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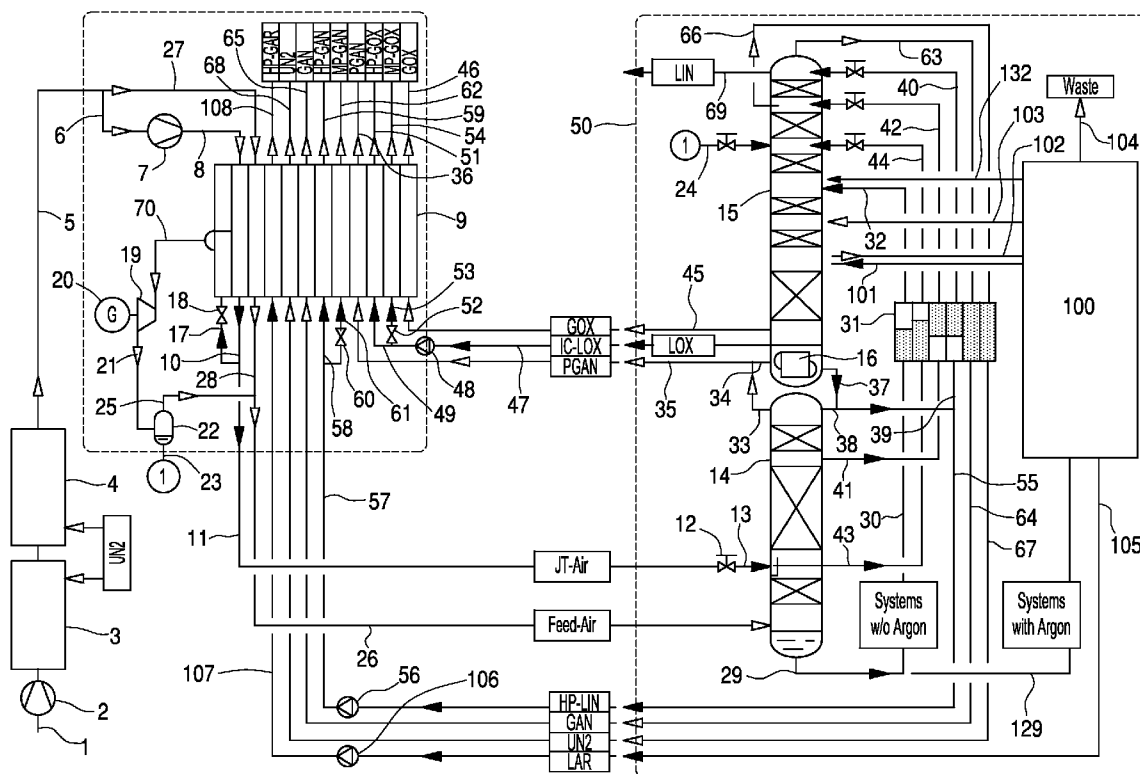
(19) **United States**(12) **Patent Application Publication**
Alekseev(10) **Pub. No.: US 2011/0067444 A1**(43) **Pub. Date: Mar. 24, 2011**(54) **PROCESSES AND DEVICE FOR LOW
TEMPERATURE SEPARATION OF AIR**(52) **U.S. Cl. 62/646**(76) **Inventor:** **Alexander Alekseev,**
Wolfratshausen (DE)(21) **Appl. No.: 12/885,603**(22) **Filed: Sep. 20, 2010**(30) **Foreign Application Priority Data**

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F25J 3/04 (2006.01)(57) **ABSTRACT**

The process and device serve for the low-temperature separation of air in a distillation-column system includes at least one separation column. A main air stream is compressed in an air compressor at a first pressure and is then purified. A first air stream, which is formed from at least one part of the purified main air stream, is further compressed at a second pressure that is higher than the first pressure. From the further compressed first air stream, a throttling stream and a turbine stream are branched off. The throttling stream is cooled down and liquefied or pseudo-liquefied in a main heat exchanger and is then passed on to expansion equipment. The expanded throttling stream is conducted into the distillation-column system. The turbine stream is cooled down in the main heat exchanger and under an intermediate temperature of the main heat exchanger is conducted into an expansion machine.



