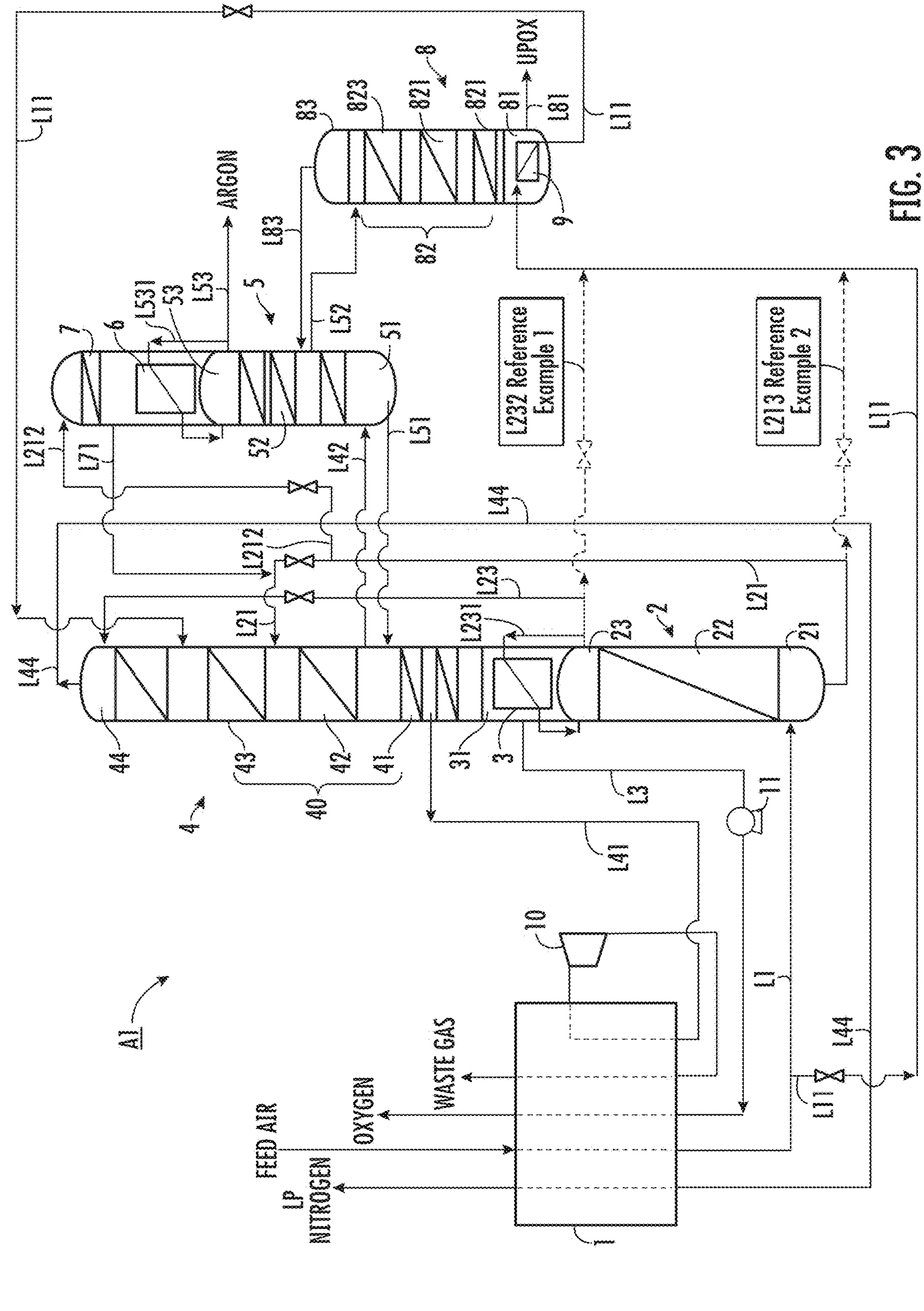
