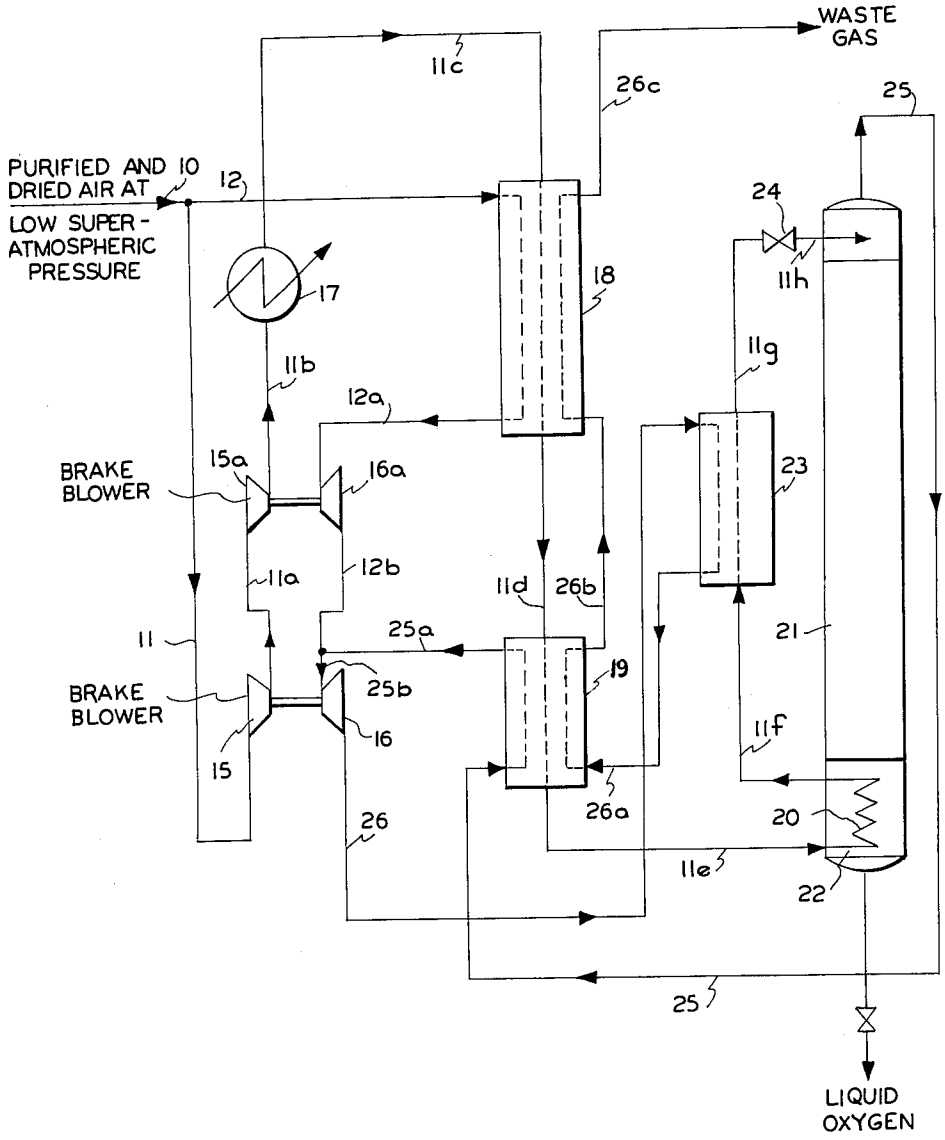
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SEPARATION OF OXYGEN FROM AIR

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SEPARATION OF OXYGEN FROM AIR

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This invention relates to the separation of oxygen from air by fractionation at low temperatures.

It is an object of the invention to provide a low temperature separation system for the economical recovery of oxygen in liquid form from air which system uses a single fractionating column and avoids the use of compressors operating in more than two stages to compress the air feed.

In the system of the invention operating with a single fractionating column in which air fed thereto at a low temperature is fractionated to yield oxygen in liquid form as a bottoms product, cold for the separation process is produced by the expansion of gas comprising at least part of the input air through one or more high-speed expansion turbines each braked by a blower, and at least part of the input air, which is at a relatively low elevated pressure such as can be achieved by the use of a normal two-stage reciprocating compressor, is further compressed by being passed through the blower or blowers of the expansion turbine or turbines. By "a relatively low elevated pressure" is meant a superatmospheric pressure of the order of about 10 atmospheres or less, preferably from about 8 to about 10 atmospheres.

