



(11) **EP 4 464 961 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
20.11.2024 Bulletin 2024/47

(51) International Patent Classification (IPC):
F25J 1/00 (2006.01)

(21) Application number: **24174443.2**

(52) Cooperative Patent Classification (CPC):
F25J 3/04878; F25J 3/0409; F25J 3/04303;
F25J 3/04321; F25J 3/04412; F25J 3/04678;
F25J 3/04769; F25J 3/04812; F25J 3/04963;
F25J 2200/20; F25J 2235/50; F25J 2240/46;
F25J 2245/50

(22) Date of filing: **07.05.2024**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL
NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

(72) Inventors:
• **HIROSE, Kenji**
KOBE, 651-0087 (JP)
• **DAISUKE, Nagata**
KOBE, 651-0087 (JP)
• **CHIAWEEFERN, Jennifer**
94503 CHAMPIGNY SUR MARNE (FR)

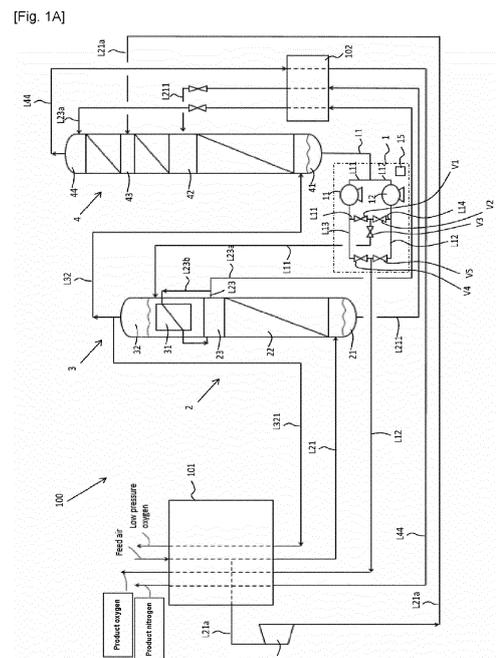
(30) Priority: **12.05.2023 JP 2023079342**

(74) Representative: **Air Liquide**
L'Air Liquide S.A.
Direction de la Propriété Intellectuelle
75, Quai d'Orsay
75321 Paris Cedex 07 (FR)

(71) Applicant: **L'AIR LIQUIDE, SOCIETE ANONYME**
POUR L'ETUDE ET
L'EXPLOITATION DES PROCEDES GEORGES
CLAUDE
75007 Paris (FR)

(54) **AIR SEPARATION UNIT AND PROCESS FOR PRODUCING A PRODUCT GAS FROM FEED AIR BY CRYOGENIC DISTILLATION**

(57) An air separation unit comprises a first rectification column (2), having a top condenser (31) and a second rectification column (4) placed side by side, a heat exchanger (101), a first pump (11) and a second pump (12) connected in parallel, the first pump being capable of producing liquid at a first liquid pressure and the second pump being capable of producing liquid at a second liquid pressure, higher than the first pressure, each pump having an inlet connected to the second column, a first outlet of the first pump being connected to a first outlet conduit (L13), a second outlet of the second pump being connected to a second outlet conduit (L12), the first and second outlet conduits being connected to the condenser section .



EP 4 464 961 A1

Description

[0001] The present disclosure relates to an air separation unit and to an air separation process for producing a product gas (e.g., nitrogen, argon or oxygen) from feed air by cryogenic distillation.

Background Art

[0002] Patent Document 1 describes a pump process in a cryogenic air separation unit, where the same pump is used for different purposes in view of the need to reduce equipment costs. Patent Document 2 indicates that two or more pumps are provided from the point of view of reliable pump operations, and when an abnormal mode has been detected in one pump, the pump in which the abnormal mode has been detected is stopped, while output of the other is increased. Patent Document 3 describes a liquid oxygen pump for supplying liquid oxygen for the production of product oxygen gas, and a liquid oxygen pump for supplying liquid oxygen to be used as a refrigerant in a crude argon condenser.

Prior Art Documents**[0003]**

Patent Document 1 = JP 6257656 B2
 Patent Document 2 = JP 5800620 B2
 Patent Document 3 = WO 2021/230911 A1

Problems to be Solved by the Invention

[0004] It is desirable for multiple pumps to be provided from the point of view of reliable pump operations, as in Patent Document 2, so that continuous operation is possible even when there is a fault. On the other hand, providing pumps for different purposes not only leads to an increase in equipment costs because of the need to install a large amount of equipment, but also leads to more pipes and a larger installation area, hence greater construction costs and worse economics. Accordingly, there is a need to develop a highly reliable, low-cost pump configuration.

[0005] Conventionally, it is simple to devise a redundant pump configuration, in which multiple pressure values for each purpose are designed as operating points, and the pumps operate at the respective pressure values according to the purpose. In Patent Document 3, for example, a cryogenic air separation apparatus may have a configuration comprising both a process pump for supplying a reflux liquid to a rectification column and a vaporizer, and a product pump for delivering a product liquefied gas. In this case, the process pump needs power for a high/low difference at a liquid supply source and supply destination. The product pump needs power for a supply pressure, in addition to a high/low difference at the liquid supply source and supply destination or vaporization point. The required power per unit flow rate of the product pump tends to be greater than that of the process pump.

[0006] In a redundant pump configuration, however, the pump design point is based on maximum pressure and flow rate, and the pumps can only be operated at a lower pressure or a lower throughput than the design point during steady operation, so that continuous operation is still possible in case there is a fault in one piece of equipment. Because the pumps have an operable range, if the demand for high-pressure purposes falls below a lower limit of the pump throughput, this produces energy loss in proportion to the difference between the demand for high-pressure purposes and the lower limit of the pump throughput.

[0007] Furthermore, when a single pump serves as both the process pump and the product pump, as in Patent Document 1, an outlet pressure of the pump needs to conform to product purposes, which causes an overpressure of the reflux liquid when the pump serves as the process pump. The energy of this overpressure produces heat penetration, which therefore leads to a loss of cold heat in a cryogenic air separation unit. A low-temperature refrigerant such as liquefied nitrogen is separately needed to replenish the loss of cold heat, and this increases costs. Furthermore, Patent Document 2 merely indicates that either one of the pumps is caused to function as a backup pump when there is an abnormality.

[0008] The objective of the present disclosure lies in providing a liquefied gas supply system for supplying liquefied gas for two purposes, which reduces power consumption by pumps and, as a result, reduces heat input to a cryogenic air separation process so that thermal efficiency can be improved, by virtue of a pump control method that minimises energy loss, and also in providing an air separation unit comprising the liquefied gas supply system.

Means for Solving the Problems

[0009] According to an object of the invention, there is provided an air separation unit comprising a first rectification

column having an operating pressure which is a first pressure, a second rectification column having an operating pressure which is a second pressure, less than the first pressure, the first rectification column having a top condenser enclosed within a condenser section having an operating pressure which is the second pressure, a supply source which is a lower region of the second rectification column, the first rectification column and the second rectification column being placed side by side, a heat exchanger, means for sending feed air to the heat exchanger to be cooled and from the heat exchanger to the first rectification column, means for sending a gas from the condenser section to the bottom of the second rectification columns, a conduit for sending the gas removed from the top of the second rectification column to the heat exchanger to be warmed, a first pump and a second pump connected in parallel, the first pump being capable of producing liquid at a first liquid pressure and the second pump being capable of producing liquid at a second liquid pressure, higher than the first pressure, preferably at least 5 bars higher than the first pressure, each pump having an inlet connected to the supply source, a first outlet of the first pump being connected to a first outlet conduit, a second outlet of the second pump being connected to a second outlet conduit, the first outlet conduit being connected at a first removal point via a first valve to the condenser section and the second outlet conduit being connected at a second removal point via a second valve to the condenser section, the first outlet conduit being optionally connected at a third removal point via a third valve to the heat exchanger and the second outlet conduit being connected at a fourth removal point via a fourth valve to the heat exchanger.

