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D E C I S I O N
of 7 June 2000

Case Number: T 0310/97 - 3.2.3

Application Number: 90308715.3

Publication Number: 0412793

IPC: F25J 3/04

Language of the proceedings: EN

Title of invention:
Process and apparatus for producing nitrogen from air

Patentee:
THE BOC GROUP, INC.

Opponent:
LINDE AKTIENGESELLSCHAFT

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step - yes (after amendments)"

Decisions cited:
-

Catchword:
-

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Case Number: T 0310/97 - 3.2.3

D E C I S I O N
of the Technical Board of Appeal 3.2.3
of 7 June 2000

Appellant: (Proprietor of the patent)
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Representative:
-

Decision under appeal:
Decision of the Opposition Division of the European Patent Office posted 24 January 1997 revoking European patent No. 0 412 793 pursuant to Article 102(1) EPC.

Composition of the Board:

Chairman: C. T. Wilson
Members: J. B. F. Kollar
M. K. S. Aúz Castro

Summary of Facts and Submissions

I. European patent application No. 90 308 715.3 filed on 8 August 1990 under publication No. 0 412 793, was granted on 28 September 1994.

II. The patent was opposed by the Respondents 1 (Opponents) and 2 on the grounds of Article 100(a) EPC.

In support of their requests to revoke the patent, the Respondents referred *inter alia* to the following documents:

(D11) US-A-4 357 153

(D17) Hansen/Linde, "Tieftemperaturtechnik", 2nd edition, Springer 1985, pages 329, 330

(D19) SU 1 451 497.

III. By a decision issued in writing on 24 January 1997 the Opposition Division revoked the patent for the reason that the subject-matter of the independent process and apparatus claims did not involve an inventive step in view of D19 or D11 in combination with D17.

IV. The Appellant (Patentee) filed an appeal against the decision on 18 March 1997 and paid the appeal fee on the same day. The Statement of Grounds of Appeal was filed on 22 May 1997.

V. With the letter dated 4 May 2000 Respondent 1 withdrew its opposition.

VI. During the oral proceedings held before the Board on 7 June 2000 the parties formulated their requests as follows:

the Appellant requested that the decision under appeal be set aside and that the patent be maintained on the basis of claims 1 to 10 for the contracting states GB, SE, LI, CH, BE, AT, LU, (first set of claims), and of claims 1 to 11 for the contracting states DE, FR, IT, NL, (second set of claims), both sets of claims filed in the oral proceedings, the corresponding descriptions filed on 5 May 2000 and a list of inserts filed for both descriptions in oral proceedings and the drawings as granted,

the Respondent requested that the appeal be dismissed.

The independent claims of the first set of claims read as follows:

"1. A process for the recovery of substantially pure nitrogen product at superatmospheric pressure from air comprising the steps of:

a) compressing gaseous feed air;

b) cooling the compressed air in a heat exchanger by heat exchange with enriched oxygen and nitrogen product streams;

c) introducing the cooled and compressed air to an intermediate stage of a single distillation column;

d) separating the air in the column into a substantially pure gaseous nitrogen overhead fraction and an oxygen enriched liquid bottoms fraction and withdrawing a stream of each fraction from the column;

e) forwarding substantially all of the oxygen enriched liquid bottoms stream and a portion of the gaseous nitrogen overhead stream to a condenser and therein indirectly exchanging heat between the bottoms stream and overhead stream thereby boiling oxygen enriched liquid to form an oxygen-enriched gas stream and condensing gaseous nitrogen to form a liquid nitrogen stream;

f) recycling at least a major portion of the resulting liquid nitrogen stream to the top of the distillation column as reflux;

g) compressing a first portion of the oxygen-enriched gas and recycling the compressed first portion of the oxygen enriched gas stream to the bottom of the distillation column without changing the composition of the oxygen-enriched gas outside the distillation column either upstream or downstream of the compression of said first portion, thereby enhancing nitrogen product recovery from the air;

