

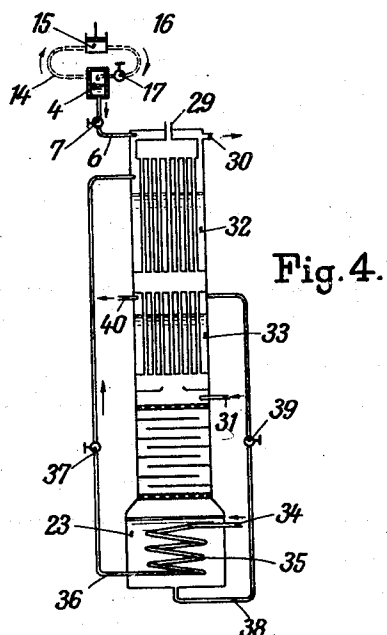
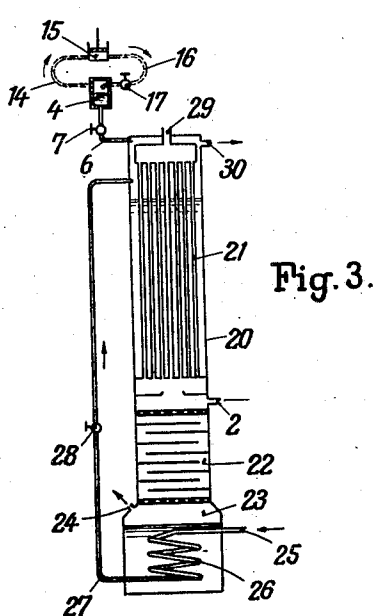
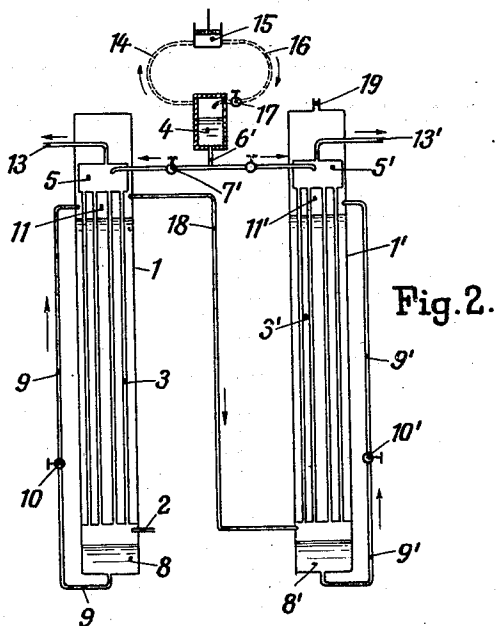
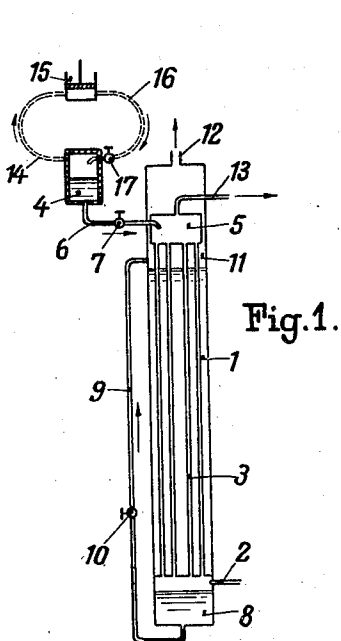
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PROCESS FOR LIQUEFYING AND SEPARATING GAS MIXTURES

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PROCESS FOR LIQUEFYING AND SEPARATING GAS MIXTURES

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My invention relates to an improvement in the processes for liquefying and separating gas mixtures, more particularly of air.

Although in the following specification there is the question of the separation of air into its main components, namely oxygen and nitrogen, it is not intended to limit the invention to air alone. The invention is applicable in the same manner to other gas mixtures comprising ingredients similar to those of air, that is to say such components as have different temperatures and different pressures of liquefaction, as well as different boiling points.

In the hitherto known processes of separation by rectification and dephlegmation, the proceeding is generally such that the air to be decomposed is first entirely or partly liquefied at a pressure of 2000-3000 lbs. per sq. in. and only then the separation into its ingredients is effected.