[0010] The unit may optionally include:

- means for mixing liquid removed via the first valve with liquid removed via the second valve and sending the mixed liquid in a common conduit to the condenser.
- the first valve and the second valve are connected to the condenser section via separate conduit means.
- the first removal point is upstream of the third removal point and/or the second removal point is upstream of the fourth removal point.
- a storage tank for storing liquid from a first or second pump upstream of the condenser section
- means for sending liquid from a first or second pump to the bottom of the second column
- means for sending liquid nitrogen from an external source to the first or second column
- a turbine and means for sending feed air or vaporised liquid oxygen from the condenser to the turbine

[0011] According to another object of the invention, there is provided an air separation process using a first rectification column operating at a first pressure, a second rectification column operating at a second pressure, less than the first pressure, the first rectification column having a top condenser enclosed within a condenser section operating at the second pressure, a supply source which is a lower region of the second rectification column, the first rectification column and the second rectification column being placed side by side and a heat exchanger wherein feed air is sent to the heat exchanger to be cooled and then from the heat exchanger to the first rectification column, a gas from the condenser section is sent to the bottom of the second rectification column, a gas is removed from the top of the second rectification column, and sent to the heat exchanger to be warmed, wherein in normal operation, a first pump and a second pump connected in parallel are used to pressurise liquid from the bottom of the second rectification column, the first pump producing liquid at a first liquid pressure and the second pump producing liquid at a second liquid pressure, higher than the first liquid pressure, preferably at least 5 bars higher than the first liquid pressure, and the first pump sends liquid at the first liquid pressure to the condenser section and the second pump sends liquid at the second liquid pressure to the heat exchanger, wherein liquid at the second liquid pressure is at least sometimes sent from the second pump to the condenser section.

[0012] According to optional features of the process:

- no liquid is sent in normal operation from the first pump to the heat exchanger.
- the liquid at the second liquid pressure sent from the second pump to the condenser section has a flowrate corresponding to between 3 and 100%, even between 3 and 50%, possibly between 3 and 15%, preferably between 5 and 10% of the flowrate of the liquid at the first liquid pressure sent from the first pump to the condenser section during normal operation.
- the liquid at the second pressure is not expanded between the second removal point and the condenser section.
- the liquid at the first liquid pressure and the liquid at the second liquid pressure are mixed upstream of the condenser section.
- the liquid at the first liquid pressure and the liquid at the second liquid pressure are not mixed upstream of the condenser section.
- the first and second liquid pressures differ by no more than 10 bars, preferably by no more than 7 bars.
- part of the refrigeration for the process is provided by liquid nitrogen from an external source.
- liquid at the second liquid pressure is sent from the second pump to the condenser section if the first pump is not operating.

EP 4 464 961 A1

- during normal operation liquid at the second liquid pressure is not sent from the second pump to the condenser section.
- liquid at the second liquid pressure is sent from the second pump to the condenser section if the first pump is operating at a reduced rate as compared to the rate during normal operation.
- the liquid at the second liquid pressure is reduced in pressure upstream of the condenser section.
- during normal operation, the molar flowrate of liquid sent from the first pump to the condenser is at least five times, preferably at least eight times higher than the molar flowrate of liquid sent from the first pump to the heat exchanger

[0013] A liquefied gas supply system according to the present disclosure may comprise:

- a first liquid feed pump which is used to feed a first liquefied gas from a supply source (e.g., a column bottom portion of a rectification column, or a product liquefied gas storage tank, etc.) to a low-pressure supply destination (e.g., a rectification column, vaporizer, or condenser, etc.) for low-pressure purposes (e.g., for the purpose of circulation to the rectification column, for refrigerant purposes in the vaporizer or condenser);
- a second liquid feed pump which is used to feed a second liquefied gas from the supply source to a high-pressure supply destination (e.g., a heat exchanger or demand destination, etc.) for high-pressure purposes (e.g., delivery to the heat exchanger for product gas purposes, etc.); and
- a control unit configured to control the first liquid feed pump and the second liquid feed pump .

[0014] The control unit may be configured to implement:

- first circulation liquid in-feed processing for feeding the first liquefied gas from the supply source to the low-pressure supply destination by means of the first liquid feed pump which is in a low-pressure operating mode; and
- first product liquid in-feed processing for feeding the second liquefied gas from the supply source to the high-pressure supply destination by means of the second liquid feed pump which is in a high-pressure operating mode.

[0015] The control unit may be configured to implement:

- second circulation liquid in-feed processing for feeding the first liquefied gas from the supply source to the low-pressure supply destination by means of the first liquid feed pump which is in the low-pressure operating mode, and also for feeding in a portion $W1$ of the second liquefied gas from the supply source to the low-pressure supply destination by means of the second liquid feed pump which is in the high-pressure operating mode; and
- second product liquid in-feed processing for feeding in the remainder $W2$ of the second liquefied gas from the supply source to the high-pressure supply destination by means of the second liquid feed pump which is in the high-pressure operating mode ($W1 + W2 =$ total in-feed amount from the second liquid feed pump).

[0016] The control unit may be configured to implement:

- when the first liquid feed pump is in a stopped state, first liquid feed pump stoppage processing for feeding in a portion $W21$ of the second liquefied gas from the supply source to the high-pressure supply destination and for feeding in the remainder $W22$ of the second liquefied gas to the low-pressure supply destination by means of the second liquid feed pump ($W21 + W22 =$ total in-feed amount from the second liquid feed pump).

[0017] The control unit may be configured to implement:

- when the second liquid feed pump is in a stopped state, second liquid feed pump stoppage processing for feeding in a portion $W11$ of the first liquefied gas from the supply source to the low-pressure supply destination and for feeding in the remainder $W12$ of the product liquefied gas to the high-pressure supply destination by means of the first liquid feed pump ($W11 + W12 =$ total in-feed amount from the first liquid feed pump).

[0018] The control unit may be configured to control:

- an amount (amount per unit time) of the first liquefied gas fed from the supply source to the low-pressure supply destination by means of the first liquid feed pump , and may control an amount (amount per unit time) of the second liquefied gas fed from the supply source to the high-pressure supply destination by means of the second liquid feed pump, correspondingly with liquid amount data from a liquid amount measurement unit (e.g., a liquid level gauge, etc.) for measuring an amount of liquid at the supply source.

[0019] The control unit may be configured to control:

EP 4 464 961 A1

- an amount (amount per unit time) of the first liquefied gas fed from the supply source to the low-pressure supply destination by means of the first liquid feed pump and may control an amount (amount per unit time) of the second liquefied gas fed from the supply source to the high-pressure supply destination by means of the second liquid feed pump, correspondingly with liquid amount data from a flow rate measurement unit (e.g., a flowmeter, etc.) for measuring an amount of liquid fed to the low-pressure supply destination.

[0020] The control unit may control:

- an amount (amount per unit time) of the first liquefied gas fed from the supply source to the low-pressure supply destination by means of the first liquid feed pump, and may control an amount (amount per unit time) of the second liquefied gas fed from the supply source to the high-pressure supply destination by means of the second liquid feed pump, correspondingly with liquid amount data from a flow rate measurement unit (e.g., a flowmeter, etc.) for measuring an amount of liquid fed to the high-pressure supply destination, or gas amount data from a gas amount measurement unit for measuring a flow rate of product gas drawn from the high-pressure supply destination.

[0021] The control unit may operate the second liquid feed pump, which is in a high-pressure operating mode, at a minimum flow rate, and may operate the first liquid feed pump, which is in a low-pressure operating mode, so as to respond to process fluctuations (e.g., fluctuation in a circulation liquid amount or fluctuation in a product gas amount).

[0022] A pipe configuration may be such that a first low-pressure liquid feed line (first branch pipe) running from the first liquid feed pump to the low-pressure supply destination, and a second low-pressure liquid feed line (circulation branch pipe L14) running from the second liquid feed pump to the low-pressure supply destination do not merge, or merge.

[0023] The pipe configuration may be such that a first high-pressure liquid feed line (product liquid branch pipe L13 or first outlet conduit) running from the first liquid feed pump to the high-pressure supply destination, and a second high-pressure liquid feed line (second branch pipe L12 or second outlet conduit) running from the second liquid feed pump to the high-pressure supply destination may or may not merge..

[0024] Valves may be provided in each of the liquid feed lines. The control unit may also control opening/closing of the valves and flow rate regulation, correspondingly with detection data of the liquid level gauge or the flow rate measurement unit. The liquefied gas supply system may comprise:

- a first return pipe for returning, to the supply source (column bottom portion of a second rectification column), a portion of the product liquefied gas (liquefied oxygen) fed from the first liquid feed pump; and
- a second return pipe for returning, to the supply source (column bottom portion of the second rectification column) a portion of the product liquefied gas (liquefied oxygen) fed from the second liquid feed pump (12).

[0025] The control unit may control the valves provided each of the pipes, and may regulate opening/closing thereof or flow rate.

