

(51) International Patent Classification:
F25J 3/04 (2006.01)(21) International Application Number:
PCT/US2013/034042(22) International Filing Date:
27 March 2013 (27.03.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
13/433,352 29 March 2012 (29.03.2012) US(71) Applicant: L'AIR LIQUIDE SOCIETE ANONYME
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22nd Floor, 2700 Post Oak Boulevard, Suite 325, Houston,
Texas 77056 (US).(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP,
KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD,
ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI,
NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU,
RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ,
TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA,
ZM, ZW.(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ,
UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,
TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,
EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,
MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
ML, MR, NE, SN, TD, TG).

Published:

— without international search report and to be republished
upon receipt of that report (Rule 48.2(g))

(54) Title: PROCESS FOR THE SEPARATION OF AIR BY CRYOGENIC DISTILLATION

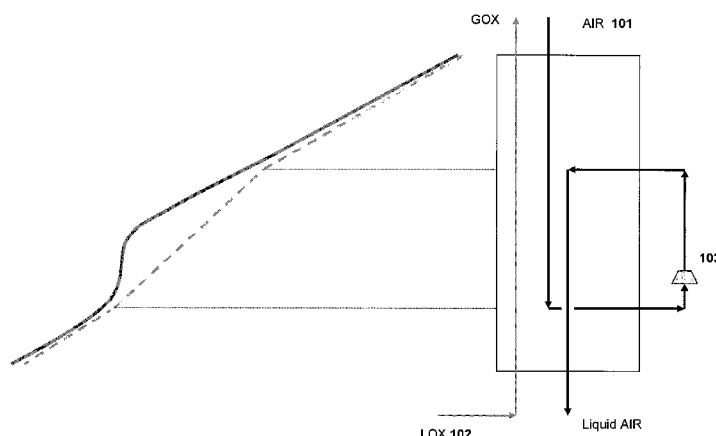


Figure 1 - Single cold compressor - PRIOR ART

(57) Abstract: A process for separation of air by cryogenic distillation, including cooling a first purified feed air stream in a heat exchanger, thereby producing a cooled first feed stream, removing a first portion from the heat exchanger at a first intermediate temperature, and compressing the cooled first portion in a first booster compressor, cooling the compressed first portion in the heat exchanger, thereby producing a cooled first portion, removing a second portion from the heat exchanger at a second intermediate temperature, and compressing the cooled second portion in a second booster compressor, cooling the compressed second portion in the heat exchanger, thereby producing a cooled second portion, and vaporizing a pressurized liquid stream from the column system in the heat exchanger at a vaporization temperature to form a pressurized gaseous product stream, wherein, both the first discharge temperature and said second discharge temperature are below - 55°C.

PROCESS FOR THE SEPARATION OF AIR BY CRYOGENIC DISTILLATION

5 **Technical Field**

The present invention relates to a process and an apparatus for the separation of air by cryogenic distillation.

10 **Background**

In what follows, “vaporization” should be considered to cover pseudo vaporization of a supercritical liquid and “vaporization temperature” should be considered to cover the inflection temperature of a supercritical liquid as it becomes less dense.

15

For impure liquids, the vaporization temperature will not be a single temperature so the term refers to the median temperature range where the liquid is vaporizing.

20

Cold compression processes are known in the field of air separation by cryogenic distillation. In general, the purpose of cold compression in air separation plant can be classified into three categories:

25

1. To improve the performance or cost effectiveness of a liquid oxygen pumped process. The improvement is achieved by injecting compression heat of cold compression into the liquid oxygen vaporization section of the heat exchanger. The new invention addresses the process improvement in this category.
2. To improve the distillation performance of an air separation plant. Heat pump cycle driven by cold compressor is a typical example of this type of cold compression plant.

3. To dissipate surplus of refrigeration provided by an external source of liquid supply.

However, the single cold compressor process as described in US-A-5475980, US-A-5966967, and US-A-5901576 is less efficient than a well optimized plant using a main air compressor in combination with a booster air compressor (MAC+BAC) by about 3-5% in terms of separation power of oxygen. By definition, the separation power of oxygen is obtained by taking the compression energy to compress feed air from atmospheric pressure to the required pressure, minus the pressure energy of the products N₂, O₂ etc. relative to atmospheric pressure. Since the distillation performance is similar for both processes, the inefficiency of the cold compressor process can be attributed to the irreversibility or inefficiency associated with the implementation of the cold compression.

Figures 3 and 4 in US-A- 6962062 show a process using two cold compressors in series to improve the process performance. The warmer cold compressor's operating temperature is much higher than the vaporization temperature of liquid oxygen, and the use of this cold compressor is applicable when large warm end temperature is encountered. The compression heat of the warmer cold compressor does not contribute to the vaporization of liquid oxygen. Only the single colder cold compressor operates in the temperature range close to the vaporization temperature of liquid oxygen and its heat of compression is injected into the exchanger to improve the vaporization of oxygen.

