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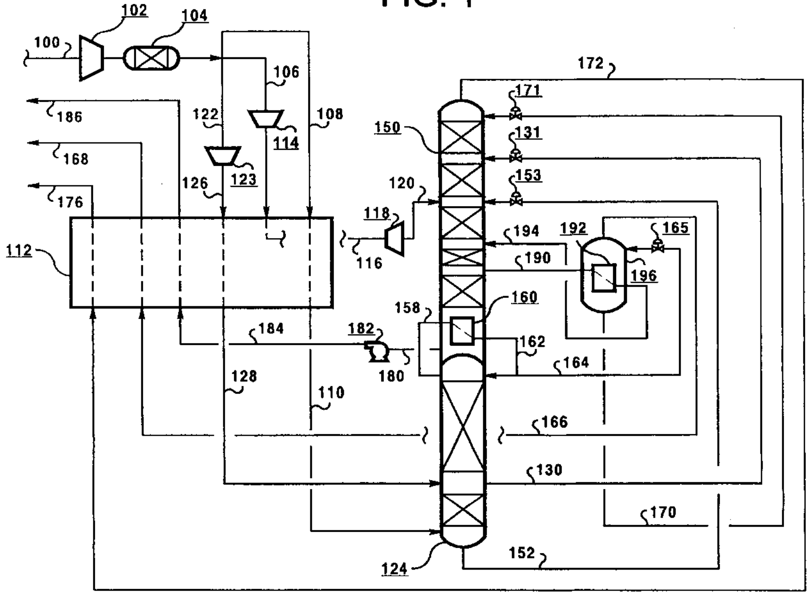
(54) **Medium-pressure nitrogen production with high oxygen recovery**

(57) Oxygen (186) and nitrogen (168) are obtained by a cryogenic air separation process using a distillation system having at least a higher pressure column (124) and a lower pressure column (150). A nitrogen-enriched liquid stream (164) is recovered from the higher pressure column (124) and is at least partially vaporized by indirect heat exchange (192) at a pressure intermediate that of the higher pressure column (124) and the lower pressure column (150). A vapor stream (190) is withdrawn from an intermediate location of the stripping section of the lower pressure column (150) and is at least partially condensed by indirect heat exchange (192) with the nitrogen-enriched liquid stream (164). At least some of the nitrogen product (168) is recovered from the vapor (166) that results from the at least partial vaporization (192) of the nitrogen-enriched liquid (164). The process is appropriate for the production of nitrogen in quantities up to 40 mole % of the incoming air flow (100).

FIG. 1



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Description

[0001] The present invention relates to cryogenic air separation processes for the production of oxygen and nitrogen products, and in particular to processes for the production of nitrogen in quantities up to 40 mole % of the incoming air flow and the production of oxygen at a purity greater than 95 mole %.

[0002] Many cryogenic air separation plants that supply oxygen as the main product also are required to produce some nitrogen. This requirement is common in various industries, such as steel production. In the well known double-column distillation configuration, nitrogen can be conveniently produced from either the lower pressure column or the higher pressure column.

[0003] Producing nitrogen as a vapor from the top of the higher pressure column decreases the amount of nitrogen that can be condensed on the top of that column and thereby decreases the amount of boilup that is produced for the lower pressure column in the thermally integrated reboiler-condenser. This action can decrease the oxygen recovery and, therefore, can increase the power consumption of that process. The increase in power consumption is due to the increased air feed flow associated with a reduction in oxygen recovery. Much of the increase in power consumption is offset by reduced nitrogen compression power, which results from recovering the nitrogen product at a pressure essentially that of the higher pressure column. If, in addition to oxygen, the plant also is producing argon, then argon recovery also decreases due to the reduced boilup in the lowest section of the lower pressure column.

[0004] If nitrogen is produced as a vapor from the top of the lower pressure column, then the boilup in the lowest section of the lower pressure column is unaffected and high levels of both oxygen and argon recovery can be maintained. However, a nitrogen product compressor typically is required to boost the nitrogen product to the desired pressure. This increases both the capital investment and the power consumption of the process. If the nitrogen requirement is relatively high (*e.g.*, nitrogen to-oxygen product ratio of more than 1.5), this may be the preferred option, as the oxygen recovery penalty for producing nitrogen from the higher pressure column becomes more significant.

[0005] JP-A-07-270064 discloses a process aimed at nitrogen production from an oxygen plant with an argon column. A portion of the higher pressure column liquid nitrogen is reduced in pressure and vaporized to drive an intermediate-condenser located in the rectification section of the lower pressure column (above the point at which the oxygen-enriched stream from the higher pressure column is introduced). The nitrogen product is derived from the liquid vaporized in the intermediate-condenser. This nitrogen can be produced at a slightly higher pressure than the lower pressure column.

[0006] US-A-4,817,394 (Erickson) and US-A-4,854,954 (Erickson) both disclose distillation systems where nitrogen is produced at a pressure greater than the lower pressure column by vaporizing a portion of higher pressure column liquid nitrogen in an intermediate-condenser attached to the argon column.

[0007] EP-A-0 639 746 (Sweeney) discloses an air separation process where a portion of the higher pressure column liquid nitrogen is vaporized to drive a condenser on top of the lower-pressure column to generate reflux for the lower-pressure column and to produce gaseous nitrogen product. In this case, the nitrogen is produced at a pressure less than that of the lower pressure column.

