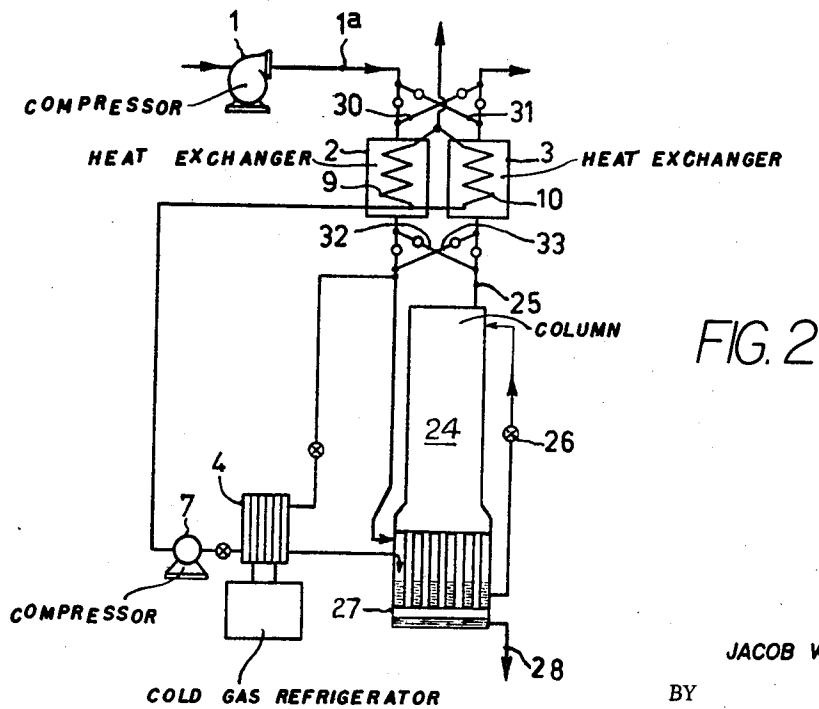
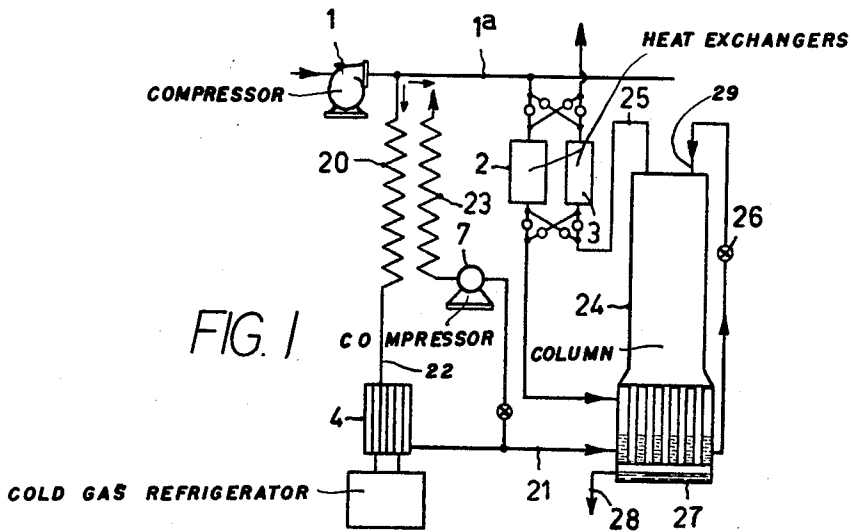


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EQUIPMENT FOR SUPPLYING BOTH AIR COMPRESSED TO
HIGH PRESSURE AND LIQUID OXYGEN
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EQUIPMENT FOR SUPPLYING BOTH AIR COMPRESSED TO HIGH PRESSURE AND LIQUID OXYGEN

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2 Claims. (Cl. 62—13)

In certain cases, there is a need for producing air compressed to a high pressure, for example 300 atmospheres.

When air is compressed to high pressure with the aid of ordinary compressors, the following disadvantages occur: a great deal of noise, a risk of explosions due to lubricating oil of the compressors finding its way into the air, which may give rise to an explosive mixture, and disturbances during operation.

These disadvantages are so serious that it is important to look for other means than ordinary compressors for obtaining air of high pressure.