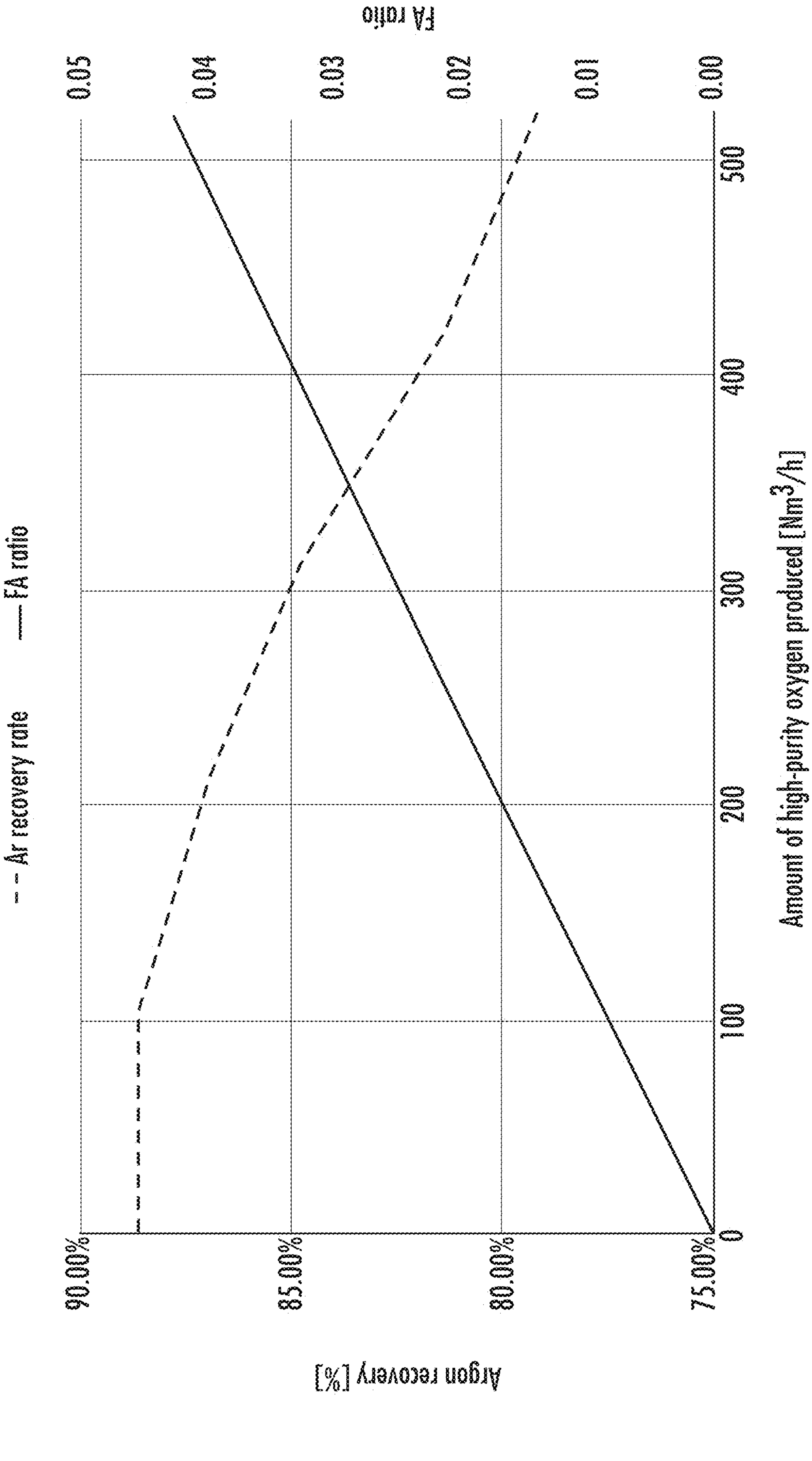