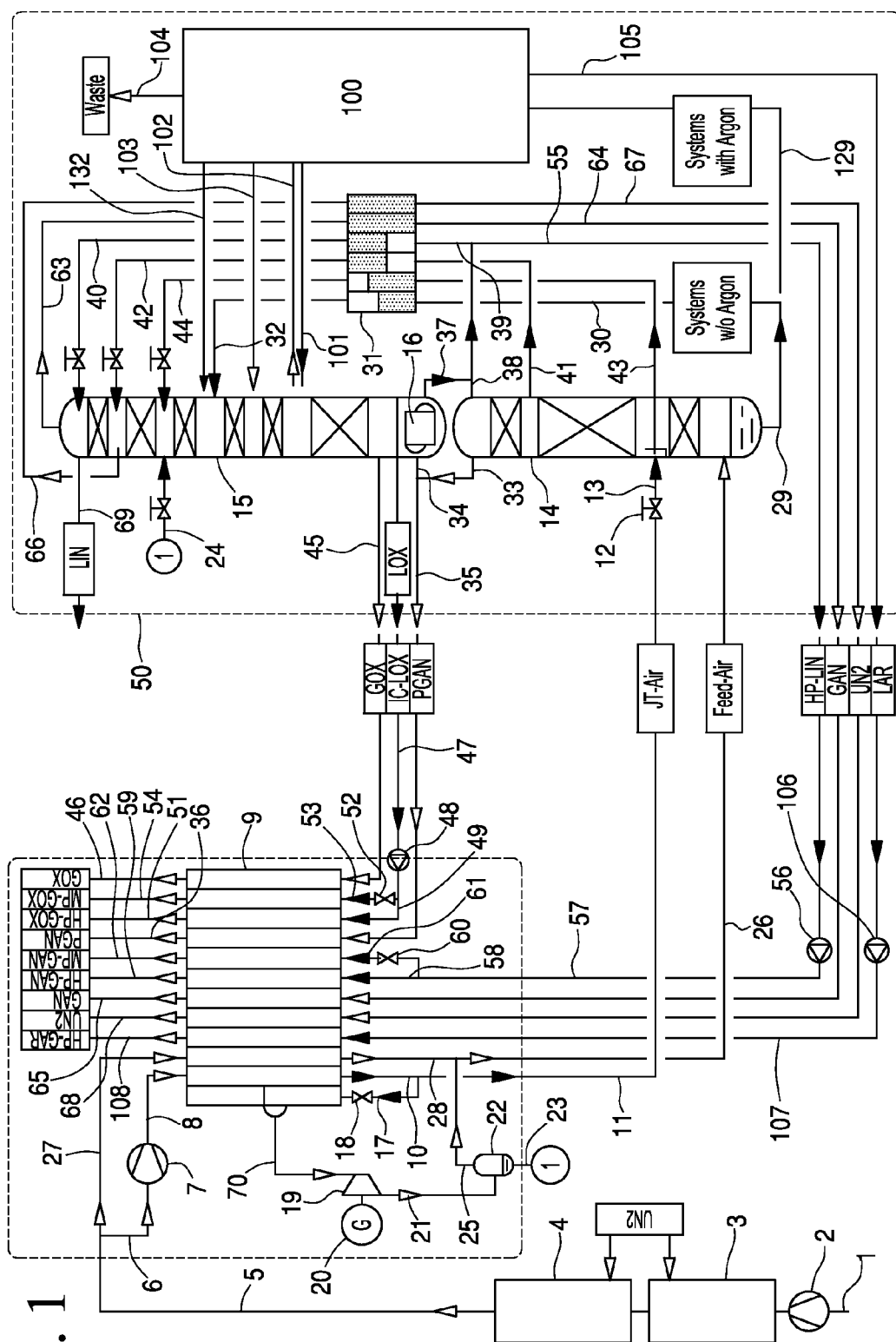


FIG. 1

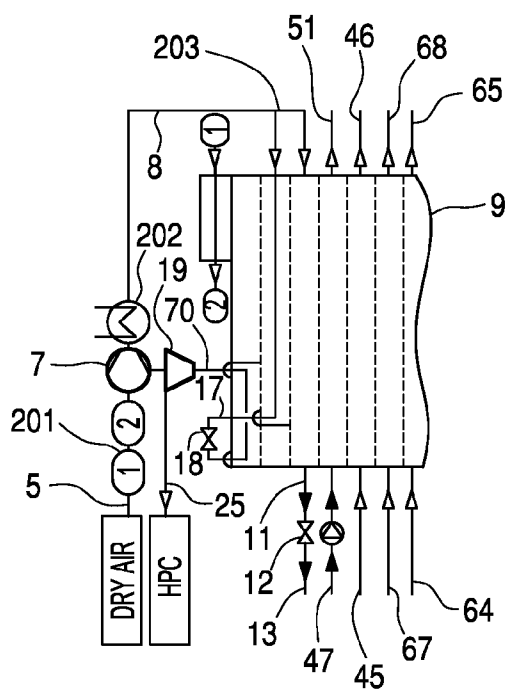


FIG. 2

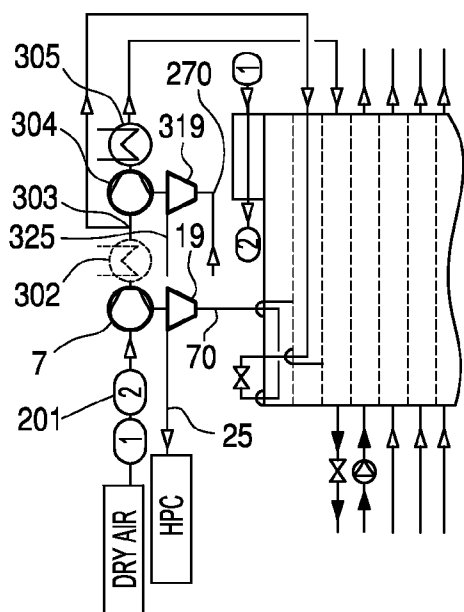


FIG. 3

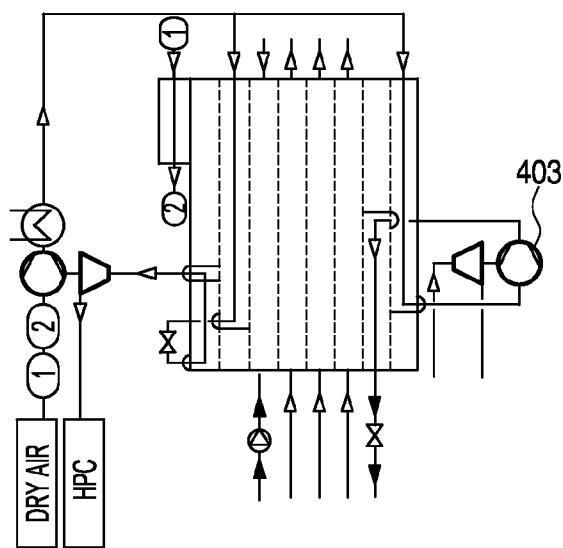
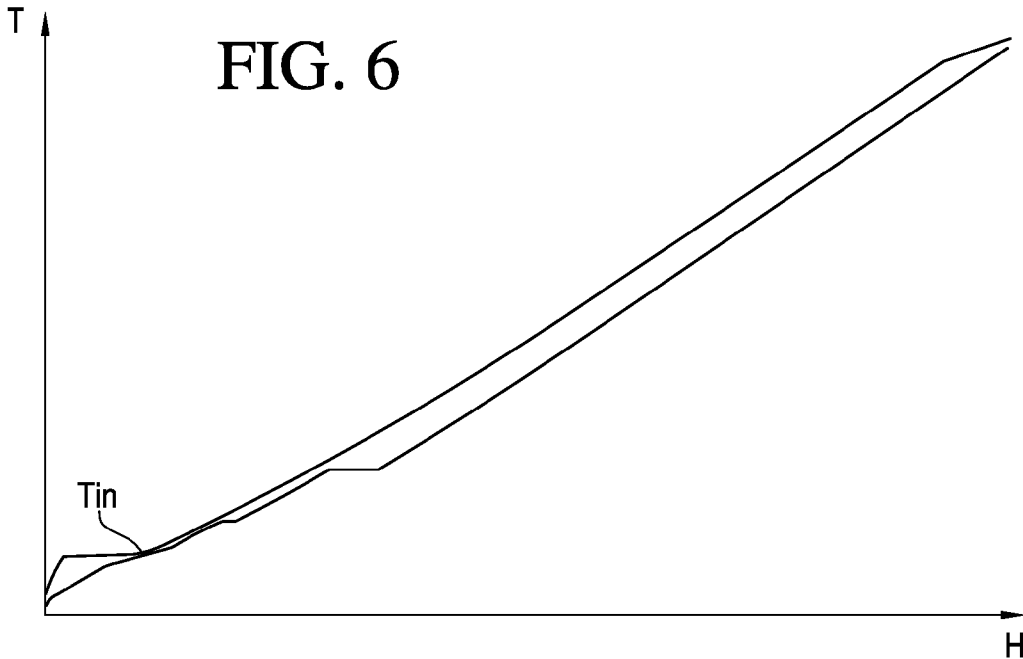
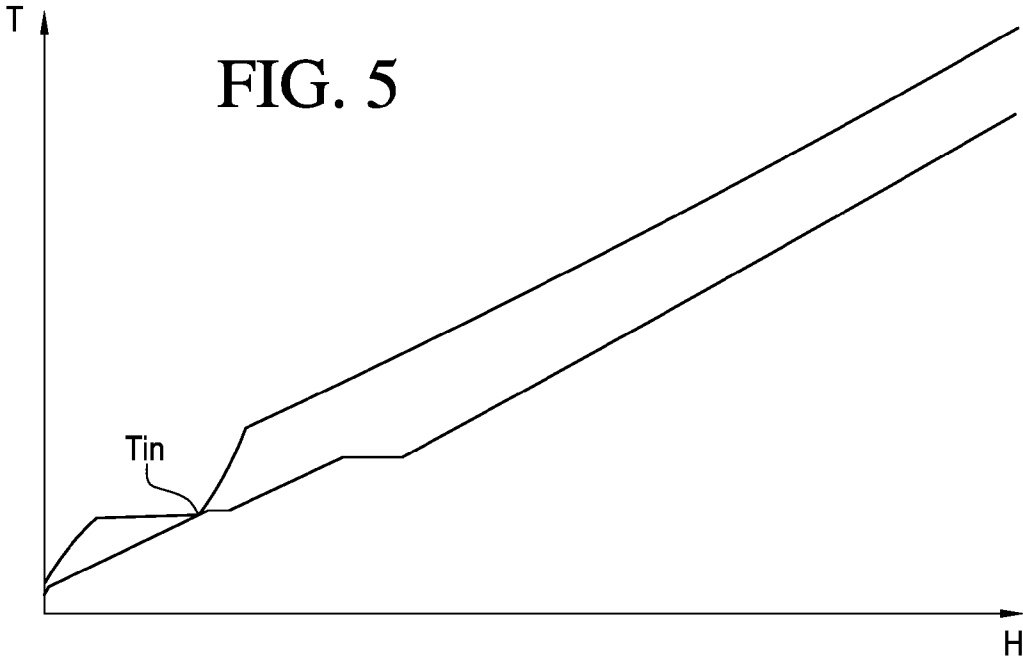


FIG. 4



PROCESSES AND DEVICE FOR LOW TEMPERATURE SEPARATION OF AIR

[0001] This U.S. patent application claims priority of German patent document DE 10 2009 042410.5 filed on Sep. 21, 2009 and German patent document DE 10 2009 0484156.6 filed on Oct. 7, 2009, the entireties of which are incorporated herein by reference.

FIELD OF INVENTION

[0002] The invention is directed to a method and device for the low temperature separation of air with a distillation-column system.

BACKGROUND OF INVENTION

[0003] A process in which a product flow of liquid at pressure is vaporized against a heat carrier and is finally obtained as a gaseous compressed product is also called an internal compression process. The process is particularly widespread for obtaining compressed oxygen, but can also be used to obtain compressed nitrogen or compressed argon. For the case of a supercritical pressure in a main heat exchanger, no phase transformation occurs in a real sense; the product stream is then “pseudo-vaporized”.

[0004] Compared to the (pseudo-)vaporized product stream, a heat carrier under high pressure is liquefied in the main heat exchanger (or pseudo-liquefied if it is under supercritical pressure), namely a fractional stream of air, which here is called a “throttling stream”.