[0026] An air separation unit according to the present disclosure may optionally comprise:

- a main heat exchanger into which feed air is introduced;
- a first rectification column into which the feed air that has passed through the main heat exchanger is introduced;
- a nitrogen condenser for condensing a nitrogen-rich substance (in the form of a gas or a gas-liquid mixture) drawn from a column top portion or an upper stage of a rectification portion of the first rectification column;
- a second rectification column having a column bottom portion for the introduction of an oxygen-rich gas drawn from a column top portion of the nitrogen condenser;
- an oxygen-enriched liquid drawing pipe for introducing an oxygen-enriched liquid drawn from the column bottom portion (21) of the first rectification column (2) into a rectification portion (first intermediate rectification portion 42) of the second rectification column;
- an expansion turbine for expanding a portion of the feed air drawn from partway through the main heat exchanger;
- a second feed air pipe through which the feed air used in the expansion turbine is introduced into a rectification portion (second intermediate rectification portion of the second rectification column);
- a nitrogen-rich substance introduction pipe for introducing a nitrogen-rich substance (in the form of a gas, a liquid, or a gas-liquid mixture) drawn from the column top portion of the first rectification column into a column top portion or an upper portion of a second rectification portion of the second rectification column;
- a product nitrogen gas pipe for extracting product nitrogen gas that has been drawn from the column top portion of the second rectification column and passed through the main heat exchanger;
- a low-pressure oxygen pipe for causing an oxygen-rich gas drawn from the column top portion of the nitrogen condenser to pass through the main heat exchanger, and extracting low-pressure oxygen gas; and

- the liquefied gas supply system .

[0027] An air separation unit according to different disclosure constitutes a high-pressure air separation unit, may comprise:

5

- a main heat exchanger into which feed air is introduced;
- a first rectification column into which the feed air that has passed through the main heat exchanger is introduced;
- a nitrogen condenser for condensing a nitrogen-rich substance (in the form of a gas or a gas-liquid mixture) drawn from a column top portion or an upper stage of a rectification portion of the first rectification column ;
- 10 • a second rectification column having a column bottom portion for the introduction of an oxygen-enriched gas drawn from a column top portion of the nitrogen condenser);
- an oxygen enriched liquid drawing pipe) for introducing an oxygen-enriched liquid drawn from the column bottom portion of the first rectification column into a rectification portion (first intermediate rectification portion) of the second rectification column ;
- 15 • an expansion turbine into which an oxygen-rich gas drawn from the column top portion of the nitrogen condenser is introduced (via a low-pressure oxygen line) after passing through a portion of the main heat exchanger;
- a low-pressure oxygen line for causing the oxygen-rich gas used in the expansion turbine to pass through the main heat exchanger, and extracting low-pressure oxygen gas;
- a nitrogen-rich substance introduction pipe for introducing a nitrogen-rich substance (in the form of a gas, a liquid, or a gas-liquid mixture) drawn from the column top portion of the first rectification column into a column top portion or an upper portion of a second rectification portion of the second rectification column ;
- 20 • a product nitrogen gas line for extracting product nitrogen gas that has been drawn from the column top portion of the second rectification column and passed through the main heat exchanger; and
- the liquefied gas supply system .

25

[0028] An air separation unit according to different disclosure constitutes a high-pressure air separation unit further provided with an argon rectification column, may comprise:

30

- a main heat exchanger into which feed air is introduced;
- a first rectification column into which the feed air that has passed through the main heat exchanger is introduced;
- a nitrogen condenser for condensing a nitrogen-rich substance (in the form of a gas or a gas-liquid mixture) drawn from a column top portion or an upper stage of a rectification portion of the first rectification column ;
- a second rectification column (4) having a column bottom portion for the introduction of an oxygen-rich gas drawn from a column top portion of the nitrogen condenser;
- 35 • an oxygen-enriched liquid drawing pipe for introducing an oxygen-enriched liquid drawn from the column bottom portion of the first rectification column into a rectification portion (first intermediate rectification portion 42) of the second rectification column ;
- an oxygen-enriched liquid drawing branch pipe for introducing an oxygen-enriched liquid drawn from the column bottom portion of the first rectification column into a column top portion of the argon rectification column or a refrigerant portion of a second condenser;
- 40 • an argon rectification column having a column bottom portion for the introduction of a first rectified substance drawn from a rectification portion (first intermediate rectification portion of the second rectification column ;
- a bottom portion drawing pipe for introducing a second rectified substance (e.g., an oxygen-rich liquid) drawn from the column bottom portion into the rectification portion of the second rectification column ;
- 45 • a first condensing portion for condensing (liquefying) an argon-rich substance (in the form of a gas or a gas-liquid mixture) drawn from a column top portion of the argon rectification column;
- a gas drawing pipe for introducing a gas (e.g., an oxygen-rich gas) drawn from a column top portion of the first condensing portion into the rectification portion of the second rectification column ;
- an expansion turbine into which an oxygen-rich gas drawn from the column top portion of the nitrogen condenser is introduced after passing through a portion of the main heat exchanger;
- 50 • a low-pressure oxygen line for causing the oxygen-rich gas used in the expansion turbine to pass through the main heat exchanger, and extracting low-pressure oxygen gas;
- a nitrogen-rich substance introduction pipe for introducing a nitrogen-rich substance (in the form of a gas, a liquid, or a gas-liquid mixture) drawn from the column top portion of the first rectification column into a column top portion or an upper portion of a second rectification portion of the second rectification column ;
- 55 • a product nitrogen gas line for extracting product nitrogen gas that has been drawn from the column top portion of the second rectification column and passed through the main heat exchanger; and
- the liquefied gas supply system.

[0029] Pressure gauges and thermometers, etc. may be provided in the first and second rectification columns and in the argon rectification column .

[0030] Gate valves, flow rate control valves, and expansion valves, etc. may be provided in each of the pipelines.

[0031] Flowmeters, pressure gauges and thermometers, etc. may be provided in each of the pipelines.

5 [0032] In the present disclosure, output pressures of the liquid feed pumps are generally determined by the pressure at the supply destination, a lift height from the pump to the supply destination, and pressure loss in the pipes. The liquid feed pumps are operable within a predetermined pressure range; in a low-pressure operating mode, the liquid feed pumps are operated at a low pressure conforming to the pressure at a low-pressure supply destination, and in a high-pressure operating mode, the liquid feed pumps are operated at a high-pressure conforming to the pressure at a high-pressure supply destination.

[Brief Description of the Drawings]

[0033]

15 [Fig. 1A] Fig. 1A is a configuration example of an air separation unit according to embodiment 1.
 [Fig. 1B] Fig. 1B is a configuration example of an air separation unit according to embodiment 2.
 [Fig. 1C] Fig. 1C is a configuration example of an air separation unit according to embodiment 3.
 [Fig. 1D] Fig. 1D is a configuration example of an air separation unit according to embodiment 4.
 20 [Fig. 2] Fig. 2 is a configuration example of a air separation unit capable of operating of at higher pressures than the units of Fig. 1.
 [Fig. 3] Fig. 3 is a configuration example of a high-pressure air separation unit comprising an argon rectification column.

25 Embodiments of the Invention

[0034] Several embodiments of the present invention will be described below. The embodiments described below illustrate examples 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 are implemented within a scope that does not alter the gist of the present invention. It should be noted that not all of the components described below are essential components of the present invention.

Definition of Terminology

35 [0035] In this specification, "upstream" and "downstream" are based on flows of gas (e.g., feed air, oxygen gas, nitrogen gas, argon gas) or various liquefied gases.

Embodiment 1

40 [0036] An air separation unit 100 according to embodiment 1 illustrated in fig. 1A constitutes a low-pressure air separation unit.

[0037] The air separation unit 100 comprises: a main heat exchanger 101, a first rectification column 2, a nitrogen condenser 3, a second rectification column 4, an expansion turbine 7 for feed air, a first heat exchanger 102, and a liquefied gas supply system 1.

45 [0038] The first rectification column 2 comprises a column bottom portion 21, a rectification portion 22, and a column top portion 23. The second rectification column 4 comprises a column bottom portion 41, a rectification portion (lower rectification portion, first intermediate rectification portion 42, second intermediate rectification portion 43 in a stage above, and upper rectification portion), and a column top portion 44.

[0039] The main heat exchanger 101 exchanges heat between feed air and another gas. A portion of the feed air drawn from the main heat exchanger 1 is introduced into the column bottom portion 21, which is a lower portion of the first rectification column 2, via a first feed air pipe L21.

50 [0040] The remainder of the feed air is drawn from partway through the main heat exchanger 1 by means of a second feed air pipe L21a which branches from the first feed air pipe L21, and fed to the expansion turbine 7. The feed air used in the expansion turbine 7 is introduced into the second intermediate rectification portion 43 of the second rectification column 4 by means of the second feed air pipe L21a.

55 [0041] A portion of the nitrogen gas drawn from the column top portion 23 of the first rectification column 2 by means of a nitrogen-rich substance drawing pipe L23b is fed to the nitrogen condenser 3, and after being cooled by means of cold heat of a refrigerant (oxygen-rich liquid) therein, the condensed nitrogen liquid is returned to the column top portion

23 of the first rectification column 2 by pipe L23.