Unlike the processes hitherto known, according to the present invention the whole of the air to be separated is introduced into the separating column at a pressure of 3-7 lbs. per sq. in. or at a pressure of 55-110 lbs. per sq. in. or with a vacuum, while for compensating or making up the loss of cold, a separate high pressure circuit is used. Nitrogen is preferably used as the medium for the high pressure circuit; however, in certain cases it appears better to use highly compressed air for the purpose.

It is known that out of 33 lbs. of evaporated liquid, 32 lbs. of liquefied vapor are obtained. Consequently, out of 33 lbs. air, 1 lb. must be liquefied by expansion (that is to say by the Joule-Thompson effect) while the remainder is liquefied by the heat exchange in the evaporator. This compensation of liquid was hitherto effected in such a manner that a portion or the whole quantity of air was raised to high pressure, liquefied in the evaporator and then delivered as a liquid expanded to the pressure column. In the present invention the air to be decomposed is delivered or introduced in a gaseous state at a low pressure or at a medium pressure, or a portion at a low pressure and a portion at a medium pressure. The washing

liquid is obtained from a circuit of the low boiling constituent. The compensation of cold or the compensation of liquid is obtained by first allowing the air to expand in a separate liquefying device to a still fairly high pressure, for instance to 350-700 lbs. per sq. in. The liquid thus obtained expanded to the pressure existing in the separating device is introduced into the column at the desired point. The gaseous part of the air is then brought in a suitable manner to the original pressure and then allowed to expand to a pressure of 350-700 lbs. per sq. in., so that this portion of the air also passes in the course of the process to the desired point, for the purpose of being liquefied and introduced into the separating column. The whole of the air to be separated is, as already indicated, introduced into the separating apparatus in the gaseous state but instead of submitting it to a rectification, it is submitted to a partial condensation in a liquid return circuit. If the separation process is carried out in one column, nitrogen of 98% purity is obtained, which has a pressure of the blown in air, as well as oxygen of 45-50% purity, which has atmospheric pressure. If the gas mixture is submitted to a partial condensation in two separation columns, the pressure in the first condensation apparatus must be higher than in the second; for instance, the first column could be worked with a pressure of 110 lbs. per sq. in. and the second with a pressure of 55 lbs. per sq. in. When carrying out the process in this manner, nitrogen of a purity of 98% and a pressure of 110 lbs. per sq. in. is obtained from the first column, and nitrogen of a purity of 98% and a pressure of 55 lbs. per sq. in. is obtained from the second column. From the first column escapes a gas mixture having a pressure of 55 lbs. per sq. in. and enriched with oxygen. This gas mixture is decomposed in the second column into the technically pure single components. The oxygen obtained escapes from the column with a purity of 90-95% and is under atmospheric pressure. If oxygen of a higher degree of purity is to be obtained, this can be done by improving the conditions for the

partial condensation, that is to say by maintaining the pressure of the second column as low as possible. This can be easily done by keeping the evaporating chamber of the second column under a vacuum. The energy

5 due to the pressure of the nitrogen obtained, can again be utilized for performing work. Figures 1 to 4 show diagrammatically, by way of example, constructions of devices by means of which the described method can

10 be carried out. In the apparatus shown in Figure 1, will be shown the single stage process. The air to be separated is admitted under low pressure into the column 1 through the inlet 2

15 and passes through the nest of tubes 3. The cold (liquid) compensation is effected in the vessel 4 in the high pressure nitrogen circuit, in place of which circuit could also be used an air circuit. The liquid remaining

20 after the expansion has taken place is introduced into the condenser head 5 through the pipe 6 provided with the expansion valve 7. The liquid rich in oxygen, which collects at the bottom of the evaporator 8, passes

25 through the pipe 9 provided with the expansion valve 10, into the evaporating chamber 11. The oxygen obtained is drawn off at 12. The high pressure nitrogen obtained

30 is drawn off by means of the pipe 13.