[0008] It is desired to have a process having a lower pressure column and a higher pressure column whereby nitrogen is produced from the process at a pressure greater than the pressure of the lower pressure column without reducing the boilup in the bottom section of the lower pressure column.

[0009] It is further desired to have a more efficient and improved process for the production of nitrogen.

[0010] It is still further desired to have a process for the production of nitrogen which overcomes the difficulties and disadvantages of the prior art to provide better and more advantageous results.

[0011] A modification of a typical two-column oxygen-producing cryogenic air separation process allows nitrogen production at a pressure between the pressures of the two columns by vaporizing liquid nitrogen product from the higher pressure column against a condensing lower pressure column stream. Such an arrangement increases oxygen recovery, thus reducing energy consumption.

[0012] The present invention is a cryogenic air separation process for the production of oxygen and nitrogen using a distillation system that comprises at least a higher pressure column and a lower pressure column. A nitrogen-enriched liquid stream is derived from the higher pressure column and is at least partially vaporized by indirect heat exchange at a pressure intermediate that of the higher pressure column and the lower pressure column. A vapor stream is withdrawn from an intermediate location of the stripping section of the lower pressure column and at least partially condensed by indirect heat exchange with the nitrogen-enriched liquid stream.

[0013] The term "stripping section" is defined to mean that section of a distillation column which resides below the location at which the feeds to that column are introduced. The associated term "intermediate location" is defined to mean a location which is not at the bottom.

[0014] The present invention is applicable for the production of oxygen at a purity greater than 95 mole % and more preferably for the production of oxygen at a purity greater than 98 mole %.

[0015] In the practice of the present invention at least some of the nitrogen product may be recovered from the vapor that results from the at least partial vaporization of the nitrogen-enriched liquid. The present invention is appropriate for the production of nitrogen in such a manner in quantities up to 40 mole % of the incoming air flow. The present invention is particularly attractive if the pressure of the nitrogen product is required to be greater than 1.5 times the pressure of the lower pressure column and less than 0.9 times the pressure of the higher pressure column.

[0016] The vapor stream which is withdrawn from an intermediate location of the stripping section of the lower pressure column typically contains less than 3 mole % nitrogen and less than 15 mole % argon, with the balance being primarily oxygen. After this vapor stream is at least partially condensed, it may be returned to the lower pressure column or alternatively, in the event that an argon column is associated with the process, it may be passed to the argon column.

[0017] A first embodiment of the invention is a process for separating air to produce an oxygen product and a nitrogen product. The process uses a distillation column system having at least two distillation columns, including a higher pressure column at a first pressure and a lower pressure column at a second pressure lower than the first pressure. The lower pressure column has a stripping section and is in thermal communication with the higher pressure column. At least a portion of a stream of compressed air is fed to the distillation column system; a nitrogen-enriched liquid stream is provided by the higher pressure column; and a vapor stream is withdrawn from the lower pressure column at an intermediate location of the stripping section of the lower pressure column. At least part of the vapor stream is heat exchanged with at least part of the nitrogen-enriched stream, thereby at least partially condensing at least part of the vapor stream to form a condensate and at least partially vaporizing at least part of the nitrogen-enriched liquid stream to form a nitrogen-enriched vapor, at an intermediate pressure between the first pressure and the second pressure.

[0018] The nitrogen-enriched liquid stream can be withdrawn from the top of the higher pressure column or from an intermediate location of the higher pressure column.

[0019] At least a portion of the nitrogen-enriched vapor can be withdrawn from the distillation column system as at least a portion of the nitrogen product. The portion of the nitrogen product that is the nitrogen-enriched vapor can be less than or equal to 40 mole % of the stream of compressed air. The nitrogen product can have a third pressure between 1.5 times the second pressure and 0.9 times the first pressure. The nitrogen-enriched vapor can be compressed at a temperature near an ambient temperature.

[0020] At least a portion of the condensate can be fed to the lower pressure column at or above the intermediate location or to an argon distillation column at or above the bottom of the argon distillation column.

[0021] Another embodiment of the invention is a process for separating air to produce an oxygen product and a nitrogen product using a distillation column system having at least three distillation columns, including a higher pressure column at a first pressure, a lower pressure column at a second pressure lower than the first pressure, and an additional column. The lower pressure column has a stripping section and is in thermal communication with the higher pressure column. At least a portion of the stream of compressed air is fed to the distillation column system; and a nitrogen-enriched liquid stream is derived from the higher pressure column. A vapor stream is withdrawn from the lower pressure column at an intermediate location of the stripping section of the lower pressure column. A first part of the vapor stream is fed to a feed location at or adjacent the bottom of the additional column. A second part of the vapor stream is heat exchanged with at least part of the nitrogen-enriched liquid stream, thereby at least partially condensing at least part of the second part of the vapor stream to form a condensate and at least partially vaporizing at least part of the nitrogen-enriched liquid stream to form a nitrogen-enriched vapor, at an intermediate pressure between the first pressure and the second pressure.

[0022] At least a portion of the condensate can be fed to the additional column or to the lower pressure column at or above the intermediate location.