FEED AIR
LP NITROGEN
OXYGEN
WASTE GAS
ARGON
UPOX
L232 Reference Example 1
L213 Reference Example 2
A1

FIG. 3



- - Ar recovery rate
—— FA ratio
Argon recovery [%]
90.00%
85.00%
80.00%
75.00%
FA ratio
0.05
0.04
0.03
0.02
0.01
0.00
0
100
200
300
400
500
Amount of high-purity oxygen produced [Nm3/h]

FIG. 4

AIR SEPARATION UNIT

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of priority under 35 U.S.C. § 119 (a) and (b) to Japanese patent application No. JP2024-019946, filed Feb. 14, 2024, which is herein incorporated by reference in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates to an air separation unit for producing high-purity oxygen and argon, and a method for producing same

BACKGROUND OF THE INVENTION

[0003] There is high demand in the semiconductor industry, etc. for high-purity oxygen and argon that does not contain high-boiling-point components such as hydrocarbons. In order to produce this high-purity oxygen and argon, U.S. Pat. No. 5,049,173, for example, describes a cryogenic air separation unit including three rectification columns, namely a medium-pressure column, a low-pressure column and a crude argon column, for producing nitrogen, oxygen and argon. U.S. Pat. No. 5,049,173 describes a method in which an oxygen-rich liquid, which is obtained from an intermediate stage of the crude-argon column and has had the high-boiling-point components removed therefrom is concentrated using medium-pressure nitrogen gas as a reboiling source. However, when medium-pressure nitrogen gas is used for reboiling high-purity oxygen in the process of U.S. Pat. No. 5,049,173, there is a proportional reduction in the quantity of medium-pressure nitrogen gas supplied to the low-pressure column bottom portion. This leads to a reduction in a vapour stream in the low-pressure column, causing a marked reduction in the recovery of argon which is especially difficult to separate, and the drop in argon recovery rate (20-30%), for example, is a source of concern.

[0004] JP 7355978 describes a cryogenic air separation unit comprising: a first rectification column, a second rectification column, a third rectification column for rectifying argon, and a high-purity oxygen rectification column for rectifying ultra-high-purity oxygen. This cryogenic air separation unit employs recycled nitrogen as a reboiling source for high-purity oxygen. The use of recycled nitrogen complicates the design of a main heat exchanger and also necessitates a nitrogen compressor. Although the use of recycled nitrogen allows surplus energy to be input to the high-purity oxygen rectification column, this does not lead to an increase in argon recovery.

[0005] WO 2022/058043 indicates that recycled nitrogen is introduced into a main condenser (top portion of high-pressure column) and a reboiler for high-purity oxygen. Furthermore, the reboiler for high-purity oxygen is also capable of receiving recycled nitrogen or high-pressure nitrogen gas drawn from a high-pressure rectification column. After condensing, the liquefied recycled gas within an outlet of the reboiler for high-purity oxygen is delivered as a reflux liquid to either the high-pressure rectification column or the low-pressure rectification column.

SUMMARY OF THE INVENTION

[0006] In light of the situation above, at least one objective of the present disclosure lies in providing an air separation unit capable of recovering high-purity oxygen at a high yield without causing a drop in the amount of argon produced as compared with conventional technology, and a method for producing same.

[0007] A further objective of the present invention lies in providing an air separation unit capable of maintaining high recovery of argon and high-purity oxygen more efficiently than with conventional technology, without making an apparatus configuration more complicated than conventionally and also without increasing the number of apparatuses; and a method for producing same.

[0008] A method for producing argon and ultra-high-purity oxygen according to the present disclosure produces the argon and high-purity oxygen by using an air separation unit (A**1**, A**2**) comprising: a main heat exchanger (**1**), a first rectification column (medium-pressure rectification column) (**2**), a nitrogen condenser (**3**), a second rectification column (low-pressure rectification column) (**4**), a third rectification column (crude argon column) (**5**), a crude argon condenser (**6**), an upper rectification portion (**7**), a high-purity oxygen rectification column (**8**), and a high-purity oxygen reboiler (**9**), and a portion of the feed air is used as a heat source in the high-purity oxygen reboiler (**9**).

[0009] The feed air used as the heat source may be introduced into a rectification portion (**43**, **44**) of the second rectification column (**4**), or may be introduced into the upper rectification portion (**7**).

[0010] The air separation units (A**1**, A**2**) may comprise:

- **[0011]** a main heat exchanger (**1**) for subjecting feed air to heat exchange;
- **[0012]** a first rectification column (medium-pressure column) (**2**) to which feed air that has passed through the main heat exchanger (**1**) is introduced, said first rectification column (medium-pressure column) (**2**) comprising a first bottom portion (**21**) in which an oxygen-rich liquid is stored, a first rectification portion (**22**) for rectifying the feed air, and a first column top portion (**23**) which is disposed at an upper portion of the first rectification portion (**22**) and stores a first vaporized gas;
- **[0013]** a nitrogen condenser (**3**) which is disposed above the first column top portion (**23**) and condenses the first vaporized gas in the first column top portion (**23**);
- **[0014]** a second rectification column (**4**) comprising a second rectification portion (**41**, **42**, **43**) and a second column top portion (**44**) from which low-pressure nitrogen gas is drawn;
- **[0015]** a third rectification column (crude argon column) (**5**) for rectifying argon, said third rectification column (**5**) comprising a third bottom portion (**51**) to which is introduced a crude argon feed gas drawn from a first intermediate stage (**41**) of the second rectification portion (**40**) of the second rectification column (**4**), a third rectification portion (**52**) for rectifying the crude argon feed gas, and a third column top portion (**53**) in which argon is stored;
- **[0016]** a crude argon condenser (**6**) which is disposed above the third column top portion (**53**) and condenses the argon in the third column top portion (**53**);
- **[0017]** an upper rectification portion (**7**) disposed above the crude argon condenser (**6**);
- **[0018]** a high-purity oxygen rectification column (**8**) for rectifying high-purity oxygen, said high-purity oxygen

rectification column (**8**) comprising an oxygen column bottom portion (**81**) having a high-purity oxygen reboiler (**9**) disposed in a lower region thereof, an upper portion (**823**) of an oxygen rectification portion (**82**) to which is introduced an oxygen-rich liquid (intermediate-portion drawn liquid) drawn from an intermediate portion of the third rectification portion (**52**) of the third rectification column (**5**), and an oxygen column top portion (**83**) from which an oxygen vaporized gas is drawn to be returned to the intermediate portion of the third rectification portion (**52**) of the third rectification column (**5**); and

[0019] a feed air introduction line (L**1**) for causing the feed air to pass through the main heat exchanger (**1**), and introducing the feed air into the first bottom portion (**21**) of the first rectification column (**2**) or into a lower region of the first rectification portion (**22**), wherein

[0020] a portion of the feed air is used as a heat source in the high-purity oxygen reboiler (**9**).

[0021] The air separation units (A**1**, A**2**) may comprise: a first heat source introduction line (L**11**) which branches from the feed air introduction line (L**1**), is used for a heat source in the high-purity oxygen reboiler (**9**), and leads into the rectification portion (**43**, **44**) of the second rectification column; or a second heat source introduction line (L**12**) which leads into the upper rectification portion (**7**).

[0022] The air separation units (A**1**, A**2**) may comprise: an oxygen drawing line (L**3**) which draws oxygen from a refrigerant phase (**31**) in the nitrogen condenser (**3**), passes through the main heat exchanger (**1**) and extracts product oxygen; a liquid feed pump (**11**) which is disposed in the oxygen drawing line (L**3**) and pumps liquid oxygen; an argon-gas drawing line (L**53**) for extracting (gas-state and/or liquid-state) argon (which may become a product) from the third column top portion (**53**); an argon-containing liquid drawing line (L**51**) for introducing an argon-containing liquid drawn from the third bottom portion (**51**) into the first intermediate stage (**41**) of the second rectification portion (**40**) of the second rectification column (**4**); a vaporized-gas introduction line (L**71**) for introducing a vaporized gas drawn from an upper region of the crude argon condenser (**6**) into a second intermediate stage (**42**) of the second rectification portion (**40**); and a high-purity liquid-oxygen drawing line (L**81**) for extracting high-purity liquid oxygen (which becomes a product) from the oxygen column bottom portion (**81**).

[0023] The air separation unit may comprise: a product nitrogen gas line (L**44**) for introducing, into the main heat exchanger (**1**), low-pressure nitrogen gas drawn from the second column top portion (**44**) of the second rectification column (**4**); an expansion turbine (**10**) for expanding a gas which has been drawn from a lower part of the first intermediate stage (**41**) of the second rectification column (**4**), introduced into the main heat exchanger (**1**) and drawn from partway therethrough; and a waste gas line (L**41**) through which a gas drawn from the lower rectification portion (**41**) of the second rectification column (**4**) is introduced into the main heat exchanger (**1**), drawn from an intermediate stage thereof, worked by the expansion turbine (**10**), then once again passed through the main heat exchanger (**1**) and extracted as waste gas.