The cold compensation or the liquid to be replaced is obtained according to the invention by first allowing the highly compressed gas to expand from the pressure of

35 about 3000 lbs. per sq. in. to a still fairly high pressure, say of 350-700 lbs. per sq. in. in the separate liquefying device 4 and by introducing the liquid portion through the pipe 6 into the column. By means of the

40 expansion valve 7 provided in the pipe 6, the liquid at a pressure of 350-700 lbs. per sq. in. is allowed to expand to the pressure existing in the column at the point of the introduction. The portion of the air which remains in gaseous state in the liquefying device 4, is conveyed by means of the pipe 14,

45 to a heat exchanger (not shown), and thence to a compressor 15 (indicated in dotted lines), and is again raised to a high pressure by the said compressor. From the compressor 15 the highly compressed gaseous air passes into the pipe 16 in which, by means of the expansion valve 17 provided in the said pipe 16,

50 the gaseous air is allowed to expand to the still high pressure and the resulting liquid is admitted into the liquefying device 4.

In the apparatus according to Figure 2, the process is carried out in two stages. The process takes place in principle in the same

60 manner. The compressed air blown in at 2, passes through the nest of tubes 3. The cold (liquid) compensation takes place in the vessel 4 in the high pressure air or nitrogen circuit. The liquid obtained is poured through the bifurcated pipe 6' provided with the ex-

pansion valves 7', into the condenser heads 5 and 5' provided at the top of the columns 1 and 1'. The liquid rich in oxygen, obtained in the evaporator 8 of the column 1, is expanded in the pipe 9 by means of the expansion valve 10 provided in the same to the pressure existing in the second column 1' and introduced into the evaporator chamber 11. This mixture of oxygen and nitrogen, after evaporation, is blown through the pipe 18 into the second column 2' and passes here through the nest of tubes 3'. The oxygen-liquid obtained in the evaporator 8' is expanded in the pipe 9' by means of the expansion valve 10' provided in the latter, to the pressure existing in the evaporator chamber 5, and can be withdrawn in gaseous state at 19. The nitrogen obtained at 13 has a purity of 98%, while the nitrogen obtained at 13' has a purity of 98% and the pressure existing in the condenser chamber 5'.

If oxygen is to be obtained with the greatest possible purity, the chamber 11' must be maintained under a sub-atmospheric pressure or vacuum. It is then possible to keep the pressures in the condenser chambers 11 and 11' at a correspondingly lower value, which results in a greater enrichment of the liquid with oxygen.

The technical advantage of my process is that the whole air to be separated has to be brought only to low pressure. If nitrogen is obtained under some, but lower pressure, a considerable portion of the energy utilized can be recovered. In the two stage rectification, some of the nitrogen has to be expanded to the atmospheric pressure, and no energy can be recovered. In the single stage rectification, the nitrogen is obtained under pressure, but a portion of the air, or of the nitrogen, must be brought to medium pressure.

Finally a further modification of the process could be obtained by introducing the air to be separated into the separating column with low pressure or with such a pressure as that in the blowers of a blast furnace installation. The air could however be drawn through the separating device by a vacuum, or first subjected to a partial condensation in the upper part of the separating column, which is also called "refining column," and then to an additional rectification in the "enrichment column", that is to say in the bottom part of the separating column. The condenser is worked by a circuit of the mixture of the component of high boiling point, which circuit is under a higher pressure than the separating pressure in the separator device. Eventually the expanded liquid of the component with the high boiling point, works a second condenser, while the cold (liquid) compensation is effected by means of a separate liquefying device, the counter current of which can be arranged in the counter current of the separating device.

The method of carrying out the process is rendered possible by the devices shown by way of example in Figures 3 and 4.

According to Figure 3, the air to be separated is forced into the separating device 20 at 2 with such a pressure as that existing in or produced by the blowers of a blast furnace installation. In the condenser 21 the air is submitted to a partial condensation. The descending liquid rich in oxygen, is freed from the remaining nitrogen in the rectifying column 22 by the oxygen vapours rising from the evaporator 23, and escapes from the separating device at 24 as pure oxygen. Low pressure air or nitrogen is supplied through the pipe 25 which is carried in the form of a coil 26 through the evaporator 23, in which coil the low pressure air or the nitrogen is liquefied. To the coil 26 is connected the pipe 27 provided with an expansion valve 28, so that the liquefied low pressure air or the nitrogen can be expanded into the condenser 21, owing to which the condenser is worked. The cold (liquid) compensation is effected by means of air liquefied in the vessel 4, which is expanded into the condenser 21 through the pipe 6 provided with the expansion valve 7. Liquefied nitrogen could also be used in place of liquefied air. The nitrogen obtained is drawn off at 29. At 30 the evaporated nitrogen leaves the circuit or cycle of the condenser.