[0023] Another aspect of the present invention is a cryogenic air separation apparatus for the production of oxygen and nitrogen using a process of the invention, said apparatus comprising:

a higher pressure column;
a lower pressure column having a stripping section;
heat exchange means for indirectly heat exchanging a vapor stream from an intermediate location of the stripping section of the lower pressure column with a nitrogen-enriched liquid stream derived from the high pressure column to at least partially condensing the vapor stream to form a condensate and at least partially vaporizing the nitrogen-enriched liquid stream to form a nitrogen-enriched vapor;
conduit means for feeding a nitrogen-enriched liquid stream derived from the higher pressure column to said heat exchange means;
pressure reducing means for reducing the pressure of said nitrogen-enriched liquid stream in said conduit means to a pressure intermediate that of the higher pressure column and the lower pressure column; and
conduit means for feeding a vapor stream from an intermediate location of the stripping section of the lower pressure column to said heat exchange means.

[0024] In a preferred embodiment of the apparatus aspect, the apparatus comprises:

a distillation column system comprising at least a higher pressure column and a lower pressure column having a stripping section and being in thermal communication with the higher pressure column;
conduit means for feeding a stream of compressed air to the distillation column system;
heat exchange means for indirectly heat exchanging a vapor stream from an intermediate location of the stripping section of the lower pressure column with a nitrogen-enriched liquid stream derived from the high pressure column to at least partially condensing the vapor stream to form a condensate and at least partially vaporizing the nitrogen-enriched liquid stream to form a nitrogen-enriched vapor;
conduit means for feeding a nitrogen-enriched liquid stream derived from the higher pressure column to the heat exchange means;
pressure reducing means for reducing the pressure of said nitrogen-enriched liquid stream in said conduit means to a pressure intermediate that of the higher pressure column and the lower pressure column; and
conduit means for feeding a vapor stream from an intermediate location of the stripping section of the lower pressure column to the heat exchange means.

[0025] The invention will be described by way of example with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram of one embodiment of the present invention;
Figure 2 is a schematic diagram of a second embodiment of the present invention; and
Figure 3 is a schematic diagram of a third embodiment of the present invention.

[0026] One embodiment of the invention is shown in Figure 1. Feed air 100 is compressed in main air compressor 102, purified in purifier 104, and divided into three streams: stream 106, stream 108, and stream 122. Stream 106 is, optionally, compressed in air booster 114, is partially cooled in main heat exchanger 112 to form stream 116, which is expanded in air expander 118, and introduced to lower pressure column 150 as feed 120. Stream 108 is partially cooled in main heat exchanger 112 and then introduced into higher pressure column 124 as feed 110. Stream 122 is increased in pressure in air booster compressor 123. The resulting pressurized stream 126 is cooled and at least partially condensed in main heat exchanger 112, and introduced to higher pressure column 124 as stream 128.

[0027] Liquid stream 130, which typically has a composition similar to that of air, is removed from an intermediate location of the higher pressure column 124 and reduced in pressure across valve 131 and introduced into the lower pressure column 150 as a feed. An oxygen-enriched stream 152 is removed from the bottom of the higher pressure column and reduced in pressure across valve 153 and introduced into the lower pressure column as an additional feed. Persons skilled in the art will recognize that other pressure reduction devices may be used in place of valve 153, including but not limited to dense fluid expanders and ejectors.

[0028] Higher pressure column overhead vapor stream 158 is condensed in reboiler-condenser 160 to produce liquid stream 162. The heat rejected by the condensation provides boilup for the bottom of the lower pressure column 150. A portion of liquid stream 162 provides reflux for the higher pressure column 124. Another portion, nitrogen-enriched liquid stream 164, is reduced in pressure across valve 165 and at least partially vaporized in heat exchanger 192. The pressure of vaporization is intermediate the pressure of the higher pressure column and the pressure of the lower pressure column.

[0029] In this embodiment, heat exchanger 192 is enclosed in vessel 196 to facilitate the separation of vapor and liquid fractions. Heat exchanger 192 and vessel 196 may be incorporated into the higher pressure or the lower pressure column design in a vertically stacked arrangement.

[0030] That portion of the at least partially vaporized nitrogen-enriched stream which remains liquid is removed from vessel 196 as stream 170. Stream 170 is reduced in pressure across valve 171 and introduced to the lower pressure column 150 as a top feed. The vapor portion from vessel 196, stream 166, is warmed in main heat exchanger 112 and recovered as medium pressure gaseous nitrogen product 168.

[0031] The heat required to at least partially vaporize the nitrogen-enriched liquid stream 164 and thereby produce vapor stream 166 is provided by at least partially condensing vapor stream 190. In accordance with the invention, stream 190 is withdrawn from a location in lower pressure column 150 below the locations at which the lower pressure column feeds enter but above the bottom reboiler-condenser 160 of the lower pressure column. In other words, vapor stream 190 is withdrawn from an intermediate location of the stripping section in the lower pressure column. Stream 190 is at least partially condensed in heat exchanger 192 to form stream 194. Stream 194 is returned to the lower pressure column at a location at or above the location from which stream 190 is withdrawn.

[0032] Liquid oxygen is removed from the lower pressure column 150 as stream 180, is raised in pressure by pump 182 to form stream 184, is vaporized and warmed in main heat exchanger 112, and is recovered as gaseous oxygen product 186. Lower pressure column vapor overhead stream 172 is a waste stream that is warmed in the main heat exchanger and vented into the atmosphere as stream 176.