[0024] By virtue of the abovementioned configuration, an oxygen-rich liquid from which components having a higher boiling point than that of oxygen, such as hydrocarbons, have been removed is supplied to the high-purity oxygen rectification column (**8**) from a lower portion of the rectification portion of the third rectification column (crude argon column) (**5**), said oxygen-rich liquid is rectified and reboiled, vapour is returned to the third rectification column, and ultra-high-purity oxygen (UPOX) is recovered from the bottom portion (**81**).

[0025] A portion of the feed air cooled in the main heat exchanger (**1**) is utilized as a heat source in the ultra-high-purity oxygen reboiler (**9**) for rectifying ultra-high-purity oxygen.

[0026] The amount of feed air supplied is controlled in order to produce fixed-purity argon and high-purity oxygen, as required at a point of demand.

[0027] As a result, there is no need to provide a nitrogen compressor or an additional condenser, so the number of apparatuses can be reduced while high-purity oxygen can also be produced without causing a reduction in the amount of argon produced.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] Other features and advantages of the invention will be further disclosed in the description that follows, and in several embodiments provided as non-limiting examples in reference to the appended schematic drawings, in which:

[0029] FIG. **1** is a diagram illustrating an air separation unit according to embodiment 1.

[0030] FIG. **2** is a diagram illustrating an air separation unit according to embodiment 2.

[0031] FIG. **3** is a diagram illustrating an air separation unit according to an example and reference examples.

[0032] FIG. **4** is a chart showing a relationship between amount of high-purity oxygen produced and argon recovery rate according to the example.

DETAILED DESCRIPTION OF THE INVENTION

[0033] Several embodiments of the present invention will be described below. The embodiments described below illustrate an example of the present invention. The present invention is in no way limited by the following embodiments, and also includes a number of variant modes which may be implemented without altering the essence of the present invention. It should be noted that not all of the components described below are essential components of the present invention.

Embodiment 1

[0034] An air separation unit A**1** according to embodiment 1 will be described with the aid of FIG. **1**.

[0035] An air separation unit **100** has a basic configuration comprising, among other things: a main heat exchanger **1**, a first rectification column (medium-pressure column) **2**, a nitrogen condenser **3**, a second rectification column (low-pressure column) **4**, a third rectification column (crude argon column) **5**, a crude argon condenser **6**, an upper rectification portion **7**, a high-purity oxygen rectification column **8**, and a high-purity oxygen reboiler **9**.

[0036] Feed air passes through the main heat exchanger **1** via a feed air introduction line L**1** and is supplied to a first bottom portion **21** or a first rectification portion **22** of the first rectification column **2**.

[0037] The first rectification column **2** comprises: a first bottom portion **21** in which an oxygen-rich liquid is stored; a first rectification portion **22** for rectifying the feed air; and a first column top portion **23** which is disposed at an upper portion of the first rectification portion **22** and stores a first vaporized gas.

[0038] The nitrogen condenser **3** is disposed above the first column top portion **23**. The nitrogen condenser **3** condenses the first vaporized gas in the first column top portion **23**.

[0039] The second rectification column **4** is disposed above the nitrogen condenser **3**. The second rectification column **4** comprises: a second rectification portion **40** (**41**, **42**, **43**); and a second column top portion **44** from which low-pressure nitrogen gas is drawn.

[0040] The third rectification column **5** rectifies argon. The third rectification column **5** comprises: a third column bottom portion **51** to which is introduced a crude argon feed gas drawn from the intermediate portion of the second rectification portion **40**, preferably from a lower stage than a central position of the second rectification portion **40**, of the second rectification column **4**; a third rectification portion **52** for rectifying the crude argon feed gas; and a third column top portion **53** in which (gas-state and/or liquid-state) argon is stored.

[0041] The crude argon condenser **6** is disposed above the third column top portion **53**. The crude argon condenser **6** condenses the (gas-state and/or liquid-state) argon in the third column top portion **53**.

[0042] The high-purity oxygen rectification column **8** rectifies ultra-high-purity oxygen. The high-purity oxygen rectification column **8** comprises: an oxygen column bottom portion **81** having a high-purity oxygen reboiler **9** disposed in a lower region thereof; an oxygen rectification portion **82** to which is introduced an oxygen-rich liquid (intermediate-portion drawn liquid) drawn from an intermediate portion of the third rectification portion **52** of the third rectification column **5**; and an oxygen column top portion **83** from which an oxygen vaporized gas is drawn to be returned to the intermediate portion of the third rectification portion **52** of the third rectification column **5**.