In US-A-7272954, an external cryogenic liquid source is fed to a distillation system to provide the refrigeration and it is suggested to use two cold compressors in series to compress cryogenically feed air to higher pressure for subsequent liquefaction in the main exchanger. It is preferable that the external source of liquid be produced during periods when power cost is low. The resulting liquid air formed by the air liquefaction is then fed to the distillation system to produce liquid oxygen, which is then pumped and vaporized to

high pressure to form gaseous oxygen product. There are some drawbacks with this approach:

1. An external liquid source is needed.
2. Feed air is essentially at the pressure of the high pressure column of the distillation system and the cold compressors in such arrangement would require quite high compression ratio such that multiple stages are needed.
3. Because of the low pressure of feed air, there is no cost savings of reduced size of the front end purification unit (FEP) for moisture and carbon dioxide removal.

Therefore, there is a need for a method and device using cold compression that provides improved power consumption.

Summary

The present invention is directed to a device and a method that satisfies at least one of these needs. Certain embodiments of the present invention relate to a process using at least two cold compressors in serial arrangement to improve the power consumption of this type of process. In certain embodiments, the cold compressors operate near the vicinity of the boiling or inflexion temperature of the vaporizing fluid from the distillation column. In another embodiment, one or more flows of pressurized air leaving a heat exchanger is expanded before entering a low pressure column, a high pressure column, or combinations thereof.

In another embodiment, a process for separation of air by cryogenic distillation is provided. In this embodiment, , including cooling a first purified feed air stream in a heat exchanger, thereby producing a cooled first feed stream, removing a first portion from the

heat exchanger at a first intermediate temperature, and compressing the cooled first portion in a first booster compressor, cooling the compressed first portion in the heat exchanger, thereby producing a cooled first portion, removing at least a portion of the cooled first portion from the heat exchanger at a second intermediate temperature, and compressing the removed portion of the cooled first portion in a second booster compressor to form a compressed second portion, cooling the compressed second portion in the heat exchanger, thereby producing a cooled second portion, and vaporizing a pressurized liquid stream from the column system in the heat exchanger at a vaporization temperature to form a pressurized gaseous product stream, wherein both said first discharge temperature and said second discharge temperature are below -55°C .

Brief Description of the Figures

Figure 1 illustrates the heat exchange diagram between vaporizing liquid oxygen under pressure, usually about 30 to 80 bar, and air as heating medium, in accordance with existing art.

Figure 2 illustrates the heat exchange diagram between vaporizing liquid oxygen under pressure, usually about 30 to 80 bar, and air as heating medium, with two cold compressors in series, in accordance with one embodiment of the present invention..

Figure 3 illustrates a schematic in accordance with one embodiment of the present invention.

Description of Preferred Embodiments

Illustrative embodiments of the invention are described below. While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and are herein described in detail. It should be understood, however, that the description herein of specific embodiments is not

intended to limit the invention to the particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

5 It will of course be appreciated that in the development of any such actual embodiment, numerous implementation-specific decisions must be made to achieve the developer's specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless
10 be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure.

The process according to certain embodiments of the invention presents several advantages over the traditional liquid pumped process:

- 15
- There is a single main air compressor (MAC): this simplifies the compression train and reduces the plant cost since the booster air compressor (BAC) is no longer needed.
 - The MAC's discharge pressure is in the range of 10 to 20 bar abs , or between 14
20 and 20 bar abs, such that the size of the front end purification unit (FEP or molsieve unit) required for moisture and CO₂ removal can be quite compact resulting in significant cost reduction.
 - By operating the MAC at such elevated pressure, the Freon ® chiller or chilled water tower for the FEP can be eliminated. This also results in significant cost
25 reduction and improving the plant reliability.

In particular it relates to a process and an apparatus for the production of gaseous oxygen under pressure, which uses two cold compressors in series to compress the feed air. A cold

compressor in this particular case is considered to be a compressor whose inlet temperature is between -60°C and -170°C .

Figure 1 illustrates the heat exchange diagram between vaporizing liquid oxygen under pressure, usually about 30 to 80 bar, and air as heating medium in accordance with the prior art. The relation between heat exchange and oxygen temperature is shown as an uninterrupted line and the relation between heat exchange and air temperature is shown as an interrupted line. A single cold compressor 103 is used in this example to compress air stream 101 to vaporize liquid oxygen stream 102. It can be seen that cold air at a temperature about 2 to 5°C warmer than the boiling point of vaporizing liquid oxygen, or the inflection temperature in case of supercritical pressure of vaporizing liquid oxygen, is admitted into the cold compressor and is compressed to higher pressure. The compressed air temperature becomes higher due to the compression heat but remains at cryogenic condition. This air is then cooled in exchanger by exchanging heat with the vaporizing oxygen. Because of the curvature almost like a step change of the heating curve of oxygen due to the phase change, it is rather difficult to minimize the temperature difference in the exchanger at those temperature levels. Large temperature difference means high irreversibility or low efficiency. The cooling of the compressed air results in the change of the slope of the air cooling curve such that the heating curve can track the cooling curve, however the linear cooling curve of air cannot efficiently warm the vaporizing liquid.