[0033] In the field of distillation, the condensation of a vapor stream from the stripping section of the lower pressure column (in the section below the column feeds) is counter to the conventional wisdom. Traditionally, intermediate-condensation is performed in the rectification section (in a section above the lowest feed). The present invention is able to depart from conventional practice due to the recognition that the stripping section of the lower pressure column is really performing two separations. In the lowest region of the stripping section, a relatively difficult oxygen-argon separation is taking place - - a separation which requires a high level of boilup. As one moves up in the stripping section, a less difficult oxygen-nitrogen separation takes place and, consequently, less boilup is required.

[0034] Figure 2 illustrates another embodiment of the invention. For brevity, streams in Figure 2 common to those in Figure 1 are omitted from the discussion below. Figure 2 shows the application of the invention when the recovery of argon is desired.

[0035] An argon-enriched vapor is withdrawn from the stripping section of the lower pressure column 150 as stream 286. Stream 286 is split into two fractions: stream 288 and stream 290. Stream 288 is introduced to the bottom of the argon column 200. Argon-enriched stream 298 is recovered off the top of the argon column 200. Argon-depleted liquid stream 296 is returned to the lower pressure column.

[0036] As in Figure 1, an oxygen-enriched stream 152 is removed from the bottom of the higher pressure column 124. However, in this embodiment at least a portion of stream 152 is reduced in pressure across valve 253 and at least partially vaporized to form stream 252. The vaporization energy is used to provide the refrigeration necessary to drive condenser 202 of argon column 200.

[0037] In accordance with the invention, stream 290, which is derived from a vapor stream 286 taken from an intermediate location of the stripping section in the lower pressure column 150, is at least partially condensed in heat exchanger 192 to form stream 294. Stream 294 is introduced to argon column 200 at a location at or above the location to which stream 288 is introduced; alternatively stream 294 may be returned to the lower pressure column at a location at or above the location from which stream 286 is withdrawn. The refrigeration to at least partially condense stream 290 is supplied by at least partially vaporizing the nitrogen-enriched stream at an intermediate pressure thereby producing vapor stream 166.

[0038] Figure 3 illustrates one possible nitrogen product compression arrangement. For brevity, streams in Figure 3 common to those in Figure 1 are omitted from the discussion below.

[0039] Referring to Figure 3, lower pressure column vapor overhead stream 172 is compressed at near ambient temperature in compressor 375 to yield nitrogen product stream 376. A portion of the higher pressure column overhead vapor stream 158 is withdrawn as high pressure nitrogen stream 300, which is compressed in compressor 309 to yield nitrogen product stream 310. The vapor portion from vessel 196, stream 166, is warmed in the main heat exchanger 112 and is compressed in compressor 367 to yield nitrogen product stream 368. At least two of those three nitrogen product streams (310, 368, 376) and stream 166, and at least one compressor, may be present in an air separation unit, and the compression service may be combined in separate or integrated machines to yield one product at a certain desired pressure.

EXAMPLE

[0040] The efficacy of the present invention is best illustrated through an example. The process of Figure 2 is selected to represent the present invention. Prior art process 1 is the process of Figure 2 with heat exchanger 192 removed and nitrogen product recovered as a vapor from the higher pressure column 124. Prior art process 2 is the process of Figure 2 with heat exchanger 192 removed and nitrogen product recovered as a vapor from the lower pressure column 150.

[0041] The basis of comparison is as follows: 1) oxygen product is produced at a pressure of 65 psia (450 kPa) and purity of 99.5 mole % oxygen; 2) nitrogen product is recovered at a pressure of 35 psia (240 kPa), 55 psia (380 kPa), or 100 psia (690 kPa) and a purity of 50 ppm oxygen - the flow of nitrogen is equal to the flow of oxygen; 3) crude argon product is recovered as a liquid at a purity of 2 mole % oxygen - the flow of argon is approximately 3% of the oxygen, this represents an argon recovery level of approximately 65%; and 4) the lower pressure column operates at approximately 18 psia (125 kPa) at the top and the higher pressure column at approximately 72 psia (500 kPa) at the top.

[0042] For the comparison basis defined above, only prior art process 2 requires post compression of the nitrogen product if required at 35 psia (240 kPa) or 55 psia (380 kPa); all three processes require post compression of nitrogen product if required at 100 psia (690 kPa). The table below summarizes key results:

TABLE

	Present Invention	Prior Art 1	Prior Art 2
	lb mole/h (kg mole/h)	lb mole/h (kg mole/h)	lb mole/h (kg mole/h)
Oxygen Flow	20.95 (9.502)	20.95 (9.502)	20.95 (9.502)
Nitrogen Flow	20.95 (9.502)	20.95 (9.502)	20.95 (9.502)
Argon Flow	0.64 (0.290)	0.64 (0.290)	0.64 (0.290)
Air Flow	104.7 (47.49)	107.2 (48.63)	100.7 (45.68)
Compression Power	kW	kW	kW
Nitrogen at 35 psia (240 kPa)	91.8	94.8	92.4
Nitrogen at 55 psia (380 kPa)	91.8	94.8	96.8
Nitrogen at 100 psia (690 kPa)	97.5	98.2	102.3

[0043] For producing nitrogen at 35 psia (240 kPa), the present invention saves 3.2% power compared to prior art process 1 and 0.7% power compared to prior art process 2. For producing nitrogen at 55 psia (380 kPa), the present invention saves 3.2% power compared to prior art process 1 and 5.2% power compared to prior art process 2. For producing nitrogen at 100 psia (690 kPa), the present invention saves 0.7% power compared to prior art process 1 and 4.7% power compared to prior art process 2. Compression power includes the power to compress all the air feeds, plus the power to boost the nitrogen to delivery pressure (when required).