h) warming the remainder of the gaseous nitrogen overhead stream in the heat exchanger by said heat exchange with the compressed air;

i) recovering the warmed nitrogen overhead stream as a substantially pure nitrogen product from the heat exchanger, and

j) turboexpanding a second portion of the said oxygen enriched gas stream in an expanding means thereby generating work output, wherein: the first portion of the oxygen enriched gas stream of step (g) starts its compression at about a temperature of the distillation column, and at least a portion of the work output obtained from the expanding means is utilised to compress the first portion of the oxygen-enriched gas stream which is recycled to the bottom of the distillation column."

"8. Apparatus for the production of nitrogen product from air comprising:

a) a first compressor for increasing the pressure of gaseous feed air;

b) a heat exchanger for cooling the high pressure air with nitrogen and oxygen-enriched products of distilled feed air;

c) a distillation column for separating the cooled air into a substantially pure gaseous nitrogen overhead fraction and an oxygen enriched liquid bottom fraction and having an outlet for the nitrogen communicating with the heat exchanger;

d) a condenser for at least partially condensing a stream of the gaseous nitrogen overhead to form a liquid nitrogen stream by indirect heat exchange with a stream of the

oxygen enriched liquid bottoms fraction to form an oxygen-enriched gas stream;

e) a first recycle means for returning a major portion of the liquid nitrogen stream from the condenser to the distillation column as reflux;

f) a second compressor for increasing the pressure of a first part of the oxygen enriched gas stream; and

g) a second recycle means for returning the increased pressure oxygen enriched gas stream to the bottom of the distillation column thereby enabling nitrogen product recovery to be enhanced, there being no means intermediate the distillation column and the inlet of the second compressor or intermediate the outlet of the second compressor and the distillation column for changing the composition of the oxygen-enriched gas;

wherein the nitrogen product is able to be recovered from the said heat exchanger; the apparatus further comprises a turboexpander for expanding a second part of the oxygen-enriched gas stream; the second compressor is coupled to the turboexpander so as, in use, to utilise at least a portion of the work output obtained from the turboexpander to compress the first part of the oxygen-enriched gas stream which is recycled to the bottom of the distillation column; and the second compressor is in a location in the apparatus such that in operation it receives

oxygen-enriched gas at a cryogenic temperature."

The independent claims of the second set of claims read as follows:

"1. A process for the recovery of substantially pure nitrogen product at superatmospheric pressure from air comprising the steps of:

a) compressing gaseous feed air;

b) cooling the compressed air in a heat exchanger by heat exchange with enriched oxygen and nitrogen product streams;

c) introducing the cooled and compressed air to an intermediate stage of a single distillation column;

d) separating the air in the column into a substantially pure gaseous nitrogen overhead fraction and an oxygen enriched liquid bottoms fraction and withdrawing a stream of each fraction from the column;

e) forwarding substantially all of the oxygen enriched liquid bottoms stream and a portion of the gaseous nitrogen overhead stream to a condenser and therein indirectly exchanging heat between the bottoms stream and overhead stream thereby boiling oxygen enriched liquid to form an oxygen-enriched gas stream and condensing gaseous nitrogen to form a liquid nitrogen stream;

f) recycling at least a major portion of the resulting liquid nitrogen stream to the top of the distillation column as reflux;

g) introducing a first portion of the oxygen enriched gas stream at a cryogenic temperature into a compressor, compressing said first portion of the oxygen-enriched gas stream, and recycling the compressed first portion of the oxygen-enriched gas stream to the bottom of the distillation column thereby enhancing nitrogen product recovery from the air;

h) warming the remainder of the gaseous nitrogen overhead stream in the heat exchanger by said heat exchange with the compressed air;

i) recovering the warmed nitrogen overhead stream as a substantially pure nitrogen product from the heat exchanger;

j) turboexpanding a second portion of the said oxygen enriched gas stream in an expanding means thereby generating work output; and

k) utilising a portion of the work output obtained from the expanding means to compress the first portion of the oxygen-enriched gas stream which is recycled to the bottom of the distillation column."