[0005] It is customary to bring a throttling stream and a turbine stream together in a recompressor or in the main air compressor at a higher pressure, as is required for the distillation. This pressure must be sufficiently high for the vaporization or pseudo-vaporization of the product stream made liquid at pressure and can be, for example, 20 or 60 bars. The turbine stream is then, of course, also expanded at this pressure (“second pressure”) at roughly the operating pressure of the high-pressure column. Alternatively, the throttling stream is further compressed at a still higher pressure (“third pressure”).

[0006] The turbine stream serves initially for refrigeration. But in systems with internal compression, it has a second function. The turbine stream helps the throttling stream to evaporate (or to pseudo-evaporate) an internally-compressed stream (nitrogen, oxygen, and/or argon). The larger the turbine stream, and the more this stream is cooled down in the main heat exchanger (the greater the temperature difference between inlet and outlet), the more heat is made available for the (pseudo-) evaporation of the internally-compressed product stream, and the smaller the throttling stream. The average temperature difference in the heat exchanger is thereby smaller, the temperature profile more favorable, and the system more efficient. This means it is always advantageous to cool the turbine stream down in the heat exchanger as much as possible. This generally leads to the stream at the turbine outlet not being gaseous, but in fact partially liquefied.

[0007] Lowering the temperature at the turbine inlet is however not unconditionally possible but, with the machines generally used, a maximum liquid fraction of roughly 6% to a maximum of 10% (design criterion) is provided. Higher liquid fractions can lead to turbine damage. The inlet temperature in an air turbine is limited by this restriction, for example,

with 60 bars at the inlet and roughly 85% efficiency at about 169 K. For an inlet pressure of 20 bars, the smallest possible turbine inlet temperature is roughly 125 K. A goal is to set the turbine inlet temperature lower without violating the turbine design criterion, resulting in a more efficient process.

SUMMARY OF INVENTION

[0008] The present invention is based on the problem of achieving an energy-efficient process and a corresponding device, with a comparatively low equipment cost.

[0009] This problem is resolved by the present invention. The turbine stream is no longer taken off in the operation of cooldown from an intermediate position of the main heat exchanger, but passes further through the main heat exchanger, so that the turbine stream, at subcritical pressure up to roughly the dewpoint temperature, is either cooled down more or, at supercritical pressure, is pseudo-liquefied. Finally, the stream is expanded in the main heat exchanger at an intermediate pressure optimized with respect to expansion to produce work and to the temperature profile. The stream is preferably expanded with a throttle valve, and is heated up again in the main heat exchanger at the intermediate temperature, which corresponds to the inlet temperature of expansion to produce work and is as low as possible, so that the turbine design criterion is not violated. This intermediate temperature lies, for example, below 169 K for a 60-bar turbine stream or below 125 K for a 20-bar turbine stream.

[0010] The cooldown and (pseudo-)liquefaction of the turbine stream in the main heat exchanger can then, if its pressure is equal to that of the throttling stream, occur along with the throttling stream or separately from it. The intermediate pressure, at which the turbine stream is expanded before its expansion to produce work, is equal to or higher than $\sqrt{P_{\text{throttling stream}} \cdot P_{\text{high-pressure column}}}$. That is, for a 60-bar throttling stream, the intermediate pressure would lie at 18 bars or higher or for a 20-bar throttling stream at 10.5 bars (under the assumption that the pressure in the high-pressure column amounts to 5.5 bars). Expansion at the intermediate pressure is preferably carried out in a throttle valve. Expansion to produce work is performed in an expansion machine, which preferably is constructed as a turbine.

[0011] In a first variant of the present invention, a recompressor operates on external power; both the throttling stream and the turbine stream are under the second pressure during cooldown in the main heat exchanger. Using a recompressor without intermediate offtake, the equipment cost can be kept low.

[0012] “Operates on external power” means that the corresponding compressor is not operated by power self-produced in the air-separation process but, for example, by an electric motor, a steam turbine, or a gas turbine.

[0013] In a second variant of the present invention, the recompressor is driven by an expansion machine, which is operated with a process stream of the procedure, in particular by an expansion machine which is operated with the turbine stream, in which the air compressor represents the only machine operated on external power for air compression.

[0014] The “only machine” is understood here to be a single-stage or multistage compressor, whose stages are all connected to the same drive, in which all the stages are put into the same housing or are connected to the same gear system. In this second variant, the “first pressure” is above the highest pressure of the distillation-column system; in particu-

lar, it is clearly above the operating pressure of the high-pressure column. This pressure difference amounts to, for example, at least 4 bars and is preferably between 6 and 16 bars. In this variant, the total air in the air compressor (except for possible smaller fractions such as, for example, instrument air) is preferably completely divided up into the throttling stream and the turbine stream.

[0015] The process stream, which is used to drive the recompressor, can instead of the turbine stream be formed, for instance, by a third air stream, which is expanded at the operating pressure of the low-pressure column (Lachmann turbine) or by compressed nitrogen from the distillation-column system, particularly from a high-pressure or low-pressure column. The compressed nitrogen can, at the inlet into the corresponding expansion machine, be almost at ambient temperature, or it is heated in front of an inlet into the expansion machine at a temperature above ambient ("hot gas expander").

[0016] In both variants of the present invention, the throttling stream can be under a higher pressure than the turbine stream. That is, the turbine stream during cooldown in the main heat exchanger is under the second pressure and the throttling stream during cooldown in the main heat exchanger is under a third pressure, which is identical to the second pressure or is higher than the second pressure.