In the present invention only part of the input air is further compressed in successive steps in the brake blowers of at least two expansion turbines and is, after cooling to the required temperature, fed to the fractionating column. The other part of the input air is passed through the expansion turbines to produce cold for the process while waste gases from the fractionating column are passed through at least the final expansion turbine to produce additional cold.

The liquid oxygen can be produced at an elevated pressure which enables it to be circulated to points of consumption without the use of an oxygen pump.

An example of the invention is illustrated diagrammatically and by way of example in the accompanying drawing.

Referring to the drawing, the air feed **10**, which has been compressed to 8 atmospheres absolute, for example in a two-stage reciprocating compressor, and has been purified and dried according to standard procedure, is divided into two streams **11** and **12**. Stream **11** consisting of about 65% of the total air feed is further compressed to 14 atmospheres absolute by being passed in succession through the brake blower **15**, line **11***a* and blower **15***a* of the high speed expansion turbines **16** and **16***a* respectively. The heat of compression is removed from the stream **11***b* by an external source of refrigeration, such as cooling water or Freon, in heat exchanger **17**. Air stream **11***c* is then passed through one set of channels of an extended surface heat exchanger **18** and thereby cooled to 140° K., the other stream of air **12** being similarly cooled by being passed through another set of channels of heat exchanger **18**. The air stream **11***d*, still at 14 atmospheres absolute, is then further cooled to 121° K. and partially liquefied in heat exchanger **19** and stream **11***e* is then completely liquefied in the reboiler **20** in the lower end of a single fractionating column **21** in indirect heat exchange with liquid oxygen **22** collected in the bottom of column **21**. The air stream **11***f*, now in liquid form, is withdrawn from reboiler **20** at a temperature of 112° K., passed through a sub-cooler **23**, in which it is cooled to 98° K. and stream **11***g* then expanded through expansion valve **24** to 5 atmospheres absolute and fed at this pressure as stream **11***h* a mixture of liquid and vapour into the top of fractionating column **21**. In column **21**, oxygen separates from the air and collects as liquid at the bottom of the column and the residual gases comprising oxygen, nitrogen and argon are withdrawn as overhead **25** from the column **21** at a temperature of 95° K. and are utilized to supply cold to heat exchanger **19**, becoming warmed up to 114° K. in passing through this heat exchanger in indirect heat exchange with the air stream **11***d*. The air stream **12** after passing through heat exchanger **18** passes to line **12***a* and is expanded through expansion turbine **16***a* to 4.8 atmospheres absolute and then passed to line **12***b* and mixed with the waste cooling gases **25** leaving heat exchanger **19** through line **25***a* and the combined stream **25***b* is expanded through expansion turbine **16** to 1.2 atmospheres absolute, becoming cooled to 87° K. in the process. This very cold mixture of gasses **26** is thereupon used to provide cold in sub-cooler **23** and heat exchangers **19** and **18** through which it passes in succession by way of lines **26***a* and **26***b*, respectively. The mixture is warmed up to 110° K. in sub-cooler **23**, to 116° K. in heat exchanger **19** and to close to ambient temperature in heat exchanger **18** which it leaves at ambient pressure as stream **26***c*.

About 7% of the total air feed is recovered as liquid oxygen and is withdrawn at 5 atmospheres absolute pressure from the bottom of column **21**.

Though the recovery of oxygen in the above described cycle is only 7% of the total air feed, the recovery is economical as the process provides its own refrigeration, apart from the small amount of external refrigeration used to remove the heat of compression, and the power requirement is very low. Additionally the process has the advantages that it requires only a two-stage compressor of standard design, operates with a single stripping column and delivers oxygen at 5 atmospheres absolute pressure which can thus be distributed to various points of consumption without the use of an oxygen pump.

The expansion turbines used in the system of the invention are high speed turbines having running speeds, for example, in excess of 6,000 r.p.m. and are provided with air blowers which act as brakes and absorb the energy delivered by the expanding gases. The blower is normally mounted on the same shaft as the rotor. The preferred turbines are of the radial inward flow type having optimum running speeds of the order of 40,000 to 45,000 r.p.m.