[0042] The remainder of the nitrogen liquid condensed in the condenser 3 is introduced into the column top portion 44 of the second rectification column 4 via a first branch pipe L23a branching from the nitrogen-rich substance drawing pipe L23.

[0043] An oxygen-enriched liquid drawn from the column bottom portion 21 of the first rectification column 2 by means of an oxygen-enriched liquid drawing pipe L211 undergoes heat exchange with another gas in the first heat exchanger 102, and is then fed to the intermediate rectification portion 42 of the second rectification column 4.

[0044] An oxygen-rich gas drawn from the column top portion 32 of the nitrogen condenser 3 by means of a low-pressure oxygen pipe L321 (or a waste gas pipe) is passed through the main heat exchanger 101 and then extracted (supplied externally) as low-pressure oxygen gas (or waste gas).

[0045] An oxygen-rich gas drawn from the column top portion 32 of the nitrogen condenser 3 by means of a low-pressure oxygen pipe L32 is sent to the bottom of the second rectification column.

[0046] Nitrogen gas drawn from the column top portion 44 of the second rectification column 4 by means of a product nitrogen gas pipe L44 is passed through the first heat exchanger 102 and passed through the main heat exchanger 101, and is then extracted as product nitrogen gas.

[0047] The liquefied gas supply system 1 comprises: a first liquid feed pump 11 operable in a low-pressure operating mode or a high-pressure operating mode; a second liquid feed pump operable in a low-pressure operating mode or a high-pressure operating mode; and a control unit 15 for controlling the first liquid feed pump 11 and the second liquid feed pump 12 in the low-pressure operating mode and/or the high-pressure operating mode.

[0048] Liquefied oxygen is drawn from the column bottom portion 41 of the second rectification column 4 by means of a first drawing pipe L1, and fed downstream to suit a predetermined purpose by means of the first liquid feed pump 11 and the second liquid feed pump 12.

[0049] The low-pressure operating mode is determined, for example, by totalling a pressure on the refrigerant side (liquid oxygen side) of the nitrogen condenser 3 or in the second rectification column 4, a pressure corresponding to a lift height required to supply a liquid from the first liquid feed pump 11 or the second liquid feed pump 12 to the refrigerant side of the nitrogen condenser 3, and pipe pressure loss.

[0050] The high-pressure operating mode is determined, for example, when a liquid is to be supplied to a supply destination, by totalling an operating pressure at the supply destination, a pressure corresponding to a lift height from the pump to the supply destination, and pipe pressure loss.

[0051] The high-pressure operating mode is determined, when the liquid is vaporized for supply to the supply destination as a gas, by totalling a pressure corresponding to the lift height from the pump to a liquid vaporization point and pipe pressure loss with the pressure at the supply destination. The low pressure is 1.5-5 barA and the high-pressure is 5-20 barA, in terms of rectification column pressure, for example.

First circulation liquid in-feed processing and first product liquid in-feed processing

[0052] The first drawing pipe L1 branches into a first branch pipe L11 and a second branch pipe L12 to feed liquefied oxygen. The first branch pipe L11 communicates with the nitrogen condenser 3, via a first removal point of pipe L13. The control unit 15 controls the first liquid feed pump 11 in the low-pressure operating mode so that a portion of branched first liquefied oxygen (corresponding to a first liquefied gas) is fed to the nitrogen condenser 3 as a circulation liquid (for the purpose of a refrigerant) (first circulation liquid in-feed processing). In this processing, a first gate valve V1 and a third gate valve V3 provided in the first branch pipe L11 are controlled to an open state by means of the control unit 15. Furthermore, a circulation branch pipe L14 branching from the second branch pipe L12 merges with the first branch pipe L11. A second gate valve V2 provided upstream from a merging position thereof and downstream of a second removal point of pipe L12 is controlled to a closed state by means of the control unit 15.

[0053] The second branch pipe L12 extends as far as the main heat exchanger 101. The control unit 15 controls the second liquid feed pump 12 in the high-pressure operating mode so that second liquefied oxygen (corresponding to a second liquefied gas) fed by the second branch pipe L12 undergoes heat exchange with another gas and is then extracted as product oxygen gas (first product liquid in-feed processing). In this processing, a fifth gate valve V5 provided in the second branch pipe L12 is controlled to an open state by means of the control unit 15. Furthermore, a product liquid branch pipe L13 branching from the first branch pipe L11 merges with the second branch pipe L12 via a third removal point. A fourth gate valve V4 provided upstream from a merging position and downstream of a fourth removal point thereof is controlled to a closed state by means of the control unit 15.

[0054] It will be seen that in this case the third and fourth removal points are in fact the same points since pipes L12, L13 merge. However pipe L13 does not necessarily exist downstream of the first removal point. Furthermore, pipes L12 and L13 do not necessarily merge upstream of the heat exchanger, so that the liquid from pumps 11, 12 could be vaporised independently.

Second circulation liquid in-feed processing and second product liquid in-feed processing

5 **[0055]** The control unit 15 feeds the first liquefied oxygen to the nitrogen condenser 3 using the first liquid feed pump 11 which is in the low-pressure operating mode, and at the same time feeds a portion (W1) of the second liquefied oxygen to the nitrogen condenser 3 also using the second liquid feed pump 12 which is in the high-pressure operating mode (second circulation liquid in-feed processing). The control unit 15 opens the second gate valve V2 to cause the portion (W1) of the second liquefied oxygen to merge into the first branch pipe L11 through the circulation branch pipe L14. Furthermore, the control unit 15 feeds the remainder (W2) of the second liquefied oxygen to the main heat exchanger 101, after which it is extracted as product oxygen gas (second product liquid in-feed processing).

10 **[0056]** The portion W1 corresponds to between 3 and 50% or even between 3 and 15%, preferably between 5 and 10% of the flowrate of the liquid at the first liquid pressure sent from the first pump 11 to the condenser section 3 in normal operation.

[0057] The control unit 15 controls the amount of circulation liquid and the amount of product oxygen gas by adjusting opening/closing or flow rate of the second gate valve V2.

15 **[0058]** During normal operation, the molar flowrate of liquid sent from the first pump to the condenser is at least five times, preferably at least eight times higher than the molar flowrate of liquid sent from the first pump to the heat exchanger; for example 95% of the liquid from the first pump 11 is sent to condenser 31 and 5% of the liquid from the first pump 11 is sent to the heat exchanger 101.

20 Embodiment 2

[0059] An air separation unit 100 according to embodiment 2 illustrated in fig. 1B comprises first and second return pipes L16, L17, in addition to the components of embodiment 1. The same component reference numbers denote the same functions, and components having additional functions or different functions will be described in particular.

25 **[0060]** The first return pipe L16 branches from the first branch pipe L11 downstream from the first liquid feed pump 11 and communicates with the column bottom portion 41 of the second rectification column 4. A sixth gate valve V6 is provided in the first return pipe L16. Opening/closing and flow rate of the sixth gate valve V6 are controlled and a return amount of the first liquefied oxygen is adjusted by means of the control unit 15.

30 **[0061]** The first return pipe L17 branches from the second branch pipe L12 downstream from the second liquid feed pump 12 and communicates with the column bottom portion 41 of the second rectification column 4. A seventh gate valve V7 is provided in the second return pipe L17. Opening/closing or flow rate of the seventh gate valve V7 is controlled and a return amount of the second liquefied oxygen is adjusted by means of the control unit 15.

35 Embodiment 3

[0062] An air separation unit 100 according to embodiment 3 illustrated in fig. 1C comprises a liquid level measurement unit F1 for the column bottom portion 41 of the second rectification column 4 and/or a flow rate measurement unit F2 for the product oxygen gas, in addition to the components of embodiment 1 or 2. The same component reference numbers denote the same functions, and components having additional functions or different functions will be described in particular.

40 **[0063]** The liquid level measuring unit F1 measures an amount of liquefied oxygen in the column bottom portion 41 of the second rectification column 4. The control unit 15 controls a feed amount of the first liquefied oxygen by means of the first liquid feed pump 11, correspondingly with the measurement data. Furthermore, the control unit 15 controls a feed amount of the second liquefied oxygen by means of the second liquid feed pump 12 correspondingly with the measurement data.

45 **[0064]** The flow rate measurement unit F2 is provided in the second branch pipe L12 downstream from the main heat exchanger 101, and measures the flow rate of product oxygen gas for a demand destination. The control unit 15 controls the feed amount of the first liquefied oxygen (the amount of circulation liquid which is fed by means of the first liquid feed pump 11, and the feed amount of the second liquefied oxygen (feed amount of the circulation liquid and amount of product oxygen gas) by means of the second liquid feed pump 12, correspondingly with the measurement data.