[0017] For the further secondary compression from the second at pressure, a second recompressor is installed in the second variant, which is driven by an expansion machine that is operated with a process stream of the procedure. Preferably, the recompressor that runs at the second pressure is driven by the expansion machine that is operated with the turbine stream, and the process stream that is used for driving the second recompressor is formed by a third air stream, which is expanded at the operating pressure of the low-pressure column (Lachmann turbine) or by compressed nitrogen from the distillation-column system, particularly from a high-pressure or low-pressure column. Alternatively, the two drives can be switched.

[0018] In a modification of the first variant, the present invention comprises at least two stages instead of the recompressor and can also be driven with external power. The further compression at the second pressure then occurs in at least a first stage of the recompressor; the throttling stream is further compressed downstream of the branching off of the turbine stream at least in the last stage of the recompressor at a third pressure, which is higher than the second pressure. The steps according to the invention of cooldown, expansion, and heat-up of the turbine stream create so much additional flexibility that the process can attain a high efficiency, even if the construction-dependent intermediate offtake pressures of the recompressors are in themselves unfavorable.

[0019] Preferably, the intermediate pressure is 1.5 to 5 bars below the second pressure, that is, the turbine stream in front of the inlet into the expansion machine is expanded by this pressure difference. This relatively low throttling at the low temperature causes practically no power loss and still allows the desired reduction in the inlet temperature of the expansion machine.

[0020] Preferably, the distillation-column system comprises a high-pressure column and a low-pressure column, which is located above a main condenser relative to heat exchange. The main condenser is constructed as a condenser-evaporator. The turbine stream is expanded in the expansion

machine preferably at roughly the operating pressure of the high-pressure column and is fed at least in part into the high-pressure column.

[0021] A liquid oxygen stream, a liquid nitrogen stream, and/or a liquid argon stream can be used as the liquid product stream from the distillation-column system. If more than one product is internally compressed, many independent and of course appropriate types of equipment for increasing pressure (as a rule, pumps or pairs of pumps) and independent paths must be provided through the main heat exchanger.

[0022] It is favorable if a second stream of air is formed out of another portion of the purified main air stream and the second stream of air is cooled down in the main heat exchanger under the first pressure and is conducted to the distillation-column system. This second stream of air is also called a direct air stream. Preferably, the main air stream, aside from a small portion of the instrument air used, if necessary, is divided up into precisely the three parts cited here, namely the direct air stream, the turbine stream, and the throttling stream.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The invention as well as further details of the invention are further clarified in the following with the aid of the embodiments schematically represented in the drawings.

[0024] FIG. 1 shows an embodiment of the first variant of the invention;

[0025] FIG. 2 shows a first embodiment of the second variant of the invention with a single turbine;

[0026] FIG. 3 shows a further embodiment of the second variant of the invention with two turbines;

[0027] FIG. 4 shows a further embodiment of the second variant of the invention with two turbines;

[0028] FIG. 5 shows a heat-exchange diagram (temperature relative to specific enthalpy) for a process according to prior art without throttling of the turbine stream; and

[0029] FIG. 6 shows a heat-exchange diagram for the process of FIG. 2.

DETAILED DESCRIPTION OF THE INVENTION

[0030] In the embodiment of FIG. 1, the distillation-column system 50 comprises, in the part which serves for the nitrogen-oxygen separation, a high-pressure column 14, a low-pressure column 15, and a main condenser 16 constructed as a condenser-evaporator, at which the two columns stand relative to heat exchange.

[0031] Atmospheric air is sucked in as main air stream 1 to an air compressor 2, and is brought there to a first pressure that corresponds roughly to the operating pressure of the high-pressure column 14, is cooled down in a primary cooling 3 to roughly ambient temperature, and is conducted to an adsorptive air purification 4. A first portion of the purified main air stream 5 is further compressed as a "first air stream" 6 in a recompressor 7 at a second pressure of at least 50 bars, for example roughly 60 bars. The high-pressure air 8 is conducted to the hot end of a main heat exchanger 9 and is cooled down and pseudo-liquefied in the main heat exchanger. The pseudo-liquefied air is drawn off through piping 10 from the cold end of the main heat exchanger and is then split up into a throttling stream 11 and a turbine stream 17. Conversely, the throttled and turbine streams after the joint recompression 7 are also cooled down and pseudo-liquefied together in the main heat exchanger. Alternatively, the turbine stream 17

could be taken off somewhat above the cold end of the main heat exchanger 9 (see FIG. 2.)

[0032] The throttling stream ("JT Air") 11 is expanded in a throttle valve 12 to roughly the operating pressure of the high-pressure column and is conducted through piping 13 in a liquid state, at least in part, into the high-pressure column 14. Instead of the throttle valve 12, a fluid turbine can be installed. One portion 43 of the throttling stream can be immediately drawn out again from the high-pressure column and after cooldown 31 can be fed through piping 44 to the low-pressure column 15 at an intermediate position.

[0033] The turbine stream 17, which is pseudo-liquefied along with throttling stream, is expanded in a throttle valve 18 at an intermediate pressure between the operating pressure of the high-pressure column and the second pressure and is then conducted again to the cold end of the main heat exchanger 9. In the main heat exchanger, it is again heated up to an intermediate temperature that is between 140 and 150 K. At this intermediate temperature, the turbine stream is drawn through piping 70 out of the main heat exchanger 9 and conducted to a turbine 19, which in the example is slowed down by a generator 20. In the turbine 19, the air is expanded to produce work at roughly the operating pressure of the high-pressure column. The expanded turbine stream 21 is conducted into a separator (phase separator) 22 in order to separate out liquid fractions, if necessary. Such liquid fractions 23 are fed in through piping 24 to a suitable location in the low-pressure column 15. The gaseous fraction 25 is conducted through piping 26 as gaseous feed air into the high-pressure column 14.