[0043] A first oxygen-rich-liquid introduction line L**21** is a line for introducing, into the intermediate portion **42** of the second rectification portion **40** (preferably into a higher stage than the central position of the second rectification portion **40**), the oxygen-rich liquid drawn from the first bottom portion **21** of the first rectification column **2**.

[0044] A first branch line L**212** branching from the first oxygen-rich liquid introduction line L**21** is a line for introducing the oxygen-rich liquid into the upper rectification portion **7**.

[0045] A first vaporized gas introduction line L**23** is a line for introducing, into the second column top portion **44** of the second rectification column **4**, the first vaporized gas drawn from the first column top portion **23** of the first rectification column **2**.

[0046] A portion of the first vaporized gas is introduced as a heat source in the nitrogen condenser **3** via a branch line L**231** branching from the first vaporized gas introduction line L**23**, the heat is released from said portion of the first vaporized gas to cool said first vaporized gas, and it is then returned to the first column top portion **23**.

[0047] An oxygen drawing line L**3** is a line for causing (gas-state and/or liquid-state) oxygen drawn from a refrigerant phase **31** in the nitrogen condenser **3** to pass through the main heat exchanger **1**, and for extracting the oxygen as product oxygen. A liquid feed pump **11** is disposed in the oxygen drawing line L**3** and feeds the liquid oxygen.

[0048] An intermediate-portion drawing line L**42** is a line for introducing, into the third column bottom portion **51** of the third rectification column **5**, the crude argon feed gas drawn from the intermediate portion **42** of the second rectification portion **40**, preferably from a lower stage than the central position of the second rectification portion **40**.

[0049] A product nitrogen gas line L**44** is a line for introducing, into the main heat exchanger **1**, low-pressure nitrogen gas drawn from the second column top portion **44** of the second rectification column **4**, and extracting this nitrogen gas as a product.

[0050] An expansion turbine **10** expands a gas which has been drawn from the lower part of the first intermediate stage **41** of the second rectification column **4**, introduced into the main heat exchanger **1** and drawn from partway therethrough. Expansion of the gas by the expansion turbine **10** and the generation of cold makes it possible to maintain a cold balance in the apparatus while making use of process gas.

[0051] A waste gas line L**41** is a line through which a gas drawn from the lower rectification portion **41** of the second rectification column **4** is introduced into the main heat exchanger **1**, drawn from an intermediate stage thereof, worked by the expansion turbine **10**, then once again passed through the main heat exchanger **1** and extracted as waste gas.

[0052] An argon-containing-liquid drawing line L**51** is a line for introducing an argon-containing liquid drawn from the third column bottom portion **51** into the first intermediate stage **41** of the second rectification portion **40**, preferably into a lower stage than the central position of the second rectification portion **40**, of the second rectification column **4**.

[0053] An intermediate-portion drawing line L**52** is a line for introducing, into an upper portion of the oxygen rectification portion **82**, preferably into a higher stage than a central position of the oxygen rectification portion **82**, an oxygen-rich liquid (intermediate-portion drawn liquid) drawn from the intermediate portion of the third rectification portion **52**, preferably from a lower stage than a central position of the third rectification portion **52**.

[0054] An argon-gas drawing line L**53** is a line for extracting (gas-state and/or liquid-state) argon from the third column top portion **53**.

[0055] The (gas-state and/or liquid-state) argon passes through a branch circulation line L**531** branching from the argon-gas drawing line L**53**, is introduced as a heat source in the crude argon condenser **6**, heat is released therefrom and said argon gas is cooled and liquefied, then returned to the third column top portion **53**.

[0056] A second-condenser vaporized-gas introduction line L**71** is a line for introducing a second-condenser vaporized gas drawn from above the crude argon condenser **6** or from the upper rectification portion **7**, into the second intermediate stage **42** of the second rectification portion **40**, or is a line for introducing the second-condenser vaporized gas into the intermediate portion **42** after merging with the first oxygen-rich liquid introduction line L**21**.

[0057] A high-purity liquid-oxygen drawing line L**81** is a line for extracting high-purity liquid oxygen from the oxygen column bottom portion **81**.