50 **[0065]** The air separation unit 100 may comprise both the liquid level measurement unit F1 and the flow rate measurement unit F2, or may comprise either one thereof.

55 **[0066]** The control unit 15 may operate the second liquid feed pump 12, which is in the high-pressure operating mode, at the minimum flow rate, and may operate the first liquid feed pump 11, which is in the low-pressure operating mode, so as to respond to process fluctuations.

Embodiment 4

[0067] An air separation unit 100 according to embodiment 4 illustrated in fig. 1D is in accordance with the configurations of embodiments 1, 2 and 3, but has a different pipe configuration in the liquefied gas supply system 1. The same component reference numbers denote the same functions, and components having additional functions or different functions will be described in particular.

[0068] The first branch pipe L11 communicates with the nitrogen condenser 3 and feeds the liquefied oxygen to the nitrogen condenser 3 as a circulation liquid. A gate valve V11 is provided in the first branch pipe L11. The fourth gate valve V4 is provided in the product liquid branch pipe L13 which branches from the first branch pipe L11 at a position upstream from the gate valve V11. The gate valve V11 is opened and the fourth gate valve V4 is closed, whereby the first liquefied oxygen is fed to the nitrogen condenser 3 by means of the first liquid feed pump 11.

[0069] The second branch pipe L12 extends to the main heat exchanger 101 and feeds liquefied oxygen. The fifth gate valve V5 is provided in the second branch pipe L12. The circulation branch pipe L14 branching from the second branch pipe L12 at a position upstream from the fifth gate valve V5 communicates with the nitrogen condenser 3. A gate valve V12 is provided in the circulation branch pipe L14. The gate valve V12 is closed and the fifth gate valve V5 is opened, whereby the second liquefied oxygen is fed only to the main heat exchanger 101 by means of the second liquid feed pump 12. Meanwhile, the gate valve V12 is opened and the fifth gate valve V5 is also opened, whereby a portion of the second liquefied oxygen (W1) is fed to the nitrogen condenser 3, and the remainder (W2) thereof is fed to the main heat exchanger 101.

[0070] According to the configuration above, by virtue of the fact that the first branch pipe L11 and the circulation branch pipe L14 do not merge, it is possible to suppress turbulence which would be at risk of occurring inside the pipes due to a liquid flow from high-pressure lines to low-pressure lines.

Embodiment 5

[0071] Embodiment 5 illustrated in fig. 1D, which is in accordance with embodiments 1, 2, 3 and 4, comprises first and second liquefied oxygen tanks T1, T2.

[0072] The first liquefied oxygen tank T1 is a tank for extracting the first liquefied oxygen from the first branch pipe L11 as it runs to the nitrogen condenser 3, and for storing the first liquefied oxygen.

[0073] The second liquefied oxygen tank T2 is a tank for extracting the second liquefied oxygen from the second branch pipe L12 as it runs to the main heat exchanger 101, and for storing the second liquefied oxygen.

[0074] The first and second liquefied oxygen storage tanks T1, T2 may supply the liquefied oxygen as a product, and may be utilized as primary storage buffers.

Embodiment 6

[0075] In embodiments 1-5, either one of the first liquid feed pump 11 and the second liquid feed pump 12 is stopped, and only the other is operated in the high-pressure operating mode, and opening/closing of the gate valves in the pipes is controlled. When only the first liquid feed pump 11 is operated in the high-pressure operating mode, a portion of the first liquefied oxygen is fed to the nitrogen condenser 3 as a circulation liquid, and the remainder thereof is fed to the main heat exchanger 101. When only the second liquid feed pump 12 is operated in the high-pressure operating mode, a portion of the second liquefied oxygen is fed to the nitrogen condenser 3 as a circulation liquid, and the remainder thereof is fed to the main heat exchanger 101. This portion may correspond to between 3 and 100% of the liquid sent from the first pump 11 to the condenser 3 in normal operation i.e. when the first and second pumps both operate, one sending liquid to the condenser and the other to heat exchanger.

[0076] When the first liquid feed pump 11 has been stopped, the control unit 15 closes the first gate valve V1 (or gate valve V11) and the fourth gate valve V4, and opens the second gate valve V2 and third gate valve V3 (or gate valve V12), and the fifth gate valve V5. The second liquid feed pump 12 is operated in the high-pressure operating mode.

[0077] Meanwhile, when the second liquid feed pump 12 has been stopped, the control unit 15 closes the second gate valve V2 (gate valve V12) and the fifth gate valve V5, and opens the first gate valve V1 and third gate valve V3 (or gate valve V11), and the fourth gate valve V4. The first liquid feed pump 11 is operated in the high-pressure operating mode.

Embodiment 7

[0078] An air separation unit 200 according to embodiment 7 illustrated in fig. 2 constitutes a high-pressure air separation unit. The same component reference numbers denote the same functions, and components having additional functions or different functions will be described in particular.

[0079] The air separation unit 200 comprises: a main heat exchanger 101, a first rectification column 2, a nitrogen

condenser 3, a second rectification column 4, an expansion turbine 71, a first heat exchanger 102, and a liquefied gas supply system 1.

[0080] An oxygen-rich gas drawn from the column top portion 32 of the nitrogen condenser 3 is fed to the expansion turbine 71 after this gas has passed through a portion of the main heat exchanger 101 via a low-pressure oxygen line L3211. The oxygen-rich gas which has been used in the expansion turbine 71 is once again fed to the main heat exchanger 101 from where it is extracted as low-pressure oxygen gas (or waste gas).

[0081] An expansion turbine 7 such as in embodiment 1 is not provided.

[0082] The configurations of embodiments 1-6 are applied to the liquefied gas supply system 1.

Embodiment 8

[0083] An air separation unit 300 according to embodiment 8 illustrated in fig. 3 constitutes a high-pressure air separation unit (embodiment 7) comprising an argon rectification column. The same component reference numbers denote the same functions, and components having additional functions or different functions will be described in particular.

[0084] The argon rectification column 5 comprises a column bottom portion 51, a rectification portion 52, and a column top portion 53. A first rectified substance (e.g., an oxygen-rich gas) drawn from the first intermediate rectification portion 42, or the rectification portion below, of the second rectification column 4 by means of an intermediate drawing pipe L42 is fed to the column bottom portion 51 of the argon rectification column 5 via the intermediate drawing pipe L42. A second rectified substance drawn from the column bottom portion 51 by means of a bottom portion drawing pipe L51 is fed to the first intermediate rectification portion 42 via the bottom portion drawing pipe L51.

[0085] An oxygen-rich liquid drawn from the column bottom portion 21 of the first rectification column 2 passes through the first heat exchanger 102 via an oxygen-rich liquid drawing pipe L211, and is fed to the first intermediate rectification portion 42 of the second rectification column 4. The oxygen-rich liquid is fed to a refrigerant portion of a first condensing portion 6 by means of an oxygen-rich liquid drawing branch pipe L211a branching from the oxygen-rich liquid drawing pipe L211 at a position downstream from the first heat exchanger 102.

[0086] An argon-rich substance drawn from the column top portion 53 of the argon rectification column 5 by means of an argon extraction pipe L53 is extracted as product argon via the argon extraction pipe L53.

[0087] A separation pipe L53a separating from the argon extraction pipe L53 communicates with the first condensing portion 6 and feeds the argon-rich substance to the first condensing portion 6, where the argon-rich substance is condensed (liquefied) and returned to the column top portion 53 of the argon rectification column 5.

[0088] A gas (oxygen-rich gas) drawn from the column top portion 62 of the first condensing portion 6 is fed to the first intermediate rectification portion 42 of the second rectification column 4 via a gas drawing pipe L62. In fig. 3, the gas drawing pipe L62 merges with the oxygen-rich liquid drawing pipe L211, but this is not limiting.

[0089] The configurations of embodiments 1-6 are applied to the liquefied gas supply system 1.

Other embodiments

[0090]

(1) In embodiments 1-8, the liquefied gas supply system 1 comprises the two liquid feed pumps, i.e., the first and second liquid feed pumps, but this is not limiting, and three or more liquid feed pumps may be provided.

(2) Application of the liquefied gas supply system 1 is not limited to the air separation units of embodiments 1-8, and it may also be applied to other air separation units.

[Key to Symbols]

[0091]

- 1 Liquefied gas supply system
- 2 First rectification column
- 3 Nitrogen condenser
- 4 Second rectification column
- 5 Argon rectification column 7 Expansion turbine
- 11 First liquid feedpump
- 12 Second liquid feed pump
- 15 Control unit
- 100 Air separation unit
- 101 Main heat exchanger

EP 4 464 961 A1

[0092] Additional refrigeration may be supplied for all the figures by the addition of liquid nitrogen to a column 2,4 from an external source (liquid assist).