Figure 2 describes the same application but two cold compressors in series are used instead of one, in accordance with one embodiment of the present invention. Air stream 201 is compressed in a first cold compressor 203. The outlet air exiting the first cold compressor 203 is cooled and admitted to a second compressor 204 for further compressed cryogenically to higher pressure. The discharge of the second compressor is then cooled and liquefied in the exchanger. In one embodiment, the operating inlet temperatures of the two cold compressors can be selected at about 2 to 5°C warmer than the boiling or inflection temperature of vaporizing oxygen 202. It can be seen that by sending the

compressed air twice into this vaporizing section, the slope of the cooling curve of air can be changed significantly to track the heating curve of oxygen better. Furthermore, by using the two cold compressors with intercooling as such, the compression ratio of the cold compressors is reduced and smaller temperature rise can be obtainable. This further improves the heat exchange diagram and the efficiency of the compression process.

Referring now to figure 3, a liquid stream 471, preferably from a cryogenic distillation process, is introduced into a heat exchanger 490, wherein it is vaporized into a pressurized gaseous product stream 472. Purified air stream 401, which can be a compressed purified air stream, may be split into a first purified air stream 402, a second purified air stream 435, and a third purified air stream 408.

The first purified feed air stream 402, which may be further boosted in pressure in warm compressor 484, is cooled in heat exchanger 490, thereby producing a cooled first feed stream 453. A first portion 403 of this cooled first feed stream 453 is removed from an intermediate portion of heat exchanger 490 at a first intermediate temperature, and compressed in a first cold compressor 482. The compressed first portion 404 at a first discharge temperature is then cooled in heat exchanger 490, thereby producing a cooled first portion 451. A fraction 474 of the cooled first portion 451 is removed from an intermediate portion of heat exchanger 490 at a second intermediate temperature, and compressed in a second cold compressor 485.

The compressed second fraction 475, which is at a second discharge temperature, is cooled in heat exchanger 490, thereby producing a cooled second fraction 450. Both the first discharge temperature and said second discharge temperature are below -55°C .

Cooled first feed stream 453, cooled first portion 451 and cooled second fraction 450 may be combined to form liquefied air stream 455 and then sent to a first distillation column 500.

5 The liquid stream 471, may be a subcritical pressurized liquid stream from the column system (e.g., 500 and 502). The first intermediate temperature and the second intermediate may then differ in temperature by less than 10°C, or preferably less than 5°C, from the vaporization temperature.

10 The liquid stream 471 may be a supercritical pressurized liquid stream from the column system. The first intermediate temperature and the second intermediate may then differ in temperature by less than 10°C, or preferably less than 5°C, from the inflection temperature.

15 In one embodiment, the third purified air stream 408 is cooled in heat exchanger 490, the cooled third feed air stream 429 may be removed from heat exchanger 490 at a temperature lower than the first intermediate temperature and the second intermediate temperature. Cooled third feed air stream 429, may be sent to first turboexpander 486, and then at least part of the expanded second feed air stream sent to first distillation column 500. First distillation column 500 may be a medium pressure column.

20 The second purified feed air stream 435 may be cooled in heat exchanger 490, removed from heat exchanger 490 as stream 433 at a temperature lower than the first intermediate temperature and the second intermediate temperature, and sent to a second turboexpander 481. At least part of the expanded stream 434 air stream may be introduced into a second distillation column 502.

25 Purified air stream 401 may be at between 15 and 20 bar abs. The liquefied air stream 455 entering the first distillation column 500 includes a stream derived from the cooled first portion 451 and the cooled first feed stream 453. Pressurized liquid stream 471 may be vaporized at a pressure of at least 30 bar abs, preferably at least 60 bar abs, and more preferably at least 80 bar abs.

In one embodiment, no stored liquid is sent to the first distillation column 500, the second distillation column 502, or the heat exchanger 490. In one embodiment, all the refrigeration for the distillation is produced by the first turboexpander 486 and the second turboexpander 481. A third purified air stream 408 may be cooled in heat exchanger 490 to yield stream 452 and combined with one or more of the cooled first feed stream 453, the cooled first portion 451, and the cooled second fraction 450, before being sent to the first distillation column 500.