"9. Apparatus for the production of nitrogen product from air comprising:

a) a first compressor for increasing the pressure of gaseous feed air;

b) a heat exchanger for cooling the high pressure air with nitrogen and oxygen-enriched products of distilled feed air;

c) a distillation column for separating the cooled air into a substantially pure gaseous nitrogen overhead fraction and an oxygen enriched liquid bottom fraction and having an outlet for the nitrogen communicating with the heat exchanger;

d) a condenser for at least partially condensing a stream of the gaseous nitrogen overhead to form a liquid nitrogen stream by indirect heat exchange with a stream of the oxygen-enriched liquid bottoms fraction to form an oxygen-enriched gas stream;

e) a first recycle means for returning a major portion of the liquid nitrogen stream from the condenser to the distillation column as reflux;

f) a second compressor for increasing the pressure of a first part of the oxygen enriched gas stream, the second compressor being positioned such that in use it receives oxygen-enriched gas at a cryogenic temperature; and

g) a second recycle means for returning increased pressure oxygen enriched gas stream to the bottom of the distillation column thereby enhancing nitrogen product recovery; wherein in use the nitrogen product is recovered from the said heat exchanger, and the apparatus further comprises a turboexpander for expanding a second part of the oxygen-enriched gas stream, the second compressor being coupled to the turboexpander so as, in use, to utilise at least a portion of the work output obtained from the turboexpander to compress the first part of the oxygen enriched gas stream which is recycled to the bottom of the distillation column."

VII. The essential arguments brought forward by the Appellant are as follows:

D19 or D11 is taken as the closest prior art.

D19, like D11, produces commercially pure oxygen product. Since the oxygen product is taken from the process the size of the bottom fraction is limited. In fact, refrigeration for the process according to D11 is created by expansion of the top vapour fraction, rather than the bottom liquid fraction and there is no disclosure of producing an impure bottom fraction in D19. Moreover, there is no disclosure in D19 of employing the work of expansion of the gas which is expanded in compressing the first portion of the oxygen-rich gas or coupling the turbo-expander to the compressors. In contrast with the assertion of the Opposition Division that the alignment of the turbo-expander 11 with compressors 9 and 10 illustrated in the drawing of D19 is indicative of there being a coupling of the three machines, it is submitted that

there is no teaching in D19 that said three machines should be coupled together. A person skilled in the art would have expected that, because the bottom fraction is pure, there would be insufficient mass flow available from the bottom fraction to meet the energy requirements of driving both compressors 9 and 10 and providing the necessary refrigeration for the separation process.

Although D17 shows that in a non-recycle process nitrogen at elevated pressure can be produced by employing the bottom fraction as the source of gas to be turbo-expanded, it warns quite clearly that there must be an adequate pressure in the rectification column.

Because a commercially pure oxygen product is produced and in view of the relatively low pressure (less than 4,8 bar) at which the rectification column of D19 is operated, it is not possible to take the bottom fraction from the rectification column and generate adequate refrigeration by expanding it in the turbo-expander 11.

A person skilled in the art, taking note of the teaching in D17 regarding the need for an adequate pressure, would not have employed the bottom fraction as a source of the liquid to be turbo-expanded.

Accordingly, documents D19 and D11, of which the latter, as mentioned above, uses by expansion the top vapour fraction, whether alone or in conjunction with D17 fail to render obvious any of the claims on file.

VIII. The Respondent made no substantial submissions against the amended documents filed by the Appellant in the oral proceedings before the Board.