The invention relates to the method of cooling air, which may be precompressed, in a heat-exchanger to little below the dew-point, then liquefying the cooled and precompressed air by means of a cold-gas refrigerator and subsequently compressing it to, for example, 300 atmospheres by means of a liquid compressor. In this method the compressed air may be heated up in the heat-exchanger by the precompressed air flowing towards the cold-gas refrigerator.

The term "cold-gas refrigerator" is to be understood herein to mean a driven piston machine comprising a first space of a variable volume, which space communicates with a second space which is likewise of a variable volume and in which a temperature prevails which exceeds that in the first machine space during operation of the machine, a regenerator being provided between the two spaces and a gaseous working medium being capable of flowing forwards and backwards between the spaces through the regenerator in order to convey heat from a lower temperature level to a higher temperature level.

This considered method is not very satisfactory for two reasons.

First, the efficiency is poor and, second, the impurities in the air, such as water and carboxylic acid, have to be frozen out.

The efficiency is poor because the cold which is required for the liquefaction is recuperated only in part. The high-pressure gas thus comes out too cold.

A possibility for improvement consists in passing a quantity of air through the heat-exchanger which in the forward direction is so much greater than in the backward direction that the heat-exchanger, instead of being unbalanced, is in a thermally balanced condition.

A saturated vapour then remains, namely that which is not returned through the heat-exchanger. According to calculations, 64% of the introduced air has to be returned, so that 36% of saturated vapour remains. This vapour may be liquefied, as a matter of fact, by means of the same or a different cold-gas refrigerator.

It is necessary to freeze out the impurities since the volume of the gas returning through the heat-exchanger is much smaller than that of the gas flowing in the forward direction. Consequently, the heat-exchanger has to be freed from ice periodically by heating.

Another possibility consists in that an excess of air is precompressed and the excess, before liquefaction of the air, is expanded to 1 atm. and is returned through the heat-exchanger. Thus, it is possible to have a result in which the volume in the return direction ex-

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ceeds that in the forward direction, so that the air may be cooled in commutable heat-exchangers, for example regenerators or recuperators, and purification of these heat-exchangers no longer causes difficulty.

The invention now provides an equipment which has the advantages of both possibilities initially described without the disadvantages thereof.

The equipment in accordance with the invention comprises a precompressor for the precompression of air (for example to 5 atmospheres), of which the outlet for precompressed air is connected to a heat-exchanger, the outlet of which leads to the cold head of a cold-gas refrigerator in which the precompressed air is liquefied and is carried away, partly to a condenser-evaporator of an oxygen-supplying column and partly to a liquid compressor which compresses the air to a high pressure (for example 300 atmospheres), a duct for the high-pressure air extending through the said heat-exchanger and cooling therein the precompressed air while the outlet of the precompressor is also connected through a heat-exchanger to the oxygen-supplying column.

In this equipment, the liquid air which is left when using the above-mentioned first possibility, is thus converted into liquid oxygen, which is a very useful product.

A flow diagram of the equipment constructed in accordance with the invention is shown in FIGURE 1.

FIG. 2 is a flow diagram of a working installation of the principles of FIG. 1.

Air is precompressed by the precompressor 1 to, for example, 5 atmospheres and passed through a duct 20 to a cold-gas refrigerator 4. The air liquefied therein flows out of a duct 21 partly to a liquid compressor 7, an outlet duct 22 of which, together with the duct 20, constitutes a heat-exchanger, and partly to a condenser-boiling or condenser-evaporation vessel 27 of an oxygen-supplying column 24.

An additional quantity of cooled air of 5 atmospheres is supplied to the boiling vessel 27 from an outlet duct 1a of the compressor 1 through a heat-exchanger 2 or 3, which heat-exchangers are again reversible. This air is cooled by waste nitrogen which leaves the column 24 at its upper end through a duct 25. Air from the boiling vessel is expanded in a Joule-Thomson cock 26 and introduced at 29 into the column. Liquid oxygen is carried away through a duct 28. Such an oxygen column is described in greater detail in U.S. patent application Serial No. 6,500, filed February 3, 1960.

The heat-exchangers 2 and 3 are in this example in thermally balanced condition.

Approximately 8 to 9 times the quantity of air supplied to the condenser in the form of liquid and discharged from the evaporator in the form of oxygen now passes through the heat-exchangers. Therefore, the heat-exchangers 2 and 3 are self-cleaning to a great extent.