Third purified air stream 408 and second purified air stream 435 are illustrated as separate streams to ease the understanding of the process but of course can be combined as a single stream.

Example

To demonstrate the efficiency of the new invention, this process is used to simulate an oxygen plant producing 80 bar low purity gaseous oxygen at 95% by volume. No pressurized nitrogen is produced. Figure 3 illustrates this process.

The process uses a main heat exchanger 490 and a double column having a high pressure column 500 and a low pressure column 502, thermally linked by a bottom reboiler at the bottom the low pressure column.

Purified feed air stream 401 from a single main air compressor (not shown) at about 10.6 bar is fed to the main exchanger 490. A portion 402 of this air is further compressed in warm compressor 484 to yield a first compressed stream 406 at about 16 bar, which is cooled to cryogenic temperature of about -109°C in main heat exchanger 490. First portion 403 of this cooled air is then cryogenically compressed in first cold compressor 482 to form a compressed first portion 404 at 31 bar. Compressed first portion 404 is then cooled in main heat exchanger 490 to form a cooled second compressed stream, a portion of which, fraction 474, is further cryogenically compressed in second cold compressor 485

having an inlet temperature of about -109°C to form a compressed second fraction 475 at 60 bar. This stream is then cooled as cooled second fraction 450 and expanded and liquefied before feeding the column system as part of liquefied air stream 455.

5 Part of first compressed stream 406 is not sent to first cold compressor 482 but is completely cooled in the main heat exchanger 490 to form cooled first feed stream 453, is expanded in a valve and sent to first distillation column 500 as liquefied air stream 455.

10 Part of the compressed air from first cold compressor 482 is not sent to second cold compressor 485 but is cooled in the heat exchanger as cooled first portion 451 to the cold end, expanded in a valve and sent to first distillation column 500 as liquefied air stream 455.

15 Third purified air stream 408 is sent to the exchanger at 10.6 bar, cooled to a lower temperature than the inlet temperatures of the cold compressors 482, 485 and divided in two. Cooled third feed air stream 429 is sent to first turboexpander 486 and is the gaseous feed 430 sent to the bottom of the high pressure column 500. The rest of third purified air stream 408 is fully cooled in heat exchanger 490 to form stream 452, expanded and sent to the high pressure column 500 as part of liquefied air stream 455.

20 Second purified air stream 435 is cooled in the exchanger at 10.6 bar, cooled to a lower temperature than the inlet temperatures of the cold compressors 482, 485 and sent entirely to second turboexpander 481 as stream 433. The expanded stream 434 is sent to the low pressure column 502.

25 Oxygen rich liquid 470 is withdrawn from the bottom of the low pressure column 502, pressurized by pump 483 to about 80 bar and vaporized in the heat exchanger 490 to form gaseous pressurized oxygen 472.

Gaseous nitrogen from the top of the low pressure column is warmed in the heat exchanger 490 to form gaseous nitrogen stream 422.

Oxygen enriched stream 410, intermediate stream 413 and nitrogen enriched stream 414 are removed from the high pressure column 500 in liquid form, expanded and sent to low pressure column 502.

The turboexpanders 481 and 486 can be arranged to drive the first cold compressor 482, second cold compressor 485 and/or warm compressor 484. The expanders can be divided into different expanders operating in parallel mode to drive the boosters. It is also possible to use electric motor to drive one or more boosters, this may lead to a reduction of the number of expanders.

Stream	401	406	403	404	474	475	433	472	429
Flow Nm ³ /h	1000	224	192	192	139	139	315	216.2	415
Pressure bara	10.6	16	15.86	30.5	30.38	59.3	10.46	80	10.49
Temperature °C	20	30	-109	-67	-109	-66.9	-123	17	-150

By using a formula: $[\text{flow} \times 0.1 \times \log (P_2/P_1)]$ to estimate the energy of a stream at pressure P_2 relative to a pressure P_1 , a separation energy of 0.3 kWh/Nm³ is achievable with this process. The obtained efficiency is quite good and is similar to the efficiency of the mixing column process. Since there is no nitrogen being produced, the process can be adapted quite conveniently for N₂ production by extracting N₂ from high pressure column 500 (stream 443). The flow of second turboexpander 481 must then be reduced when N₂ is being produced, and the air pressure of purified air stream 401 can be raised to compensate for the reduction of expander flow.

It can be seen that in addition to the liquid formed by cooling air from the second cold compressor, a total of about 131 Nm³/h liquid air can be extracted at several pressures from the exchanger to improve the efficiency: stream 452 at 10.4 bar, cooled first feed stream

453 at 15.8 bar, cooled first portion 451 at 30.4 bar. This represents almost the same flow as the flow of the second cold compressor. Since this flow of liquefied air is not compressed by the second cold compressor, significant power savings can be obtained.