Reasons for the Decision

1. The appeal is admissible.

2. *Amendments*

2.1 Claims for the contracting states GB, SE, LI, CH, BE, AT, LU (the first set of claims).

Claim 1 comprises all the features according to Claim 1 as granted and discloses additionally feature (j) which incorporates the features of Claims 2, 6 and 7 as granted.

The words "to provide refrigeration for the process" have been omitted from the feature taken from Claim 2 as granted for reasons of clarity. Support for this omission may be found in the sentence at column 3, lines 16 to 19 of the patent specification or at column 3, lines 21 to 23 and Claim 10 as originally filed.

It is stated in feature (g) that it is "a first part" of the oxygen-rich gas which has its pressure increased. The feature taken from Claim 7 as granted has been amended for reasons of consistency with the afore-mentioned part of the patent specification to state that "at least a portion of the work output is utilised".

The prefix "turbo-" has been used in front of terms "expanding", "expansion" and "expanded" in feature (j) of Claim 1 and in Claims 2 and 3, respectively, for consistency with the description of the embodiments according to Figures 4 and 5 as granted.

Claims 2 and 5 to 7 have been deleted. The remaining claims and their dependencies have been altered accordingly.

The apparatus claim has been renumbered as Claim 8. It comprises all the features according to Claim 12 as granted and incorporates the features of Claims 13 and 15 as granted. In addition the functions of the turbo-expander and its coupling to the second compressor have been identified using essentially the same wording as the independent process Claim 1.

The words "for generating refrigeration" have been omitted from the feature introduced into the apparatus claim from Claim 13 as granted. The reasons for this omission are the same as the reasons for the analogous amendment of the process Claim 1.

Claims 13 and 15 as granted have been deleted. Claims 14 and 16 have been renumbered 9 and 10, respectively.

2.2 Claims for the contracting states DE, FR, IT, NL (the second set of claims).

The second set of claims has been formulated by taking the granted second set and amending it in a manner similar to that adopted for the first set.

Claim 1 discloses all the features according to Claim 1 as granted and discloses additionally features (j) and (k) which incorporate the features of Claims 2 and 6 as granted.

The dependent process claims have been renumbered and their dependencies have been changed.

The independent apparatus claim has been renumbered as Claim 9. It comprises all the feature of Claim 11 as granted and incorporates the features of Claim 12 as granted. In addition the functions of the turbo-expander and its coupling to the second compressor have been identified using essentially the same wording as the independent process claim.

For the same reasons as set out above in respect of the first set of claims, the independent claims of the second set do not state that the turbo-expansion provides refrigeration for the process.

2.3 Claims of the first and second set comply therefore with Article 123(2) EPC. The amendments to the independent claims are of a character restricting the scope of said claims, which therefore satisfy also Article 123(3) EPC.

3. *Novelty*

The Board is satisfied that the subject-matter of the independent claims according to the first and second set of claims is novel over each document mentioned during the proceedings. Since this has not been disputed in the contested decision or by the Respondent there is no need for further detailed discussion of this matter.

4. *Inventive step*

4.1 According to the introductory part of the patent specification the prior art separation of air to produce nitrogen required complex and costly equipment and was disadvantageous in that it was only able to recover a low percentage of the feed air as nitrogen product (35 to 40 mole percent) with the result that some nitrogen was not recovered.

4.2 In the light of D19 or D11 forming the closest prior art, the technical problem underlying the present invention may be seen in the provision of a process and an apparatus whereby both the mole percentage recovery of nitrogen from the feed air and the pressure of gaseous nitrogen stream is able to be significantly increased.

4.3 According to the invention, this technical problem is solved by the combination of the features disclosed in the independent claims of both sets of claims. The basis for the solution form particularly the following features of the invention:

(a) compressed air is separated at pressure in a distillation column into a substantially pure gaseous nitrogen overhead fraction and an oxygen enriched liquid bottoms fraction;

(b) the bottoms fraction is not a pure fraction, is not used as oxygen product, but is rather a waste nitrogen fraction;

(c) substantially all of a stream of oxygen enriched liquid bottoms is forwarded to a condenser; the stream is vaporised; one part of the vaporised stream is compressed and recycled to the bottom of the distillation column; and another part is expanded to provided refrigeration;

(d) the nitrogen product is produced at pressure from the distillation column.