Such is not the case however, with the heat-exchangers 20, 23.

It is possible for all of the heat exchangers to be made self-cleaning by using an embodiment of the invention comprising two reversible heat-exchangers which are constructed as regenerators or recuperators and each of which is designed so that both the precompressed air passed to the cold head of the cold-gas refrigerator and the precompressed air passed directly to the boiling vessel of the oxygen column may flow through them in one direction and furthermore the air compressed to a high pressure and the waste nitrogen from the column may flow through them in the opposite direction, the arrangement being such that the two regenerators are both balanced and self-cleaning.

FIGURE 2 shows the principle of the diagram then obtained.

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The boiling vessel of the column is designated 27.

The heat-exchangers 2 and 3 are again reversible as indicated by the presence of ducts 30, 31, 32, 33.

Reference numerals 9 and 10 denote ducts for air of a very high pressure originating from the liquid compressor 7.

The air now fully passes through the heat-exchangers 2 and 3 which are both balanced and self-cleaning.

This construction may also be regarded as an addition to the equipment for the supply of liquid oxygen as described in said U.S. patent application No. 6,500, comprising a device for producing also a quantity of air of a very high pressure, which is brought about by the addition of a liquid compressor and high-pressure returns ducts 9 and 10 respectively, which extend through the heat-exchangers 2 and 3, respectively.

Such an equipment supplies the same quantity of oxygen as that without the addition and moreover 1.5 to 1.7 times this quantity in the form of high-pressure air. Also it is not necessary periodically to free the system of ice.

The cold energy supplied by the cold-gas refrigerator is employed very efficaciously in such an equipment.

What is claimed is:

1. An apparatus for supplying both high pressure air and liquid oxygen comprising a cold-gas refrigerator, a liquid oxygen supplying column provided with a condenser-evaporator, conduit means for connecting said condenser-evaporator to said column for supplying gaseous oxygen thereto, a high pressure liquid compressor for producing high pressure air, a precompressor for precompression of atmospheric air to relatively low pressures, a heat exchanger, the outlet of said precompressor being operatively connected to said heat exchanger for cooling said precompressed air, conduit means for partly conducting the precompressed, cooled air to the cold head of said cold-gas refrigerator and partly to the condenser-evaporator of said liquid oxygen supplying column, means for cooling said precompressed air flowing through said column by the waste gases of said column flowing in the opposite direction, said cold-gas refrigerator being provided with a liquid discharge conduit arrangement for conveying part of the liquefied air from said high pressure liquid compressor to the condenser-evaporator of said column and part to said high pressure liquid compressor, and a discharge duct connecting said high pressure liquid compressor to said heat exchanger in which said high pressure air is in heat exchanging contact with at least that part of the precompressed air that flows to said cold gas refrigerator.

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2. An apparatus for supplying both compressed air and liquid oxygen comprising a cold-gas refrigerator, a liquid oxygen supplying column provided with a condenser-evaporator, conduit means for connecting said condenser-evaporator to said column for supplying gaseous oxygen thereto, a high pressure liquid compressor for producing high pressure air, a pair of reversible heat exchangers, a precompressor for precompression of atmospheric air to relatively low pressures, said heat exchangers being provided with ducts whereby both the precompressed air passed directly to said condenser-evaporator of said oxygen column and the precompressed air passed to the cold head of said cold-gas refrigerator flows through one heat exchanger and passes alternately and selectively in one direction in a selected duct while said air compressed to a high pressure by said high pressure liquid compressor and the waste nitrogen from the column flows alternately and selectively through another selected duct and another heat exchanger in an opposite direction, said heat exchangers being both balanced and self-cleaning, the outlet of said precompressor being operatively connected to said heat exchanger for cooling said precompressed air, conduit means for partly conducting the precompressed, cooled air to the cold head of said cold-gas refrigerator and partly to the condenser-evaporator of said liquid oxygen supplying column, means for cooling said precompressed air flowing through said column by the waste gases of said column flowing in the opposite direction, said cold-gas refrigerator being provided with a liquid discharge conduit arrangement for conveying part of the liquefied air to the condenser-evaporator of said column and part to said high pressure liquid compressor, a discharge duct connecting said high pressure liquid compressor to said heat exchanger in which said high pressure air from said high pressure liquid compressor is in heat exchanging contact with at least that part of the precompressed air that flows to said cold gas refrigerator.

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