We claim:

1. A process for separating liquid oxygen from air by low temperature fractionation in a single fractionation column comprising:

(a) supplying a feed air stream at a relatively low super-atmospheric pressure; including, a first part of said feed air stream to be fractionated and a second part of said feed air stream to be utilized to provide at least a part of the cooling required for the fractionation of said first part of said feed air stream;

(b) further compressing said first part of said feed air stream through a brake blower forming an integral part of at least one high speed expansion turbine, to produce a further compressed first part of said feed air stream;

(c) removing at least a part of the heat of compression from said further compressed first part of said feed air stream by passing said further compressed first part of said feed air stream through a cooling unit

supplied by an external source of coolant, to produce partially cooled first part of said feed air stream;

(d) passing said partially cooled first part of said feed air stream through at least one heat exchange unit, to produce a cooled first part of said feed air stream;

(e) passing said cooled first part of said feed air stream to said fractionation column to separate said cooled first part of said feed air stream into a liquid oxygen stream and an overhead gas stream;

(f) withdrawing said liquid oxygen stream as a product;

(g) passing said overhead gas stream through said heat exchange unit, in indirect heat exchange with and countercurrent to the direction of flow of said partially cooled first part of said feed air stream;

(h) passing said second part of said feed air stream through said expansion turbine, to produce an expanded second part of said feed air stream; and

(i) passing said expanded second part of said feed air stream through said heat exchange unit, in indirect heat exchange with and countercurrent to the direction of flow of said partially cooled first part of said feed air stream;

(j) said first part of said feed air stream being separated from said second part of said feed air stream prior to the passage of said expanded second part of said feed air stream through said heat exchange unit.

2. A process in accordance with claim 1 wherein the first part of the feed air stream is separated from the second part of the feed air stream prior to further compressing said first part of said feed air stream, removing the heat of compression therefrom, and passing said first part of said feed air stream through the heat exchange unit.

3. A process in accordance with claim 2 wherein the separated second part of the feed air stream is passed through the heat exchange unit in indirect heat exchange with and concurrently to the direction of flow of the partially cooled first part of the feed air stream through said heat exchanger.

4. A process in accordance with claim 1 wherein at least two expansion turbines are utilized and the first part of the feed air stream and the second part of the feed air stream pass serially through the brake blowers and the expansion turbines of said expansion turbines, respectively.

5. A process in accordance with claim 1 wherein the overhead gas stream is combined with the expanded second part of the feed air stream before the passage of said expanded second part of said feed air stream through said heat exchange unit.

6. A process in accordance with claim 1 wherein at least two heat exchange units are utilized and the overhead gas stream passes through one of said heat exchange units and is thereafter combined with the expanded second part of the feed air stream for passage through the remaining ones of said heat exchange units.

7. A process in accordance with claim 1 wherein at least two expansion turbines are utilized and at least two heat exchangers are utilized and the overhead gas stream passes through one of the heat exchange units and is thereafter combined with the second part of the feed gas stream before passage of said second part of said feed air stream through the last stage of said expansion turbines.

8. A process in accordance with claim 1 wherein the low super-atmospheric pressure of the feed air stream is less than about 10 atmospheres.

9. A process for separating liquid oxygen from air by

low temperature fractionation in a single fractionation column comprising:

(a) supplying a feed air stream at a relatively low super-atmospheric pressure; including, a first part of said feed air stream to be fractionated and a second part of said feed air stream to be utilized to provide at least a part of the cooling required for the fractionation of said first part of said feed air stream;

(b) further compressing said first part of said feed air stream through a brake blower forming an integral part of at least one high speed expansion turbine, to produce a further compressed first part of said feed air stream;

(c) removing at least a part of the heat of compression from said further compressed first part of said feed air stream by passing said further compressed first part of said feed air stream through a cooling unit supplied by an external source of coolant, to produce partially cooled first part of said feed air stream;

(d) passing said partially cooled first part of said feed air stream through at least one heat exchange unit, to produce a further cooled first part of said feed air stream;

(e) passing said further cooled first part of said feed air stream to said fractionation column to separate said further cooled first part of said feed air stream into a liquid oxygen stream and an overhead gas stream;

(f) withdrawing said liquid oxygen stream as a product;

(g) combining said overhead feed air stream with said second part of said feed air stream to form a combined overhead gas and second part of said feed air stream;

(h) passing said combined overhead gas and second part of said feed air stream through said expansion turbine, to produce an expanded, combined overhead gas and second part of said feed air stream; and

(i) passing said expanded, combined overhead gas and second part of said feed air stream through said heat exchange unit, in indirect heat exchange with and countercurrent to the direction of flow of said partially cooled first part of said feed air stream;

(j) said first part of said feed air stream being separated from said second part of said feed air stream prior to the combination of said overhead gas stream with said second part of said feed air stream.

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