In the apparatus according to Figure 4, the separation process is carried out under pressure and takes place in the same way as in the apparatus shown in Figure 3, only the air to be separated is admitted at 31 at low pressure. The pressure of the compressed nitrogen obtained at 29 is utilized for performing work. The condenser in this apparatus is made in two parts. The condenser 32 is worked by expanding the low pressure air or the nitrogen supplied through the pipe 34 and liquefied in the coil 35, through the pipe 36, connected to the coil 35 and provided with the expansion valve 37, into the condenser 32. The other part, 33, of the condenser is worked by taking the oxygen obtained in the evaporator 23 in the form of liquid through the pipe 38 and pouring it through the expansion valve 39 provided in the said pipe, into the upper part of the condenser 33. Under the condenser 33 are placed trays or cups, so that the liquid collecting there trickles down in uniform distribution on the separator column and can be eventually withdrawn from the apparatus. The liquid for the compensation of the losses of cold can also be poured into the separating chamber proper at some other place than that shown. Pure gaseous oxygen is drawn off from the pipe at 40.

I claim:

1. The process for the separation of gaseous mixtures, more particularly of air, including

compressing a gaseous mixture to a high pressure, expanding it to partially liquefy the same under a lower pressure, returning the unliquefied portions of said mixture to be recompressed, causing air to flow upwardly in a stream under still lower pressure, expanding the first mentioned liquid to the last mentioned pressure, and delivering it to the upper end of said stream to flow downwardly therein and effect partial condensation of said air, and evaporating the liquid collecting at the lower end of said stream in heat interchanging relationship with said stream to further cool and further partially condense the air.

2. The process for the separation of gaseous mixtures, more particularly of air, including circulating a gaseous medium in a closed cycle having high and lower pressure portions whereby partial liquefaction is effected in the lower pressure portion, expanding the resulting liquid to still lower pressure and delivering it to the upper portion of an upwardly flowing air stream, cooling said upwardly flowing air stream to effect partial condensation, and producing said cooling by evaporating the condensate in heat-interchanging relationship to but out of contact with said upflowing stream.

3. The process of separating gaseous mixtures, including the steps of partially condensing the mixture, vaporizing the condensed portion in heat interchanging relationship with the mixture to effect said partial condensation, withdrawing the vapor evolved from the condensed portion, partially condensing it to form a second liquid, vaporizing said second liquid in heat interchanging relationship to said evolved vapor to effect said partial condensation thereof, partially liquefying another gaseous mixture under high pressure and adding said last mentioned liquid to both of the portions of the first mentioned gaseous mixture undergoing partial condensation.

4. The process for the separation of gaseous mixtures, more particularly air, including compressing a gaseous medium to 150 to 200 atmospheres pressure, expanding to about 50 atmospheres pressure under conditions resulting in partial liquefaction, returning the unliquefied portion for recompression, fractionally condensing the gaseous mixture to be separated under low pressure by the latent heat of evaporation of the portion condensed and also by the cooling effect of the first mentioned liquid under low pressure.

5. The process for the separation of gaseous mixtures, particularly of air, which includes compressing a gaseous mixture to a high pressure, expanding it to form a liquid portion under a lower pressure, returning the unliquefied portion of said mixture to be recompressed, evaporating said liquid at a

still lower pressure, causing air to flow upwardly in a stream under low pressure, partially liquefying the air in said stream, collecting the liquid at the lower end of said stream, evaporating said last mentioned liquid, and transferring heat from said stream to both of said liquids to effect the evaporation of both and to effect the said partial liquefaction.

10 In testimony whereof I have signed this specification.

KARL EDUARD RUDOLF MEWES.

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