[0044] The results show that the present invention saves power over prior art process 1 even when the pressure of the nitrogen product exceeds that of the higher pressure column. The results also show that the present invention saves power over prior art process 2 when the pressure of the nitrogen product exceeds twice that of the lower pressure column. Even in those cases where the power of prior art process 2 is less than that of the present invention (when nitrogen pressure is less than 30 psia (210 kPa)), the present invention has an advantage over prior art process 2 in that the costly compression machinery for the nitrogen product can be eliminated.

[0045] Numerous modifications or additions may be applied to the embodiments shown in Figures 1, 2 and 3.

[0046] For example, the discussion has centered around processes that produce oxygen by pumping the oxygen liquid and vaporizing it in the main heat exchanger 112. However, persons skilled in the art will recognize that the present invention also is applicable when the liquid oxygen pressure is increased without the use of a pump 182 prior to vaporization. Furthermore, the oxygen product need not be vaporized in the main heat exchanger nor is it essential that pressurized air stream 126 be at least partially condensed - - some other suitable pressurized stream may be employed. In addition, the oxygen product need not be withdrawn from the lower pressure column 150 as a liquid. Rather, the oxygen may be withdrawn from the lower pressure column as a vapor, in which event pressurized air stream 126 would not be necessary.

[0047] In the preceding discussions, the liquefied air feed stream 128 is shown to be directed to the higher pressure column 124. Persons skilled in the art that will recognize some or all of the air feed stream 128 also may be sent to the lower pressure column 150. In such an event, liquid stream 130 would not be required.

[0048] Refrigeration for the process has been illustrated by the expansion of a portion of air to the lower pressure column 150. However, persons skilled in the art will recognize that other refrigeration means exist. Examples include but are not limited to: 1) expansion of a portion of air to the higher pressure column 124; 2) expansion of waste stream 172 from the lower pressure column; and 3) expansion of a vapor from the higher pressure column, such as a portion of stream 158. Furthermore, it is entirely feasible to expand vapor stream 166 in a turbo expander to provide some or all of the refrigeration required by the process.

[0049] It will be understood that other processing steps may exist before any pressure reduction or other operation. For example, it is common practice to cool liquid streams prior to their introduction to the lower pressure column 150. This cooling is provided by warming cold returning vapor streams, such as stream 172.

[0050] The focus of the discussion has been on the production of a single oxygen product and a single nitrogen product. However, persons skilled in the art will recognize that the present invention also is applicable when multiple oxygen products and/or multiple nitrogen products are produced. Furthermore, these products need not be the same purity. With regard to multiple nitrogen products, one may elect to produce a portion of nitrogen from either or both of the higher pressure column 124 and/or the lower pressure column 150 in addition to the primary, intermediate pressure nitrogen product stream 168.

[0051] The reflux, or top feed, for the lower pressure column 150 is shown as stream 170. Other optional reflux streams exist. Examples include but are not limited to: 1) a liquid from an intermediate location of the higher pressure column 124; and 2) a portion of liquid stream 162 (liquid from the top of the higher pressure column). In such an event, stream 170 may or may not be optionally required.

[0052] Nitrogen-enriched liquid stream 164 is shown to be recovered from the top of the higher pressure column 124. It is within the scope of the present invention to remove stream 164 as a liquid from an intermediate location of the higher pressure column. Typically, this location will be above that point from which stream 130 is removed.

[0053] Although illustrated and described herein with reference to certain specific embodiments, the present invention is nevertheless not intended to be limited to the details shown. Rather, various modifications may be made in the details within the scope of the following claims.

Claims

1. A cryogenic air separation process for the production of oxygen and nitrogen, said process using a distillation system that comprises at least a higher pressure column and a lower pressure column, the lower pressure column having a stripping section, **characterized in that** a nitrogen-enriched liquid stream derived from the higher pressure column and at a pressure intermediate that of the higher pressure column and the lower pressure column is at least partially vaporized by indirect heat exchange with a vapor stream which is withdrawn from an intermediate location of the stripping section of the lower pressure column and at least partially condensed by said indirect heat exchange.

2. A process as claimed in Claim 1 for separating air to produce an oxygen product and a nitrogen product, said process using a distillation column system having at least two distillation columns, including a higher pressure column at a first pressure and a lower pressure column at a second pressure lower than the first pressure, the lower pressure column having a stripping section and being in thermal communication with the higher pressure column, comprising:

feeding at least a portion of a stream of compressed air to the distillation column system;
providing a nitrogen-enriched liquid stream from the higher pressure column;
withdrawing a vapor stream from the lower pressure column at an intermediate location of the stripping section of the lower pressure column; and
heat exchanging at least part of the vapor stream with at least part of the nitrogen-enriched liquid stream, thereby at least partially condensing at least part of the vapor stream to form a condensate and at least partially vaporizing at least part of the nitrogen-enriched liquid stream to form a nitrogen-enriched vapor, at an intermediate pressure between the first pressure and the second pressure.

3. A process as claimed in Claim 1 or Claim 2, comprising feeding at least a portion of the condensate to the lower pressure column at or above the intermediate location.

4. A process as claimed in any one of the preceding claims, comprising feeding at least a portion of the condensate to an argon distillation column at or above the bottom of the argon distillation column.