- 5 This type of process can also be used for an air separation unit producing argon with good efficiency.

It will be appreciated that the present invention also applies to the case of multiple pressurized liquids where one of the pressurized liquids is a nitrogen rich liquid.

10

Depending upon the pressure of the pressurized stream(s) and the quantity of liquid products to be produced by the air separation plant, the pressure of the main air stream from the air compressor can be between 10 and 20 bar, preferably between 11 and 15 bar.

- 15 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
20 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.

- 25 The singular forms "a", "an" and "the" include plural referents, unless the context clearly dictates otherwise.

"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.

5 “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 a range is expressed, it is to be understood that another embodiment is from the one.

10 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.

Ranges may be expressed herein as from about one particular value, and/or to about another particular value. When such particular value and/or to the other particular value, along with all combinations within said range.

15 All references identified herein are each hereby incorporated by reference into this application in their entireties, as well as for the specific information for which each is cited.

What is claimed is:

1. A process for separation of air by cryogenic distillation using a heat exchanger, a column system comprising a low pressure column and a high pressure column, the process comprising the steps of:

5 a) cooling a purified air stream in the heat exchanger to produce a liquefied air stream, the heat exchanger having a warm end, a cold end, and an intermediate portion, wherein the purified air stream is at a pressure substantially greater than the high pressure column, wherein the liquefied air stream is at a temperature T_c when leaving the cold end of the heat exchanger;

10 b) introducing the liquefied air stream to the column system under cryogenic conditions configured to produce an oxygen rich stream and a nitrogen rich stream via cryogenic distillation within the column system;

 c) withdrawing the oxygen rich stream from the column system and pressurizing the oxygen rich stream using a pump to produce a pressurized oxygen rich stream;

15

 d) introducing the pressurized oxygen rich stream to the cold end of the heat exchanger; and

 e) vaporizing the pressurized oxygen rich stream to produce a gaseous oxygen product stream at the warm end of the heat exchanger,

20 wherein step a) further includes the steps of:

 i) removing a first portion of the purified air stream from the intermediate portion of the heat exchanger and compressing the first portion in a

first cold compressor to form a boosted first portion, wherein the first portion is at a temperature T_i when leaving the intermediate portion;

ii) cooling the boosted first portion in the heat exchanger to form a cooled first portion;

5 iii) removing the cooled first portion from the intermediate portion of the heat exchanger and compressing the cooled first portion in a second cold compressor to form a boosted second portion, wherein the cooled first portion is at a temperature T_{ii} when leaving the intermediate portion; and

10 iv) cooling the boosted second portion in the heat exchanger to form the liquefied air stream,

wherein the first cold compressor operate near the vaporization temperature of vaporizing oxygen;

wherein step b) further includes the steps of:

15 i) removing a second portion of the purified air stream from the intermediate portion of the heat exchanger at a temperature T_2 and then expanding the second portion using a first turboexpander to form an expanded second portion;

 ii) introducing the expanded second portion to a low pressure column of the column system;

20 iii) removing a third portion of the purified air stream from the intermediate portion of the heat exchanger at a temperature T_3 and then expanding the third portion using a second turboexpander to form an expanded third portion; and

iv) introducing the expanded third portion to a high pressure column of the column system.

2. The process as claimed in Claim 0, wherein the purified air stream is at a pressure between about 10 and about 20 bar absolute.

5 3. The process as claimed in Claim 0, wherein the purified air stream is at a pressure between about 14 and about 20 bar absolute.

4. The process as claimed in Claim 0, wherein T_2 is colder than T_i and T_{ii} .

5. The process as claimed in Claim 0, wherein T_3 is colder than T_i and T_{ii} .

6. A process for separation of air by cryogenic distillation using a heat exchanger, a
10 column system comprising a low pressure column and a high pressure column, the process comprising the steps of:

a) cooling a purified air stream in the heat exchanger to produce a liquefied air stream, the heat exchanger having a warm end, a cold end, and an intermediate portion, wherein the purified air stream is at a pressure greater than the high pressure column,
15 wherein the liquefied air stream is at a temperature T_c when leaving the cold end of the heat exchanger;

b) introducing the liquefied air stream to the column system under cryogenic conditions configured to produce an oxygen rich stream and a nitrogen rich stream via cryogenic distillation within the column system;

c) withdrawing the oxygen rich stream from the column system and pressurizing the oxygen rich stream using a pump to form a pressurized oxygen rich stream;

d) introducing the pressurized oxygen rich stream to the cold end of the heat exchanger; and

e) vaporizing the pressurized oxygen rich stream to produce a gaseous oxygen product stream at the warm end of the heat exchanger, wherein the pressurized oxygen rich stream provides at least part of the refrigeration to cool the purified air stream,

wherein step a) further includes the steps of:

i) removing a first portion of the purified air stream from the intermediate portion of the heat exchanger and compressing the first portion in a first cold compressor to form a boosted first portion, wherein the first portion is at a temperature T_i when leaving the intermediate portion;

ii) cooling the boosted first portion in the heat exchanger to form a cooled first portion;

iii) removing the cooled first portion from the intermediate portion of the heat exchanger and compressing the cooled first portion in a second cold compressor to form a boosted second portion, wherein the cooled first portion is at a temperature T_{ii} when leaving the intermediate portion; and

iv) cooling the boosted second portion in the heat exchanger to form the liquefied air stream,

wherein T_i and T_{ii} are at about the same temperature and warmer than T_c .