[0034] The remainder of the purified main air stream 5 is passed, without pressure-altering steps, through the main heat exchanger 9 as a direct air stream ("second air stream") 27, 28 and flows further through piping 26 into the high-pressure column 14.

[0035] In a first version of the embodiment (system without argon yield), raw liquid oxygen 29 flows from the sump of the high-pressure column 14 through piping 30, undercooling counterflow 31, and further through piping 32 to an intermediate position on the low-pressure column. The gaseous nitrogen head 33 of the high-pressure column 14 is condensed at least for the portion 34 in the liquefaction space of the main condenser 16. Another portion can be passed over piping 35 through the main heat exchanger 9 and can finally be drawn off through piping 36 as a gaseous intermediate-pressure product (PGAN).

[0036] The condensed nitrogen 37 is delivered from the main condenser 16 to a first portion 38 as a return flow at the high-pressure column 14. A second portion 39 is cooled down in the undercooling counterflow 31 and passed through piping 40 to the low-pressure column 15 as return flow.

[0037] Likewise, a nitrogen-enriched stream 41, 42 can be conducted from an intermediate position on the high-pressure column 14 through the undercooling counterflow 31 to an intermediate position on the low-pressure column 15.

[0038] From the sump of the low-pressure column, a low-pressure gaseous oxygen product 45 (GOX) can be directly taken off, heated in the main heat exchanger 9, and be drawn off through piping 46 as a low-pressure product.

[0039] The oxygen desired as a gaseous compressed product is drawn off as a liquid (LOX) out of the low-pressure column or out of the evaporation space of the main condenser 16 and passes as a "first liquid product stream 47 of internal compression (IC-LOX). Here it is brought in a liquid state by

an oxygen pump 48 to the desired increased pressure (first increased pressure) and conducted through piping 49 to the cold end of the main heat exchanger 9. In the main heat exchanger 9, the liquid oxygen stream 49 is vaporized or pseudo-vaporized under the increased pressure and heated up to roughly ambient temperature. It finally leaves the system through piping 51 as a first gaseous compressed product (HP-GOX).

[0040] If desired, a further gaseous oxygen product 53, 54 (MP-GOX) can be obtained under an intermediate pressure that is between the operating pressure of the low-pressure column 15 and the increased pressure downstream of the pump 48, in which this fraction branches off downstream of the pump 48, is appropriately throttled down 52, and is finally vaporized and heated up separately in the main heat exchanger 9.

[0041] Alternatively, or in addition to the internally compressed oxygen stream or streams, nitrogen can be passed on for internal compression. What is more, a third portion 55 of the condensed nitrogen 37 is brought as a second "liquid product stream" out of the main condenser 16 (HP-LIN) into a nitrogen pump 56 at a second increased pressure that corresponds to the desired product pressure and which must not be the same as the first increased pressure. The high-pressure nitrogen is conducted through piping 57, 58 to the cold end of the main heat exchanger 9. In the main heat exchanger 9, the liquid or supercritical nitrogen stream 58 is vaporized or pseudo-vaporized under the increased pressure and is heated up to roughly ambient temperature. It finally leaves the system through piping 59 as a second gaseous compressed product (HP-GAN).

[0042] If desired, a further gaseous nitrogen product 61, 62 (MP-GAN) can be obtained under an intermediate pressure that is between the operating pressure of the high-pressure column 16 and the increased pressure downstream of the pump 56, in which this portion branches off downstream of the pump 56, accordingly throttled down 60, and finally vaporized and heated up separately in the main heat exchanger 9.

[0043] As further return flows, unpurified nitrogen 63, 64, 65 and unpurified nitrogen 66, 67, 68 are drawn gaseous out of the low-pressure column 15 into the undercooling counterflow 31 and are further heated up in the main heat exchanger 9 and drawn off as low-pressure products (GAN, UN2). Finally, a portion of the products are also obtained as liquid, for example liquid nitrogen (LIN) 69 or a portion of the liquid oxygen (LOX) 47 from the sump of the low-pressure column 15.

[0044] The process of the embodiment of the first version can, for example, also be operated with only one liquid product stream and one gaseous compressed product (for instance, either oxygen or nitrogen), or alternatively with any combination of the streams depicted 49, 53, 58, and 61 made liquid at pressure.

[0045] In an embodiment of the second version, the distillation-column system of the embodiment additionally exhibits an argon fraction 100 for the equipment for nitrogen-oxygen separation, which serves to yield pure liquid argon (LAR) 105. The argon fraction comprises one or more raw-argon columns for argon-oxygen separation and a pure-argon column for argon-nitrogen separation, which is operated in the known manner. The lower end of the raw-argon column communicates through the piping 101 and 102 with an intermediate area of the low-pressure column 15. The raw liquid

oxygen **29** is conducted out of the high-pressure column **11**, in this case through the pipes **129** (systems with argon), into the argon fraction and is partially vaporized, particularly at least in part in the top condenser of the raw-argon column(s) (not depicted). The at least partially vaporized raw oxygen is fed in through piping **103** into the low-pressure column **15**, which remains liquid through piping **132**. Likewise, a gaseous residue stream (waste) **104** is drawn off from the argon fraction **100**.