5. A process as claimed in any one of the preceding claims, wherein the nitrogen-enriched liquid stream is derived from the top of the higher pressure column.

6. A process as claimed in Claim 5, wherein the nitrogen-enriched liquid stream is provided by condensation of a nitrogen-enriched vapor stream withdrawn from the higher pressure column by indirect heat exchange against vaporizing oxygen-enriched liquid from the lower pressure column.

7. A process as claimed in any one of Claims 1 to 4, wherein the nitrogen-enriched liquid is withdrawn from an intermediate location of the higher pressure column.

8. A process as claimed in any one of the preceding claims, wherein at least a portion of the nitrogen-enriched vapor is withdrawn from the distillation column system as at least a portion of the nitrogen product.

9. A process as claimed in Claim 8, comprising compressing said nitrogen-enriched vapor at a temperature near an ambient temperature.

10. A process as claimed in Claim 8 or Claim 9, wherein the portion of the nitrogen product that is the nitrogen-enriched vapor is less than or equal to 40 mole % of the stream of compressed air.

11. A process as claimed in Claim 8 or Claim 9, wherein the nitrogen product has a third pressure between 1.5 times the second pressure and 0.9 times the first pressure.

12. A process as claimed in any one of the preceding claims, wherein at least a portion of the condensed vapor stream is returned to the lower pressure column.

13. A process as claimed in any one of the preceding claims, wherein the distillation column system has an additional column, wherein a further part of the vapor stream is fed to a feed location at or adjacent the bottom of the additional column.

14. A process as claimed in Claim 13, comprising feeding at least a portion of the condensate to the additional column.

15. A process as claimed in Claim 14, wherein the additional column produces a liquid bottoms which is fed to the lower pressure column at an intermediate location.

16. A process as claimed in Claim 15, wherein the additional column produces a vapor overhead which is condensed and contributes to reflux of the lower pressure column.

17. A cryogenic air separation apparatus for the production of oxygen and nitrogen using a process as defined in Claim 1, said apparatus comprising:

a higher pressure column (124);
a lower pressure column (150) having a stripping section;
heat exchange means (192) for indirectly heat exchanging a vapor stream from an intermediate location of the stripping section of the lower pressure column (150) with a nitrogen-enriched liquid stream derived from the high pressure column (124) to at least partially condensing the vapor stream to form a condensate and at least partially vaporizing the nitrogen-enriched liquid stream to form a nitrogen-enriched vapor;
conduit means (164) for feeding a nitrogen-enriched liquid stream derived from the higher pressure column (124) to said heat exchange means (192);
pressure reducing means (165) for reducing the pressure of said nitrogen-enriched liquid stream in said conduit means to a pressure intermediate that of the higher pressure column (124) and the lower pressure column (150); and
conduit means (190) for feeding a vapor stream from an intermediate location of the stripping section of the lower pressure column (150) to said heat exchange means (192).

18. An apparatus as claimed in Claim 17 for separating air to produce an oxygen product and a nitrogen product using a process as defined in Claim 2, said apparatus comprising:

a distillation column system comprising at least a higher pressure column (124) and a lower pressure column (150) having a stripping section and being in thermal communication (160) with the higher pressure column (124);
conduit means (110) for feeding a stream of compressed air to the distillation column system;
heat exchange means (192) for indirectly heat exchanging a vapor stream from an intermediate location of

the stripping section of the lower pressure column (150) with a nitrogen-enriched liquid stream derived from the high pressure column (124) to at least partially condensing the vapor stream to form a condensate and at least partially vaporizing the nitrogen-enriched liquid stream to form a nitrogen-enriched vapor;
conduit means (164) for feeding a nitrogen-enriched liquid stream derived from the higher pressure column (124) to the heat exchange means (162);
pressure reducing means (165) for reducing the pressure of said nitrogen-enriched liquid stream in said conduit means to a pressure intermediate that of the higher pressure column (124) and the lower pressure column (150); and
conduit means (190) for feeding a vapor stream from an intermediate location of the stripping section of the lower pressure column (150) to the heat exchange means (192).

19. An apparatus as claimed in Claim 18, wherein the distillation column system has an additional column (200) and conduit means (288) for feeding a part of the vapor stream withdrawn from said intermediate location to a feed location at or adjacent the bottom of the additional column (200).