[0058] An oxygen vaporized-gas drawing line L**83** is a line for feeding oxygen vaporized gas drawn from the oxygen column top portion **83** to a higher stage than a drawing position of the intermediate-portion drawing line L**52** from the rectification portion **52** of the third rectification column **5**.

[0059] The high-purity oxygen reboiler **9** is arranged in the oxygen column bottom portion **81** in the lower region of the high-purity oxygen rectification column **8**. A portion of the feed air that has passed through the main heat exchanger **1** is utilized as a heat source in the high-purity oxygen reboiler **9**.

[0060] A first heat source introduction line L**11** is a line which branches from the feed air introduction line L**1**, is used for a heat source in the high-purity oxygen reboiler **9**, and leads into the intermediate stage or upper portion (**43** or **44**) of the rectification portion of the second rectification column **4**.

Embodiment 2

[0061] An air separation unit A**2** according to embodiment 2 will be described with the aid of FIG. **2**. A description will be given for components which are different from those in FIG. **1** relating to embodiment 1, and descriptions of components which are the same will be omitted or simplified.

[0062] A second heat source introduction line L**12** is a line which branches from the feed air introduction line L**1**, is used for a heat source in the high-purity oxygen reboiler **9**, and leads into the upper rectification portion **7**.

Example

[0063] FIG. **3** shows an example (embodiment 1) and reference examples 1 and 2. As an alternative to embodiment 1, according to reference example 1, a portion of the first vaporized gas is introduced as a heat source in the high-purity oxygen reboiler **9** through a branch line L**232** branching from the first vaporized gas introduction line L**23**. According to reference example 2, a portion of the oxygen-rich liquid is introduced as a heat source in the high-purity oxygen reboiler **9** through a second branch line L**213** branching from the first oxygen-rich liquid introduction line L**21**.

[0064] In order to generate the same amount (1 mol) of high-purity oxygen, quantities supplied as a heat source in the high-purity oxygen reboiler (**9**) were as follows. That is to say, using the feed air as a heat source is more efficient than other means.

Example (portion of the feed air)	1:10
Reference Example 1 (portion of the nitrogen gas)	1:140
Reference Example 2 (portion of the oxygen-rich liquid)	1:375

[0065] A nitrogen generating apparatus according to embodiment 1 was designed with a capacity of 65 kNm^3/h. There is a reduction in the amount of argon produced when there is an increase in the amount of high-purity oxygen produced. According to this embodiment 1, it is possible to maintain the amount of high-purity oxygen generated while also suppressing a reduction in the amount of argon generated. Table 1 and FIG. **4** show the relationship between the amount of high-purity oxygen produced and the argon recovery rate. For example, when high-purity oxygen (generated oxygen content purity 99.0% or greater) at a fixed quantity in a range of 300-400 Nm^3/h was produced, the argon recovery rate fell from approximately 88.58% to approximately 82-85%. This example makes it possible to keep the argon recovery loss down to around 5%, as compared with reference examples 1 and 2.

TABLE 1

Amount of high-purity oxygen produced (Nm^3/h)	Argon recovery rate (A)	Argon production reduction rate (B)	FA ratio
0	88.58%	—	0
104.4	88.57%	0.01%	0.88%
212.2	86.95%	1.63%	1.77%
311.8	84.78%	3.80%	2.58%
421.1	81.36%	7.22%	3.45%
523.4	79.15%	9.43%	4.27%

[0066] Although not explicitly stated, pressure regulators and flow rate controllers, etc. may be provided in each line in order to regulate pressure and regulate flow.

[0067] While the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications, and variations will be apparent to those skilled in the art in light of the foregoing description. Accordingly, it is intended to embrace all such alternatives, modifications, and variations as fall within the spirit and broad scope of the appended claims. The present invention may suitably comprise, consist or consist essentially of the elements disclosed and may be practiced in the absence of an element not disclosed. Furthermore, if there is language referring to order, such as first and second, it should be understood in an exemplary sense and not in a limiting sense. For example, it can be recognized by those skilled in the art that certain steps can be combined into a single step.

[0068] The singular forms "a", "an" and "the" include plural referents, unless the context clearly dictates otherwise.