[0093] The present invention solves above technical problems by the configuration characterized as follows.

Case	Invention	Dedicated pump arrangement with one pump feeding the condenser only and another feeding the heat exchanger only	Shared pumps (JP6257656B2)
Heat leak (Mcal/h)	20	19	22
Compensation by N2 liquid assist (kW)	6	Base	15
Investment (mJPY)	-1	-7	-1
NPV (mJPY)	-4.9	-9.2	-10.7

Claims

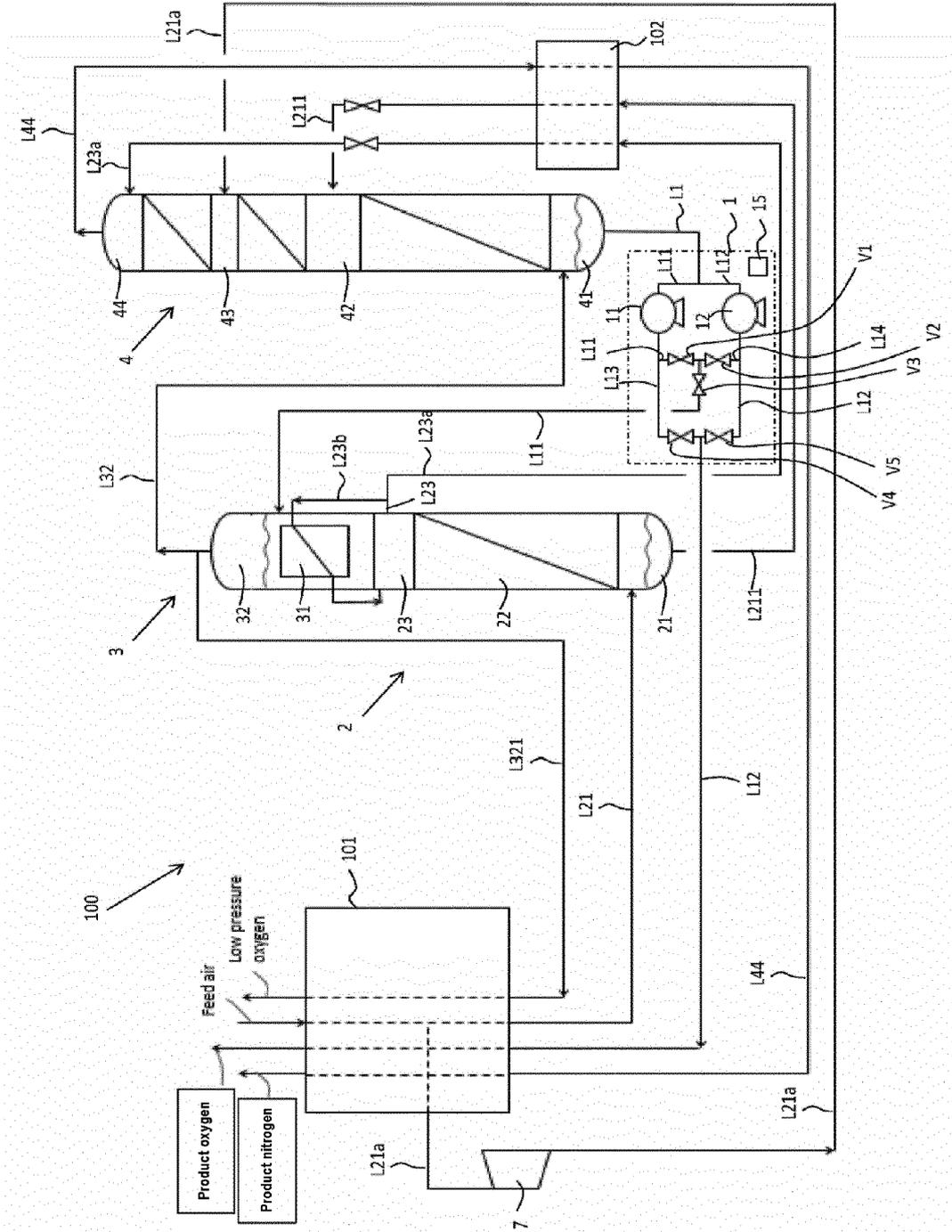
1. Air separation unit comprising a first rectification column (2) having an operating pressure which is a first pressure, a second rectification column (4) having an operating pressure which is a second pressure, less than the first pressure, the first rectification column having a top condenser (31) enclosed within a condenser section (3) having an operating pressure which is the second pressure, a supply source (41) which is a lower region of the second rectification column, the first rectification column and the second rectification column being placed side by side, a heat exchanger (101), means for sending feed air (L21) to the heat exchanger to be cooled and from the heat exchanger to the first rectification column, means for sending a gas (L32) from the condenser section to the bottom of the second rectification columns, a conduit for sending the gas (L44) removed from the top of the second rectification column to the heat exchanger to be warmed, a first pump (11) and a second pump (12) connected in parallel, the first pump being capable of producing liquid at a first liquid pressure and the second pump being capable of producing liquid at a second liquid pressure, higher than the first pressure, preferably at least 5 bars higher than the first pressure, each pump having an inlet connected to the supply source, a first outlet of the first pump being connected to a first outlet conduit (L13), a second outlet of the second pump being connected to a second outlet conduit (L12), the first outlet conduit being connected at a first removal point via a first valve (V1) to the condenser section and the second outlet conduit being connected at a second removal point via a second valve (V2) to the condenser section, the first outlet conduit being optionally connected at a third removal point via a third valve (V4) to the heat exchanger and the second outlet conduit being connected at a fourth removal point via a fourth valve (V5) to the heat exchanger.
2. Unit according to Claim 1 comprising means for mixing liquid removed via the first valve (V1) with liquid removed via the second valve (V2) and sending the mixed liquid in a common conduit (L11) to the condenser (31).
3. Unit according to Claim 1 wherein the first valve and the second valve are connected to the condenser section (3) via separate conduit means (L11, L14).
4. Unit according to any preceding claim wherein the first removal point is upstream of the third removal point and/or the second removal point is upstream of the fourth removal point.
5. Air separation process using a first rectification column (2) operating at a first pressure, a second rectification column (4) operating at a second pressure, less than the first pressure, the first rectification column having a top condenser (31) enclosed within a condenser section (3) operating at the second pressure, a supply source (41) which is a lower region of the second rectification column, the first rectification column and the second rectification column being placed side by side and a heat exchanger (101) wherein feed air is sent to the heat exchanger to be cooled and then from the heat exchanger to the first rectification column, a gas (L32) from the condenser section is sent to the bottom of the second rectification column, a gas (L44) is removed from the top of the second rectification column, and sent to the heat exchanger to be warmed, wherein in normal operation, a first pump (11) and a second pump (12) connected in parallel are used to pressurise liquid from the bottom of the second rectification column, the first pump producing liquid at a first liquid pressure and the second pump producing liquid at a second liquid pressure, higher than the first liquid pressure, preferably at least 5 bars higher than the first liquid pressure, and the