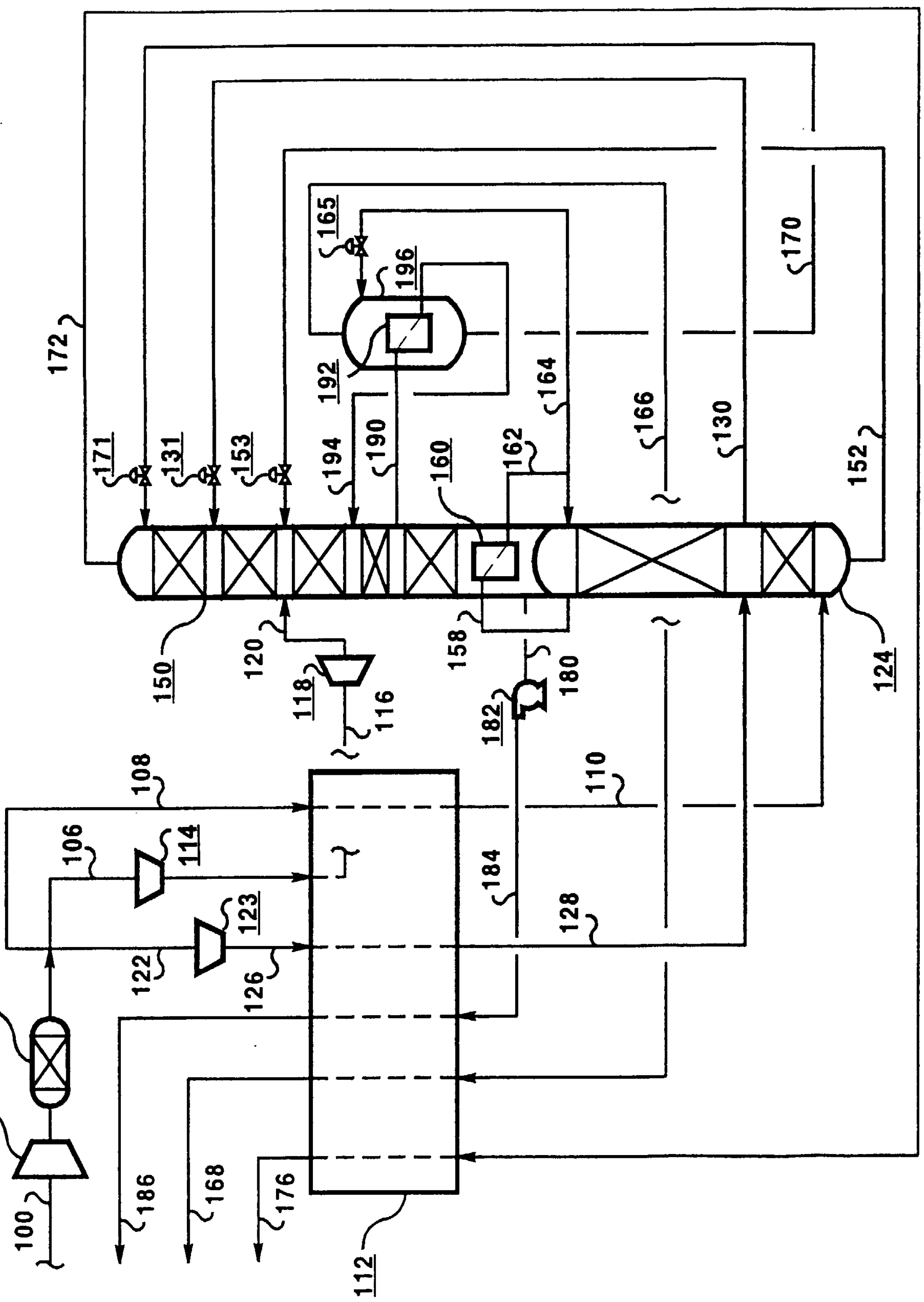
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FIG. 1