[0046] Alternatively, or in addition to the internally compressed products described for the first version, the pure liquid argon **105** can be passed on for internal compression, in which it is brought as a third "liquid product stream" into an argon pump **106** at a third increased pressure that corresponds to the desired product pressure and which must not be the same as the first and/or second increased pressure. The high-pressure argon is conducted through piping **107** to the cold end of the main heat exchanger **9**. In the main heat exchanger **9**, the argon stream **107** is vaporized or pseudo-vaporized under the increased pressure and is heated up to roughly ambient temperature. It finally leaves the system through piping **108** as a third gaseous compressed product (HP-GAR).

[0047] The main heat exchanger can be executed as integral or split. The drawings show only the function of the exchanger: hot streams are cooled to cold.

[0048] FIG. 2 corresponds in large part to FIG. 1. Hence the same references are used as for the procedural steps and apparatus parts already described above, and the air compressor, the air purification, and the distillation-column system are not depicted in FIG. 2.

[0049] A difference from FIG. 1 is the higher outlet pressure of the air compressor ("first pressure"), which in FIG. 2 clearly lies above the operating pressure of the high-pressure column and amounts to 17 bars in the actual example. On this basis, the direct air stream (**27** in FIG. 1) is also missing. Rather, the total air **8** is divided downstream of the recompressor **7** under roughly 22 bars ("second pressure") at **203** into the turbine stream **17** and the throttling stream **11**. (In FIG. 2, the cooldown of the turbine and throttling streams could also be executed together, whereby the fractionation within the main heat exchanger **9** could be executed just in front of its cold end). The temperature of the turbine stream **17** in the example, before throttling **18**, is 1 K to 50 K above the temperature of the cold end and is also above the temperature at which the throttling stream **11** leaves the main heat exchanger. Alternatively, the turbine stream could also, as shown in FIG. 1, be passed on as far as the cold end of the main heat exchanger **9**.

[0050] In addition, the aftercooler **202** of the recompressor is represented in FIG. 2, which may also be used in the process according to FIG. 1 but is not shown. The reference number **201** indicates the optional cooldown of the main air stream **5** downstream of the recompressor **7** in the main heat exchanger **9**.

[0051] FIG. 3 is distinguished from FIG. 1 by a second expansion machine **319**, a recompressor **304**, and an aftercooler **305**. The branch-off of turbine stream and throttling stream takes place here in heat at **303**, whereby the throttling stream in the second recompressor **304** with the second pressure (here, for example, 22 bars) is further compressed to a third pressure (here, for instance 25 bars). The aftercooler **302** behind the first recompressor **7** can be omitted if the pre-cooling **201** of the main air stream is used.

[0052] The process stream **270**, with which the second expansion machine is operated, can be formed by one of the following streams:

[0053] A partial stream of the turbine stream **70** (in this case, the expanded stream **325** is mixed with the stream **25** from the first expansion machine (both expansion machines in parallel).

[0054] A further air stream, which under the inlet pressure of the first recompressor **7** or under the outlet pressure of the first **7** or second **304** recompressors is taken off at an intermediate temperature from the main heat exchanger and is fed downstream of the expansion machine **319** into the low-pressure column or into the high-pressure column (**15** and **14** in FIG. 1) (Lachmann or a second Claude turbine).

[0055] A compressed nitrogen stream (**35**, **64**, **67** in FIG. 1 or a partial stream respectively thereof) out of the high-pressure column or the low-pressure column.

[0056] Alternatively, the coupling between the turbines **19**, **319** and the recompressors **7**, **304** is also the converse of that depicted in FIG. 3.

[0057] FIG. 4 is thereby distinguished from FIG. 3, in that the second recompressor **403**, which further compresses only the throttling stream, is constructed as a cold compressor.

[0058] In FIGS. 5 (for prior art) and 6 (for FIG. 2), the effect of throttling according to the invention downstream of the expansion machine is read off on the H-T diagram of the main heat exchanger. In FIG. 6, the turbine inlet temperature (stream **70** in FIG. 2; T_{in}) is clearly lower than in FIG. 5. The curves for the cooled-down streams (above) and the heated-up streams (below) lie considerably closer to one another. The exchange losses are accordingly smaller.

What is claimed is:

1. A process for the low-temperature separation of air with a distillation-column system comprising at least one separation column, said process comprising:

compressing a main air stream in an air compressor at a first pressure and purifying the main air stream in a purification device;

compressing a first air stream, which is formed from at least one portion of the purified main air stream, in a recompressor at a second pressure that is higher than the first pressure;

branching off a throttling stream and a turbine stream from the further compressed first air stream;

cooling the throttling stream and liquefying or pseudo-liquefying the throttling stream in a main heat exchanger and passing the throttling stream to an expansion equipment;

conducting the expanded throttling stream into the distillation-column system;

cooling the turbine stream in the main heat exchanger and, under an intermediate temperature of the main heat exchanger, conducting the turbine stream into an expansion machine and expanding the turbine stream to produce work;

conducting the expanded turbine stream at least in part into the distillation-column system;

taking off a liquid product stream from the distillation-column system at an increased pressure and vaporizing or pseudo-vaporizing the liquid product stream by indirect heat exchange with the throttling stream and drawing off as a gaseous product stream,

wherein the turbine stream is cooled so that, if the pressure of the turbine stream is subcritical, the dewpoint temperature or a lower temperature is attained, or, if the pressure of the turbine stream is subcritical, the turbine stream is pseudo-liquefied,

wherein the cooled-down or pseudo-liquefied turbine stream is expanded at least at the dewpoint temperature at an intermediate pressure that is below the second pressure, and

wherein the turbine stream expanded at the intermediate pressure is heated up in the main heat exchanger at the intermediate temperature before it is conducted to an expansion machine.

2. A process according to claim 1, wherein the recompressor is driven by external power and both the throttling stream and the turbine stream upon cooldown in the main heat exchanger are under the second pressure, where the intermediate pressure is in between the first and the second pressure.