[0069] "Comprising" in a claim is an open transitional term which means the subsequently identified claim elements are a nonexclusive listing (i.e., anything else may be additionally included and remain within the scope of "comprising"). "Comprising" as used herein may be replaced by the more limited transitional terms "consisting essentially of" and "consisting of" unless otherwise indicated herein.

[0070] "Providing" in a claim is defined to mean furnishing, supplying, making available, or preparing something. The step may be performed by any actor in the absence of express language in the claim to the contrary.

[0071] Optional or optionally means that the subsequently described event or circumstances may or may not occur. The description includes instances where the event or circumstance occurs and instances where it does not occur.

[0072] Ranges may be expressed herein as from about one particular value, and/or to about another particular value. When such a range is expressed, it is to be understood that another embodiment is from the one particular value and/or to the other particular value, along with all combinations within said range.

KEY TO SYMBOLS

[0073] **1** Main heat exchanger

[0074] **2** First rectification column

[0075] **3** Nitrogen condenser

[0076] **4** Second rectification column
[0077] **5** Third rectification column
[0078] **6** Crude argon condenser
[0079] **7** Upper rectification portion
[0080] **8** High-purity oxygen condenser
[0081] **9** Ultra-high-purity oxygen reboiler
[0082] **10** Expansion turbine
[0083] **11** Liquid feed pump

1. An air separation unit comprising:
a main heat exchanger configured to subject feed air to heat exchange;
a first rectification column to which feed air that has passed through the main heat exchanger is introduced, said first rectification column comprising a first bottom portion in which an oxygen-rich liquid is stored, a first rectification portion for rectifying the feed air, and a first column top portion which is disposed at an upper portion of the first rectification portion and stores a first vaporized gas;
a nitrogen condenser, which is disposed above the first column top portion, configured to condense the first vaporized gas in the first column top portion;
a second rectification column comprising a second rectification portion and a second column top portion from which low-pressure nitrogen gas is drawn;
a third rectification column for rectifying argon, said third rectification column comprising a third bottom portion to which is introduced a crude argon feed gas drawn from an intermediate portion of the second rectification portion of the second rectification column, a third rectification portion for rectifying the crude argon feed gas, and a third column top portion in which argon is stored;
a crude argon condenser, which is disposed above the third column top portion, configured to condense the argon in the third column top portion;
a high-purity oxygen rectification column for rectifying high-purity oxygen, said high-purity oxygen rectification column comprising an oxygen column bottom portion having a high-purity oxygen reboiler disposed in a lower region thereof, an upper portion of an oxygen rectification portion to which is introduced an oxygen-rich liquid drawn from an intermediate portion of the third rectification portion of the third rectification column, and an oxygen column top portion from which an oxygen vaporized gas is drawn to be returned to the intermediate portion of the third rectification portion of the third rectification column; and
a feed air introduction line configured to cause the feed air to pass through the main heat exchanger, and introduce the feed air into the first bottom portion of the first rectification column or into a lower region of the first rectification portion, wherein
a portion of the feed air is used as a heat source in the high-purity oxygen reboiler.

2. The air separation unit according to claim **1**, further comprising an upper rectification portion disposed above the crude argon condenser, wherein a portion of an oxygen-rich liquid introduced from the first bottom portion of the first rectification column is introduced into an upper portion of the upper rectification portion and oxygen in the oxygen-rich liquid is rectified.

3. The air separation unit according to claim **1**, further comprising a first heat source introduction line which branches from the feed air introduction line, is used for a heat source in the high-purity oxygen reboiler, and leads into a rectification portion of the second rectification column, wherein the feed air which is used as a heat source in the high-purity oxygen reboiler is introduced into an intermediate portion of the second rectification portion of the second rectification column.

4. The air separation unit according to claim **2**, further comprising a second heat source introduction line which branches from the feed air introduction line, is used for a heat source in the high-purity oxygen reboiler, and leads into an upper region of the upper rectification portion, wherein the feed air which is used as a heat source in the high-purity oxygen reboiler is introduced into the upper rectification portion.

5. A method for producing argon and ultra-high-purity oxygen, the method comprising the steps of:
providing the air separation unit of claim **1**; and
using a portion of the feed air, which has passed through the main heat exchanger, as a heat source in the high-purity oxygen reboiler.

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