7. The process as claimed in Claim 6, wherein the first cold compressor and the second cold compressor operate near the vaporization temperature of vaporizing oxygen.

8. The process as claimed in Claim 6, wherein the first cold compressor and the second cold compressor operate within about 10°C of the vaporization temperature of vaporizing oxygen.

9. The process as claimed in Claim 6, wherein the first cold compressor and the second cold compressor operate within about 5°C of the vaporization temperature of vaporizing oxygen.

10. The process as claimed in Claim 6, wherein T_i and T_{ii} are less than about -55°C.

11. The process as claimed in Claim 6, wherein the purified air stream is at ambient temperature conditions just prior to being cooled in the heat exchanger.

12. The process as claimed in Claim 6, further comprising the steps of:

removing a second portion of the purified air stream from the intermediate portion of the heat exchanger at a temperature T_2 and then expanding the second portion using a first turboexpander to form an expanded second portion; and

introducing the expanded second portion to a low pressure column of the column system.

13. The process as claimed in Claim 12, wherein T_2 is colder than T_i and T_{ii} .

14. The process as claimed in Claim 6, further comprising the steps of:

removing a third portion of the purified air stream from the intermediate portion of the heat exchanger at a temperature T_3 and then expanding the third portion using a second turboexpander to form an expanded third portion; and

5 introducing the expanded third portion to a high pressure column of the column system.

15. The process as claimed in Claim 14, wherein T_3 is colder than T_i and T_{ii} .

16. The process as claimed in Claim 6, further comprising compressing the purified air stream in a warm booster prior to step a).

10 17. The process as claimed in Claim 6, wherein the purified air stream is at a pressure between about 10 and about 20 bar absolute.

18. The process as claimed in Claim 6, wherein the pressurized oxygen rich stream is at a pressure of at least 50 bar abs.

15 19. The process as claimed in Claim 6, wherein the pressurized oxygen rich stream is at a pressure of at least 60 bar abs.

20. The process as claimed in Claim 6, wherein the pressurized oxygen rich stream is at a pressure of at least 70 bar abs.

21. The process as claimed in Claim 6, wherein the compression heat of the first cold compressor and the second cold compressor contributes to vaporizing the pressurized oxygen rich stream.