In view of results specified in column 3, lines 14 to 39 and described by way of embodiments with reference to the drawings of the patent specification, the Board is satisfied that the above-defined problem is solved.

4.4 On the question of whether or not the state of the art would lead the person starting from the teaching of D19 or D11 to a process and an apparatus according to the independent claims as amended the following is observed:

4.5 The argumentation forwarded in the decision under appeal that document D19 or D11 in combination with document D17 anticipates the inventive step of the subject-matter of the patent in suit does not convince the Board.

4.6 Combination of D19 and D17.

In view of the relatively low pressure at which the rectification column (3) of D19 is operated (4,3 to 4,8 bar), it appears to be not possible to take the bottom fraction from the rectification column and generate adequate refrigeration by expanding it in the turbo-expander (11).

A person skilled in the art would have expected that, because the bottom fraction is pure, there would not be sufficient mass flow available from the bottom fraction to meet the energy requirements of driving both compressors (9) and (10) and providing the necessary refrigeration for the separation process.

Although D17 shows that in a non-recycle process nitrogen at elevated pressure can be produced by employing the bottom fraction as the source of gas to be turbo-expanded, it warns quite clearly that there must be an adequate pressure in the rectification column.

A person skilled in the art, taking into consideration the teaching of D17 regarding the need for an adequate pressure, would not therefore have considered that the bottom fraction of D19 could have been used as a source of the fluid to be turbo-expanded.

Accordingly none of the claims appear to be rendered obvious by the combination of D19 and D17.

4.7 Combination of D11 and D17

The process according to D11 is concerned, when it is applied to air separation, with producing a commercially pure oxygen stream.

Although D11 does show the turbo-expander and the recycle compressor mounted on a common shaft, both embodiments in Figure 1 and Figure 3 employ one expansion turbine for meeting the refrigeration power requirements and another for meeting the heat pump cycle power requirement. In Figure 2 there is only one expansion turbine which meets both the requirements for process refrigeration and work in operating the heat pump cycle. Refrigeration for the process is created, however, by expansion of the top vapour fraction, rather than the bottom liquid fraction. Looking for alternative sources of fluid to expand when using the oxygen fraction as the heat pump fluid the person skilled in the art would have rejected the use of the bottom fluid (oxygen), since - as stated in column 6, lines 53 to 58 of D11 - there would be concerns over safety and there would have been an inadequate production of oxygen to fulfil the aim of the invention, bearing in mind that oxygen constitutes only a small proportion by volume of air.

D17 makes it clear that expansion of the bottom fraction may not meet the refrigeration requirements of the process. Similarly, D11 points out at column 6, lines 15 to 20 that the heat pumping requirements of the process are greater than the refrigeration requirements. Accordingly, this teaching would reinforce the expectations of the person skilled in the art that compressing and turbo-expanding different portions of the bottom oxygen fraction was not a viable option.

It is therefore concluded that D11, both alone and in combination with D17, fails to render obvious any claim of the request.

5. In view of the above, the Board concludes that the subject-matter of the claims of the Appellant's request involves an inventive step within the meaning of Article 56 EPC and the patent has to be maintained on the basis of these claims.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the first instance with the order to maintain the patent in amended form on the basis of Claims 1 to 10 for the contracting states GB, SE, LI, CH, BE, AT, LU and Claims 1 to 11 for the contracting states DE, FR, IT, NL both sets of claims filed in oral proceedings, the corresponding descriptions filed 5 May 2000 and a list of inserts filed for both descriptions in oral proceedings and the figures as granted.

The Registrar: The Chairman:

A. Counillon C. T. Wilson