EP 4 464 961 A1

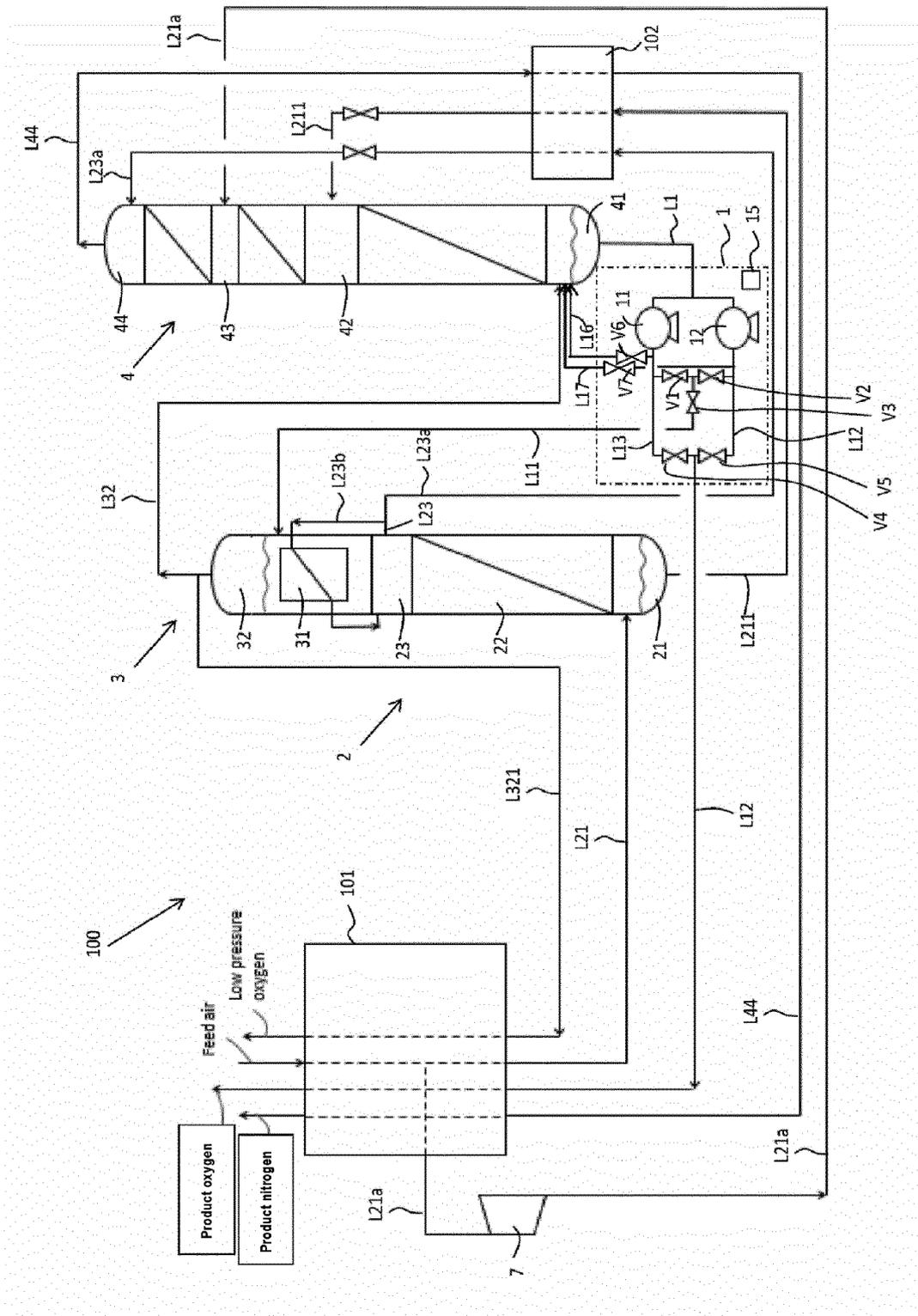
first pump sends liquid at the first liquid pressure to the condenser section and the second pump sends liquid at the second liquid pressure to the heat exchanger, wherein liquid at the second liquid pressure is at least sometimes sent from the second pump to the condenser section.

- 5
6. Process according to Claim 5 wherein no liquid is sent in normal operation from the first pump (11) to the heat exchanger (101).
7. Process according to Claim 5 or 6 wherein the liquid at the second liquid pressure sent from the second pump (12) to the condenser section has a flowrate corresponding to between 3 and 100%, or to between 3 and 50% or even
10 between 3 and 15%, preferably between 5 and 10% of the flowrate of the liquid at the first liquid pressure sent from the first pump (11) to the condenser section (3) in normal operation.
8. Process according to one of Claims 5 to 7 wherein the liquid at the second pressure is not expanded between the second removal point and the condenser section (3).
- 15
9. Process according to one of Claims 5 to 8 wherein the liquid at the first liquid pressure and the liquid at the second liquid pressure are mixed upstream of the condenser section (3).
10. Process according to one of Claims 5 to 9 wherein the first and second liquid pressures differ by no more than 10 bars, preferably by no more than 7 bars.
- 20
11. Process according to one of Claims 5 to 10 wherein part of the refrigeration for the process is provided by liquid nitrogen from an external source.
- 25
12. Process according to one of Claims 5 to 11 wherein liquid at the second liquid pressure is sent from the second pump (12) to the condenser section (3) if the first pump (11) is not operating.
13. Process according to Claim 12 wherein during normal operation liquid at the second liquid pressure is not sent from the second pump (12) to the condenser section (3).
- 30
14. Process according to one of Claims 5 to 11 wherein liquid at the second liquid pressure is sent from the second pump (12) to the condenser section (3) if the first pump (11) is operating at a reduced rate as compared to the rate during normal operation.
- 35
15. Process according to Claim 12 or 14 wherein the liquid at the second liquid pressure is reduced in pressure upstream of the condenser section (3).
- 40
- 45
- 50
- 55

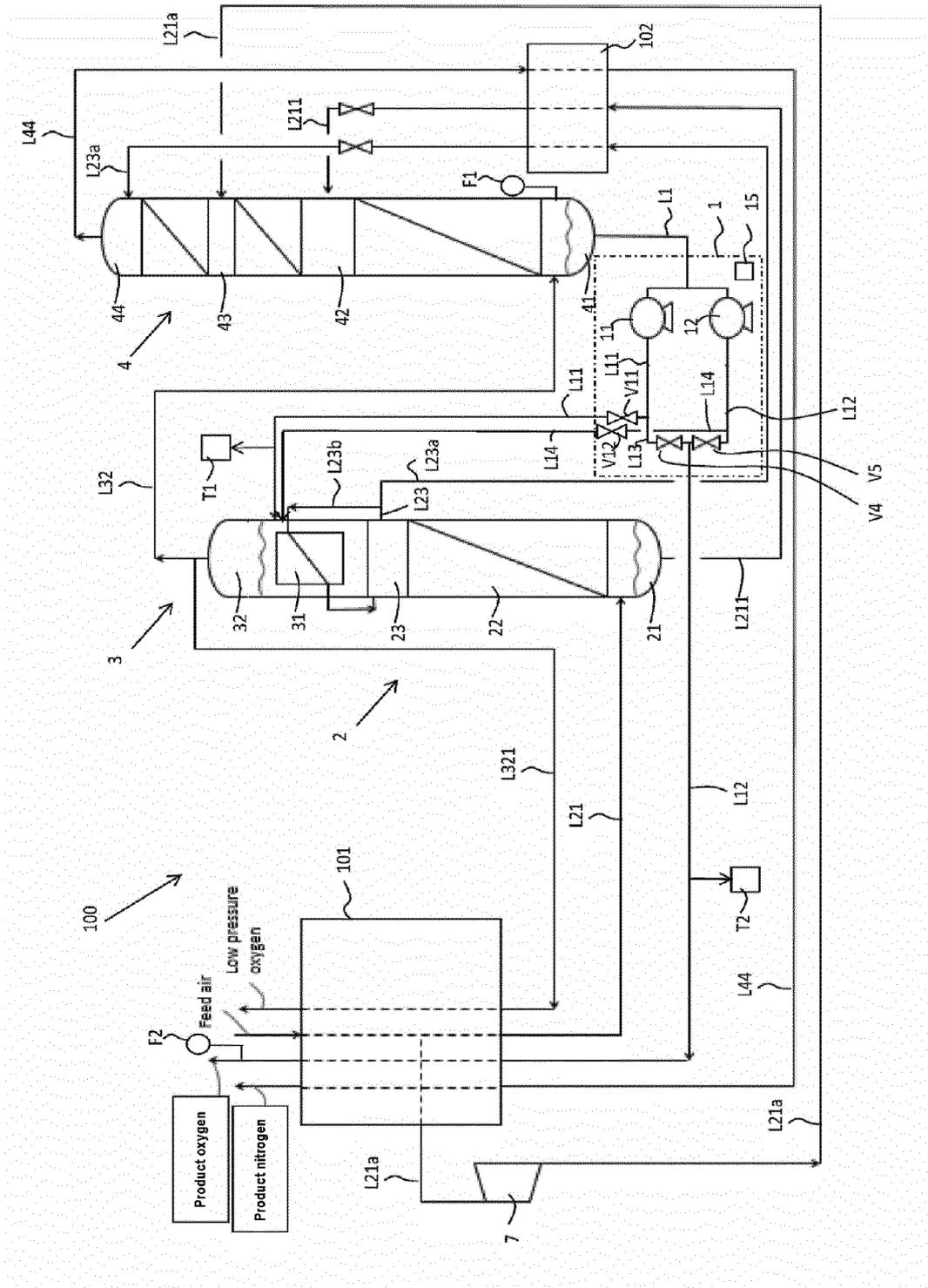
[Fig. 1A]