3. A process according to claim 1, wherein the recompressor is driven by an expansion machine, which is operated with a process stream, in particular by the expansion machine that is operated with the turbine stream, in which the air compressor is the only machine driven by external power for the compression of air.

4. A process according to claim 3, wherein the recompressor is driven by an expansion machine operated with the turbine stream.

5. A process according to claim 1, wherein the turbine stream upon cooldown in the main heat exchanger is under the second pressure and the throttling stream upon cooldown in the main heat exchanger is under a third pressure that is the same as the second pressure or is higher than the second pressure.

6. A process according to claim 1, wherein the intermediate pressure is 1.5 to 5 bars below the second pressure.

7. A process according to claim 1, wherein the distillation-column system comprises a high-pressure column and a low-pressure column located above a main condenser.

8. A process according to claim 7, wherein a liquid oxygen stream is taken off from the low-pressure column or the main condenser and is used as a liquid product stream.

9. A process according to claim 7, wherein a liquid nitrogen stream is taken off from the high-pressure column or the main condenser and is used as a liquid product stream.

10. A process according to claim 1, wherein a liquid argon stream is taken off and used as a liquid product stream.

11. A process according to claim 1, wherein a second air stream is formed from a portion of the purified main air stream and the second air stream is cooled down under the first pressure in the main heat exchanger and is conducted to the distillation-column system.

12. A device for the low-temperature separation of air with a distillation-column system having at least one separation column, comprising:

an air compressor for compressing a main air stream at a first pressure;

a purification device for purifying the main air stream compressed at the first pressure;

a recompressor for compressing a first air stream, which is formed from at least one portion of the purified main air stream, at a second pressure that is higher than the first pressure;

means for branching off a throttling stream and a turbine stream from the cooled, further compressed first air stream;

a main heat exchanger for cooldown of the throttling stream and the turbine stream;

means for liquefying or pseudo-liquefying the throttling stream in the main heat exchanger;

expansion equipment for expanding the liquefied or pseudo-liquefied throttling stream;

means for conducting the expanded throttling stream into the distillation-column system;

means for conducting the turbine stream under an intermediate temperature of the main heat exchanger into an expansion machine for expansion of the turbine stream to produce work;

means for conducting the turbine stream, expanded to produce work, into the distillation-column system;

means for offtake of a liquid product stream from the distillation-column system, for an increase in its pressure in a liquid state to an increased pressure, and for vaporization under this increased pressure by indirect heat exchange with the throttling stream;

means for drawing off the (pseudo-)vaporized product stream as a gaseous product stream;

means for drawing off the turbine stream from the main heat exchanger at a position at which, in the operation of the device, if the pressure of the turbine stream is subcritical, roughly the dewpoint temperature of the turbine stream or a lower temperature is attained, or if the pressure of the turbine stream is subcritical, the turbine stream is pseudo-liquefied;

means for expanding the turbine stream drawn off from the main heat exchanger at an intermediate pressure that lies below the second pressure; and

means of heating up the turbine stream expanded at the intermediate pressure, in the main heat exchanger to the intermediate temperature, in which said means is downstream of the expansion machine.

13. A process for the low-temperature separation of air, comprising:

compressing a main air stream to a first pressure;

purifying the main air stream;

forming a first air stream from at least one portion of the purified main air stream;

compressing the first air stream to a second pressure that is higher than the first pressure;

branching off a throttling stream and a turbine stream from the compressed first air stream;

liquefying or pseudo-liquefying the throttling stream in a main heat exchanger;

cooling the turbine stream in the main heat exchanger so far that, if the pressure of the turbine stream is subcritical, the dewpoint temperature or a lower temperature is attained, or, if the pressure of the turbine stream is subcritical, the turbine stream is pseudo-liquefied;

expanding the cooled or pseudo-liquefied turbine stream to an intermediate pressure that is below the second pressure;

heating the turbine stream expanded at the intermediate pressure in the main heat exchanger is heated up at the intermediate temperature;

conducting the heated expanded turbine stream at the intermediate pressure to an expansion machine and conduct-

ing at least a part of the further expanded turbine stream to a distillation-column system; and
taking a liquid product stream off from the distillation-column system, bringing the liquid product stream to an increased pressure, vaporizing or pseudo-vaporizing the liquid product stream by indirect heat exchange with the throttling stream and drawn off as a gaseous product stream.

14. A device for the low-temperature separation of air, comprising:
an air compressor for compressing a main air stream;
a purification device for purifying the compressed main air stream;
a recompressor for compressing a first air stream, formed from at least one portion of the purified main air stream;
a line for branching off a throttling stream and a turbine stream from the compressed first air stream;
a main heat exchanger for cooling the throttling stream and the turbine stream, thereby liquefying or pseudo-liquefying the throttling stream;
an expansion equipment for expanding the liquefied or pseudo-liquefied throttling stream;

a line for conducting the expanded throttling stream into a distillation-column system;
a line for drawing off the turbine stream from the main heat exchanger;
an expansion machine for expanding the turbine stream drawn off from the main heat exchanger to an intermediate pressure;
a line for conducting the expanded turbine stream at intermediate pressure to the main heat exchanger to heat to an intermediate temperature;
a line for conducting the turbine stream under an intermediate temperature to an expansion machine;
a line for conducting the expanded turbine stream into the distillation-column system;
a line for conducting a liquid product stream from the distillation-column system, and having a pump to increase its pressure in a liquid state, and for vaporization in the main heat exchanger with the throttling stream; and
a line for drawing off the (pseudo-)vaporized product stream as a gaseous product stream.

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