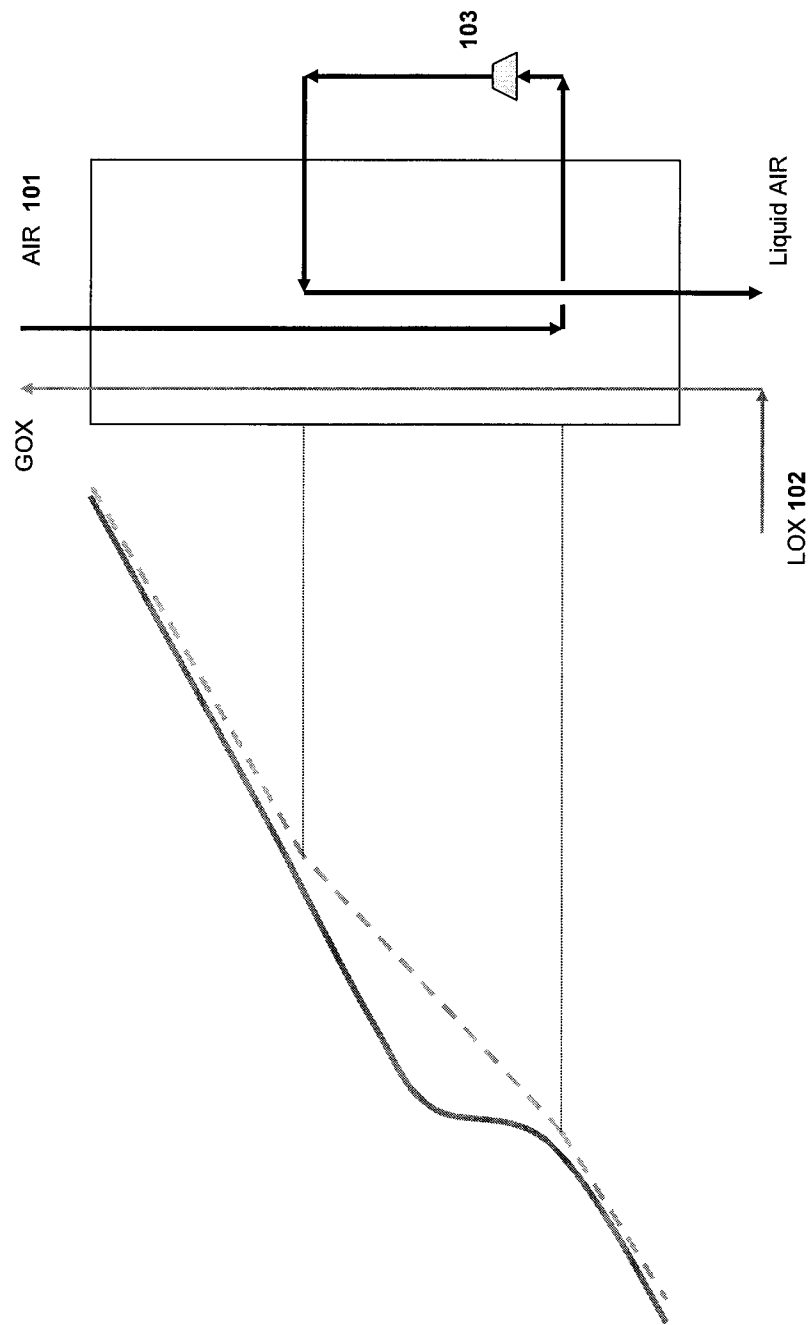


Figure 1 - Single cold compressor – PRIOR ART