FIG. 2

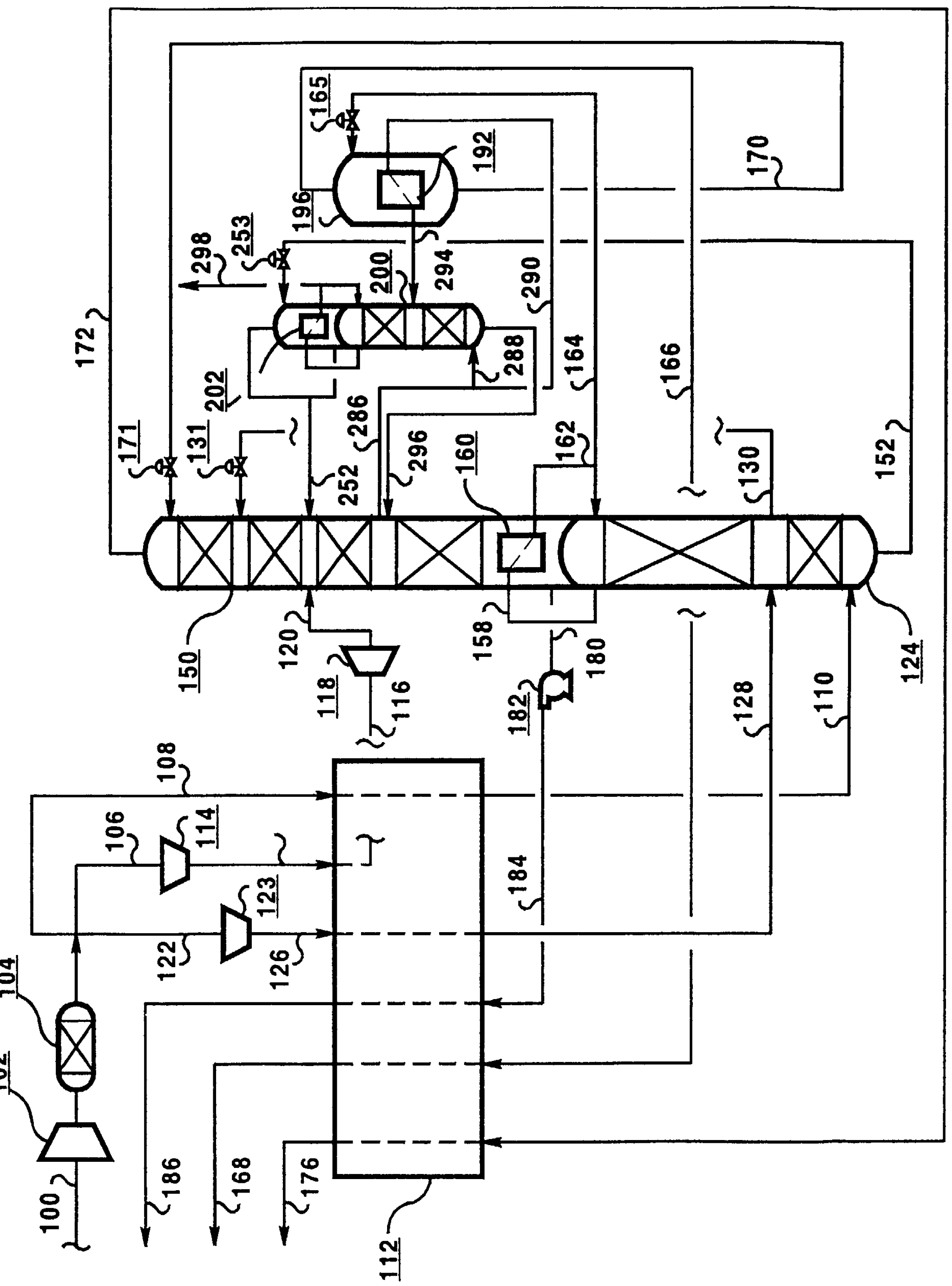
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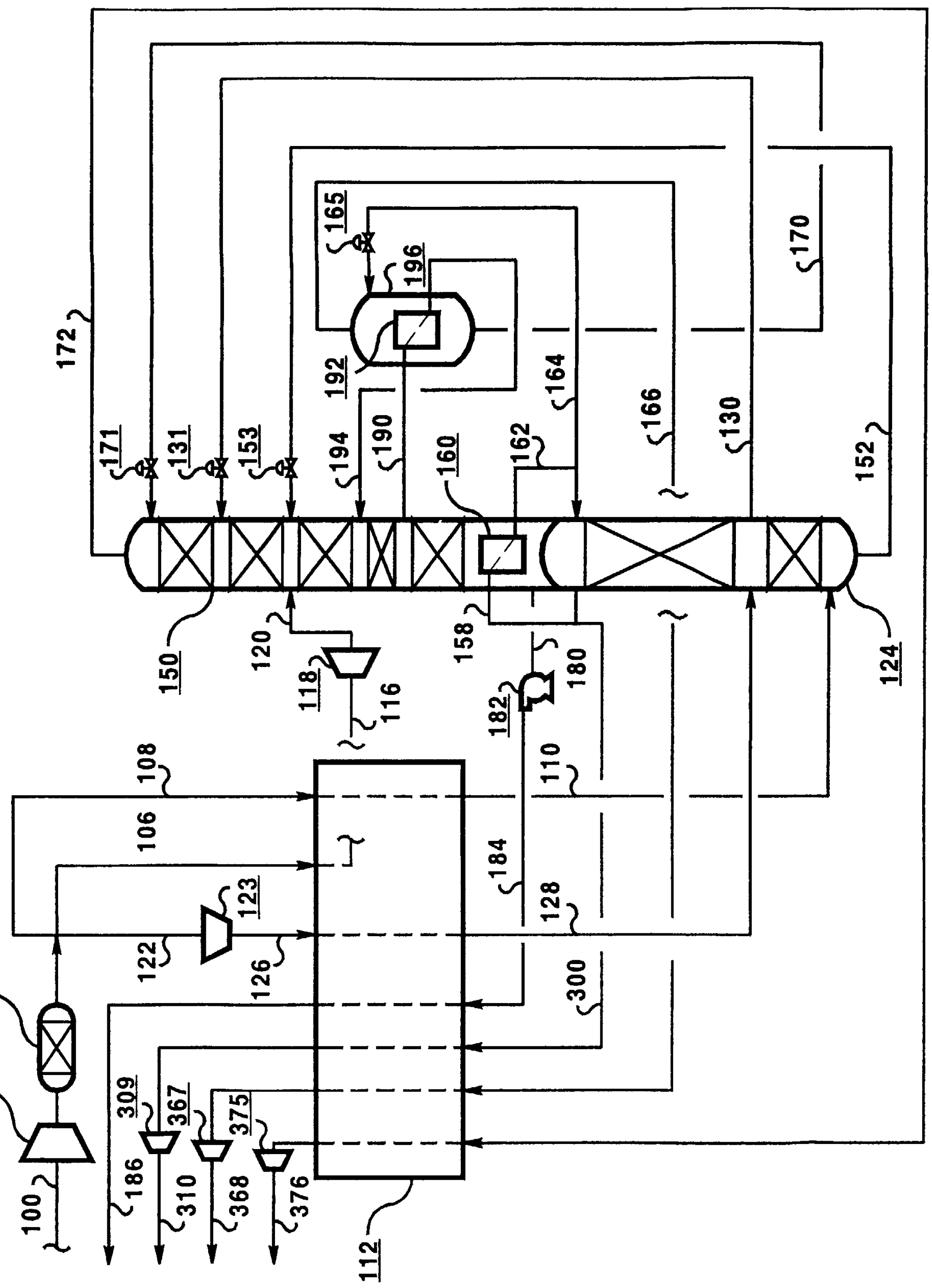
FIG. 3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EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	21 August 2002	Göritz, D

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