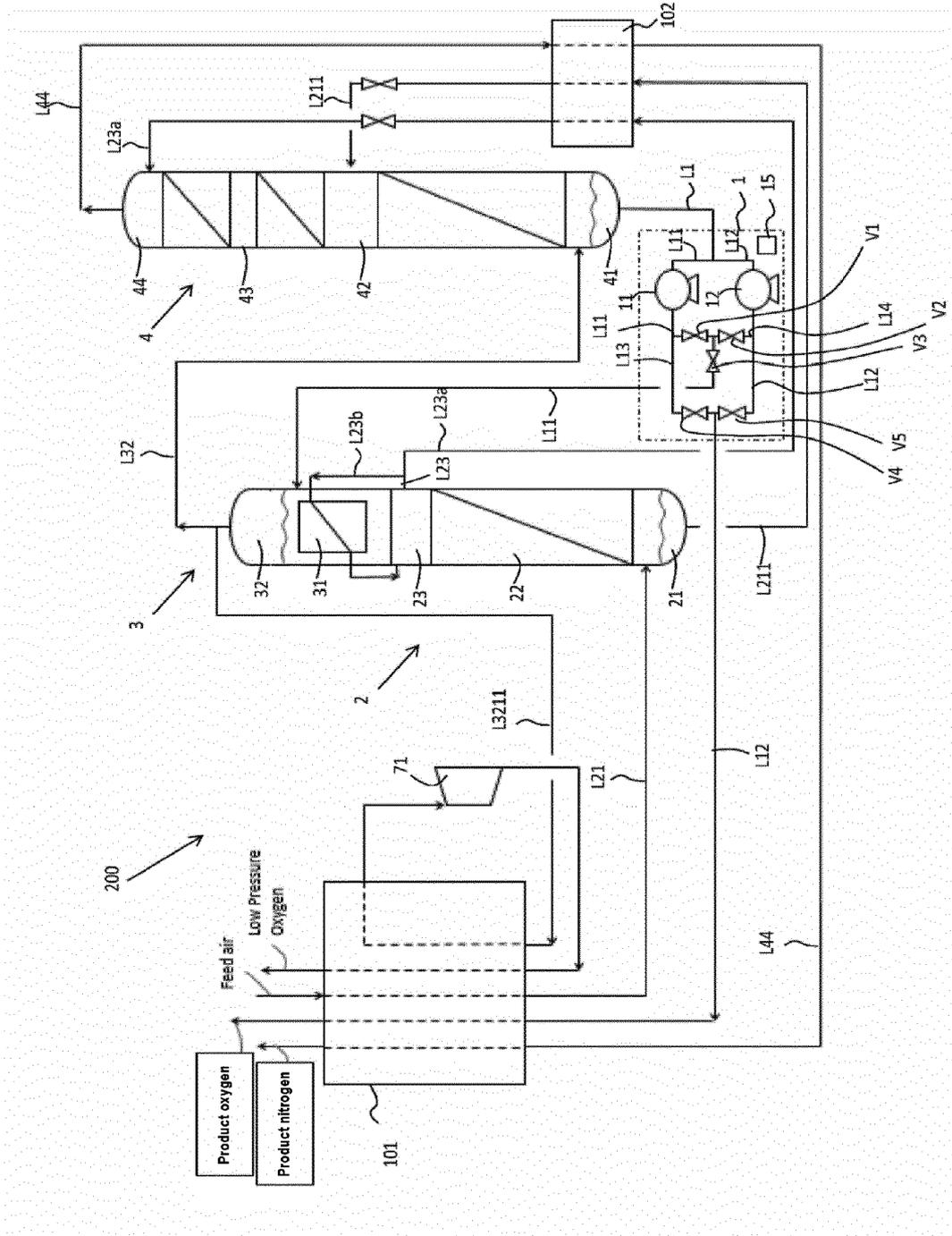
[Fig. 1B]



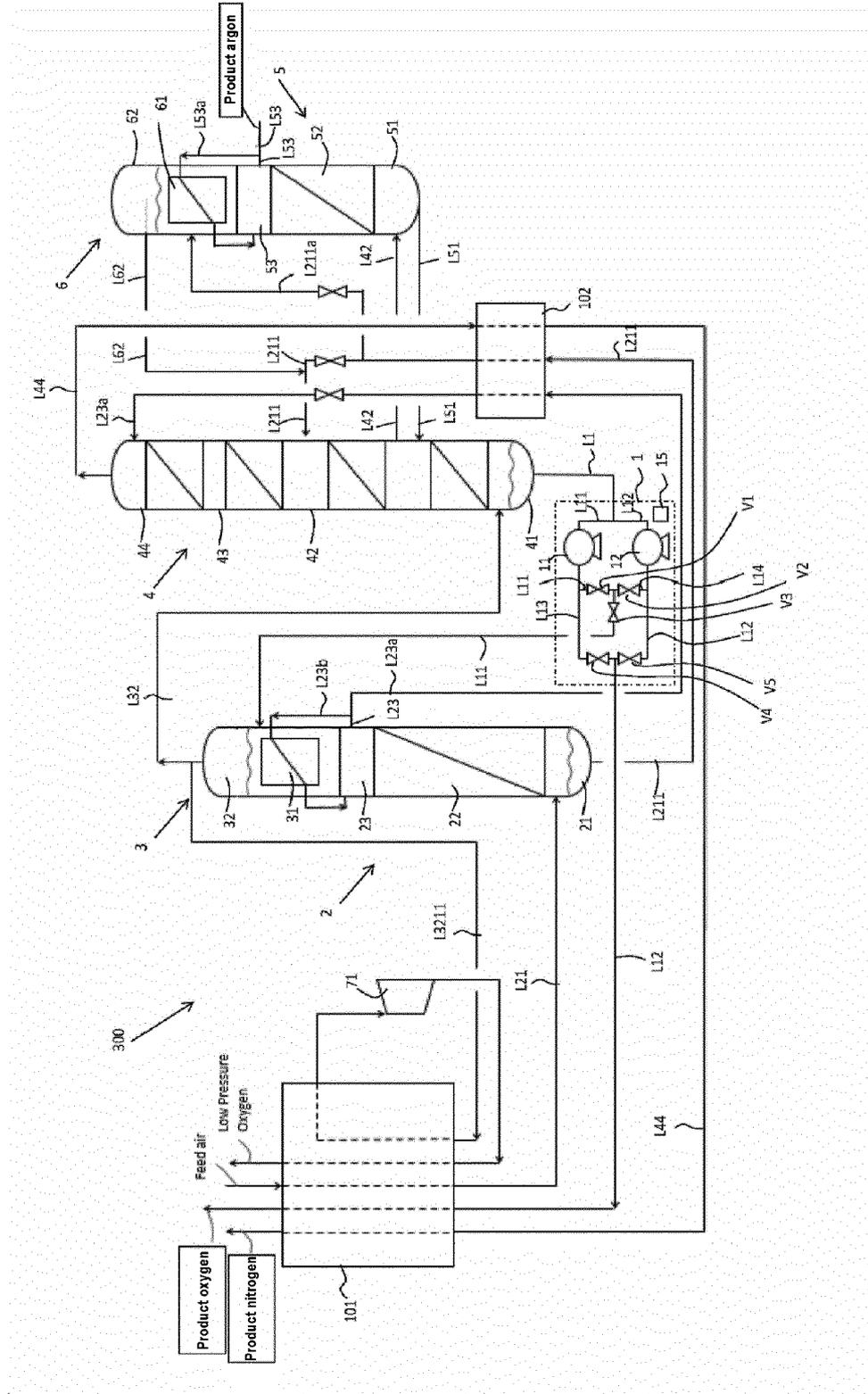
[Fig. 1D]



[Fig. 2]



[Fig. 3]





EUROPEAN SEARCH REPORT

Application Number
EP 24 17 4443

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 5 400 600 A (GRENIER MAURICE [FR]) 28 March 1995 (1995-03-28)	1-7,9-15	INV. F25J1/00
A	* paragraph [0014]; figure 1 * -----	8	
			TECHNICAL FIELDS SEARCHED (IPC)
			F25J
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 15 October 2024	Examiner Schopfer, Georg
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

1
EPO FORM 1503 03:82 (F04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 24 17 4443

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

15 - 10 - 2024

	Patent document cited in search report	Publication date	Patent family member(s)	Publication date
10	US 5400600 A	28 - 03 - 1995	AU 4135793 A	06 - 01 - 1994
			CA 2098895 A1	24 - 12 - 1993
15			CN 1080390 A	05 - 01 - 1994
			DE 69305246 T2	07 - 05 - 1997
			EP 0576314 A1	29 - 12 - 1993
			FR 2692664 A1	24 - 12 - 1993
20			JP H0658662 A	04 - 03 - 1994
			US 5400600 A	28 - 03 - 1995
			ZA 934204 B	10 - 01 - 1994
			-----	-----
25				
30				
35				
40				
45				
50				
55				

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 6257656 B [0003] [0093]
- JP 5800620 B [0003]
- WO 2021230911 A1 [0003]