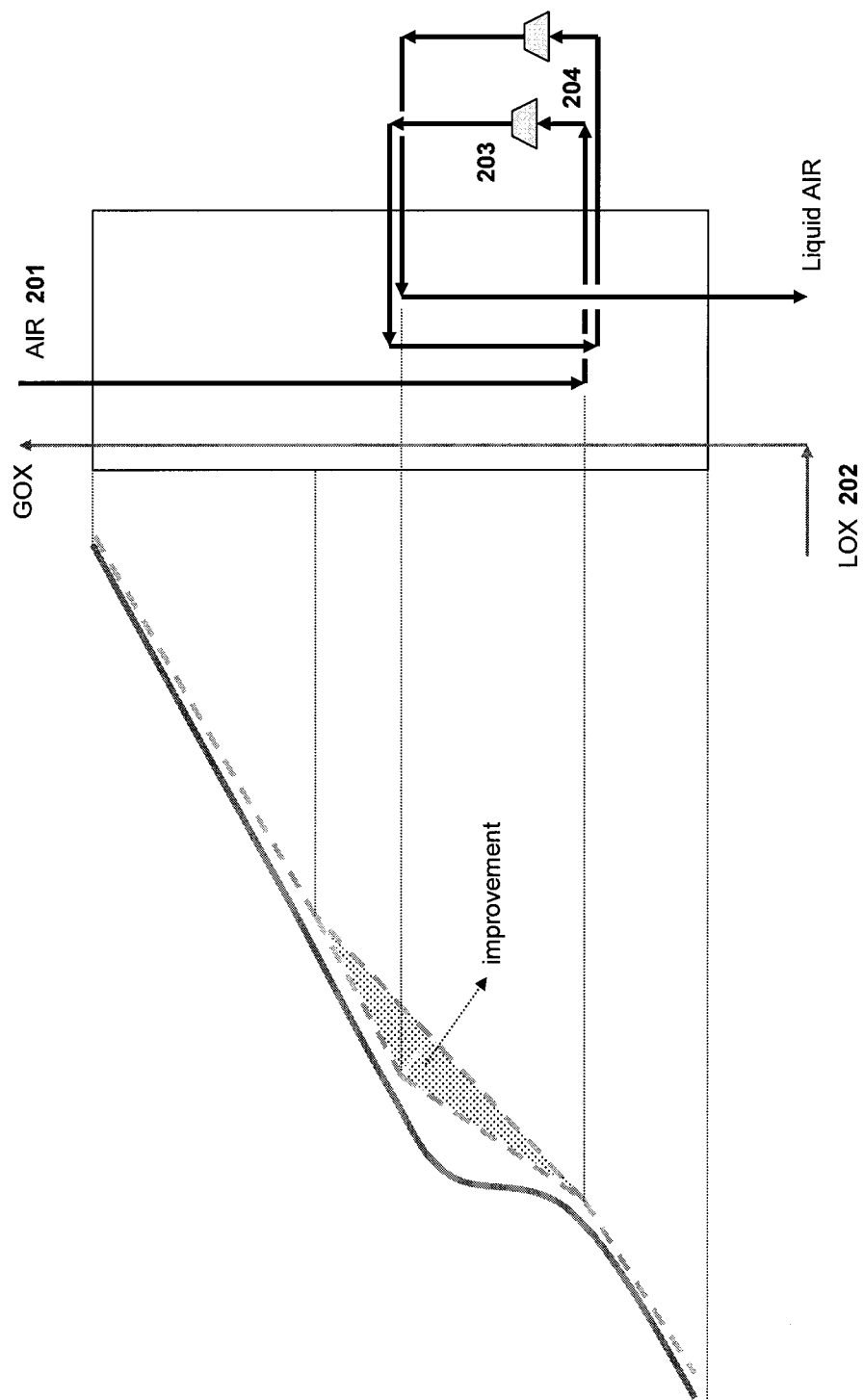


Figure 2

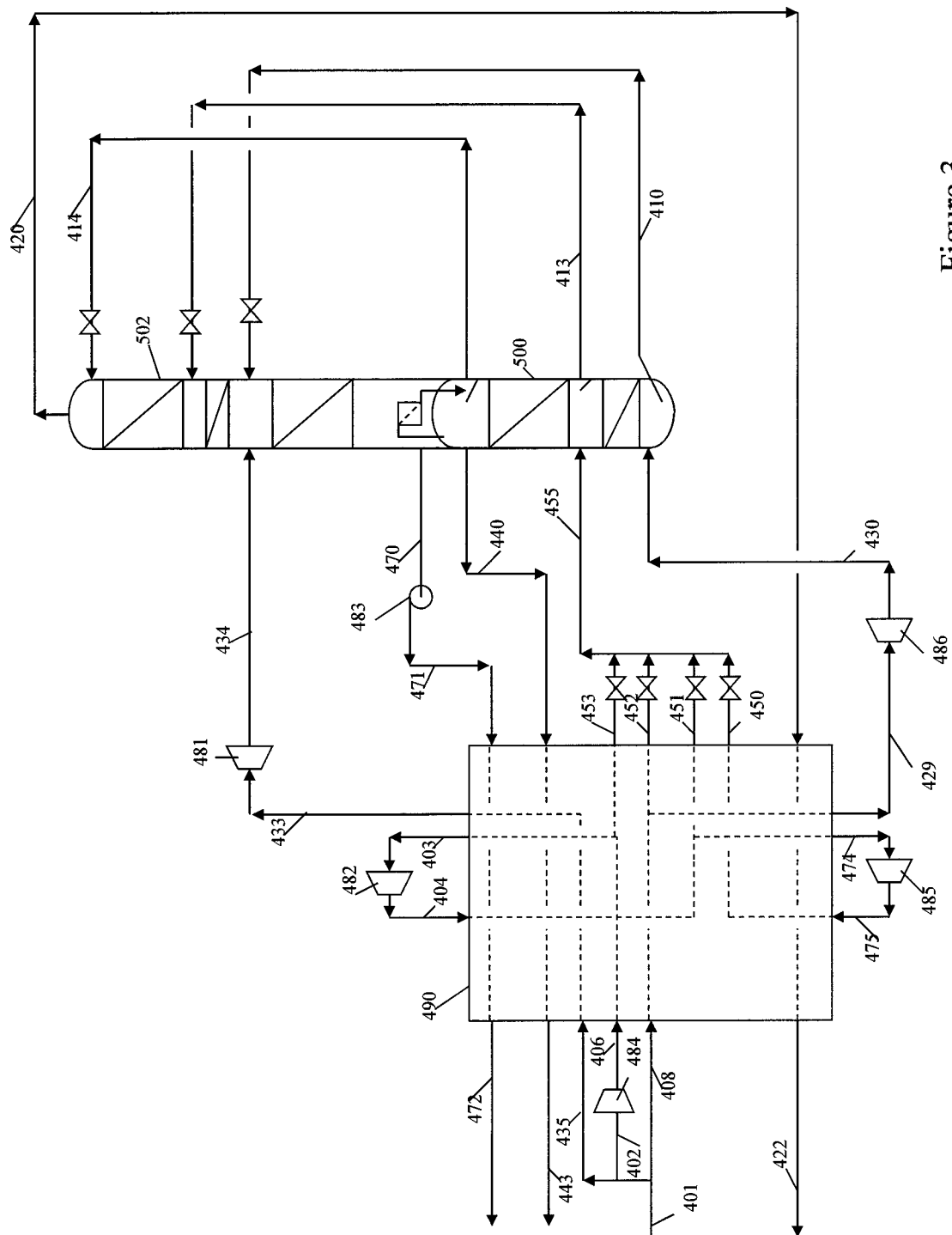


Figure 3