

M. HAZARD-FLAMAND.
 APPARATUS FOR DIVIDING AIR INTO ITS ELEMENTS BY FRACTIONAL DISTILLATION.
 APPLICATION FILED DEC. 9, 1908.
 1,201,043. Patented Oct. 10, 1916.
 3 SHEETS—SHEET 1.

Fig. 1

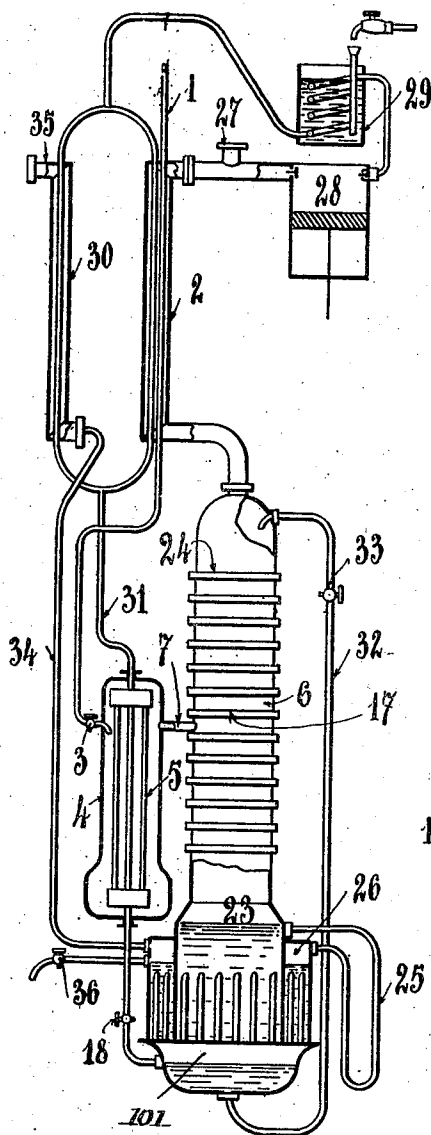


Fig. 2

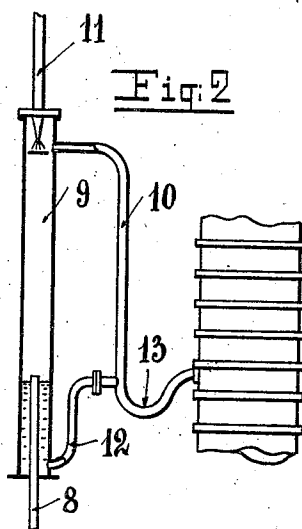
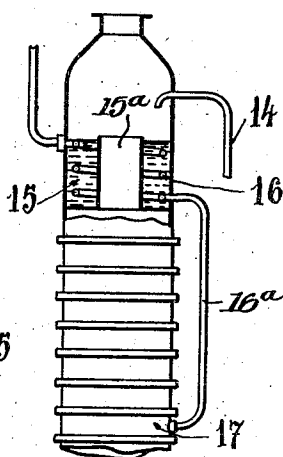


Fig. 3



Witnesses

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Fig. 4

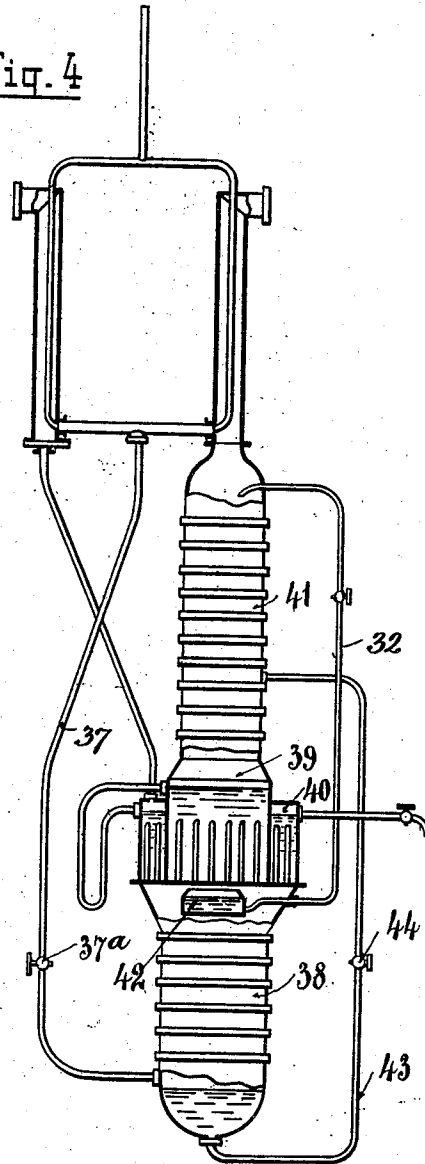
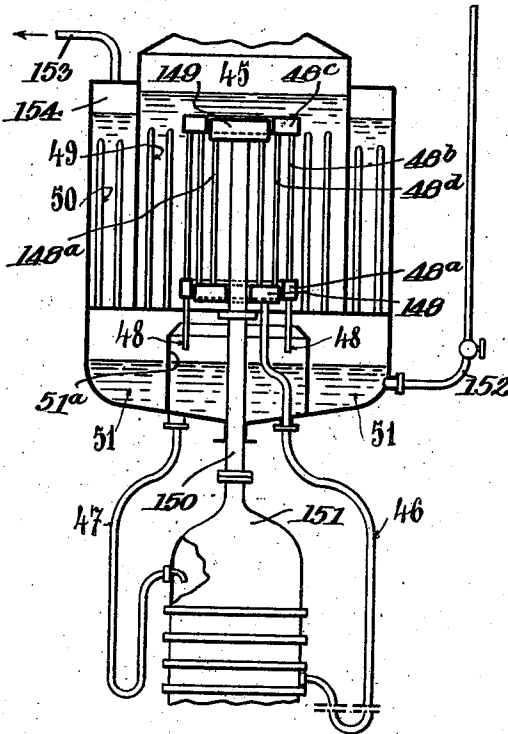
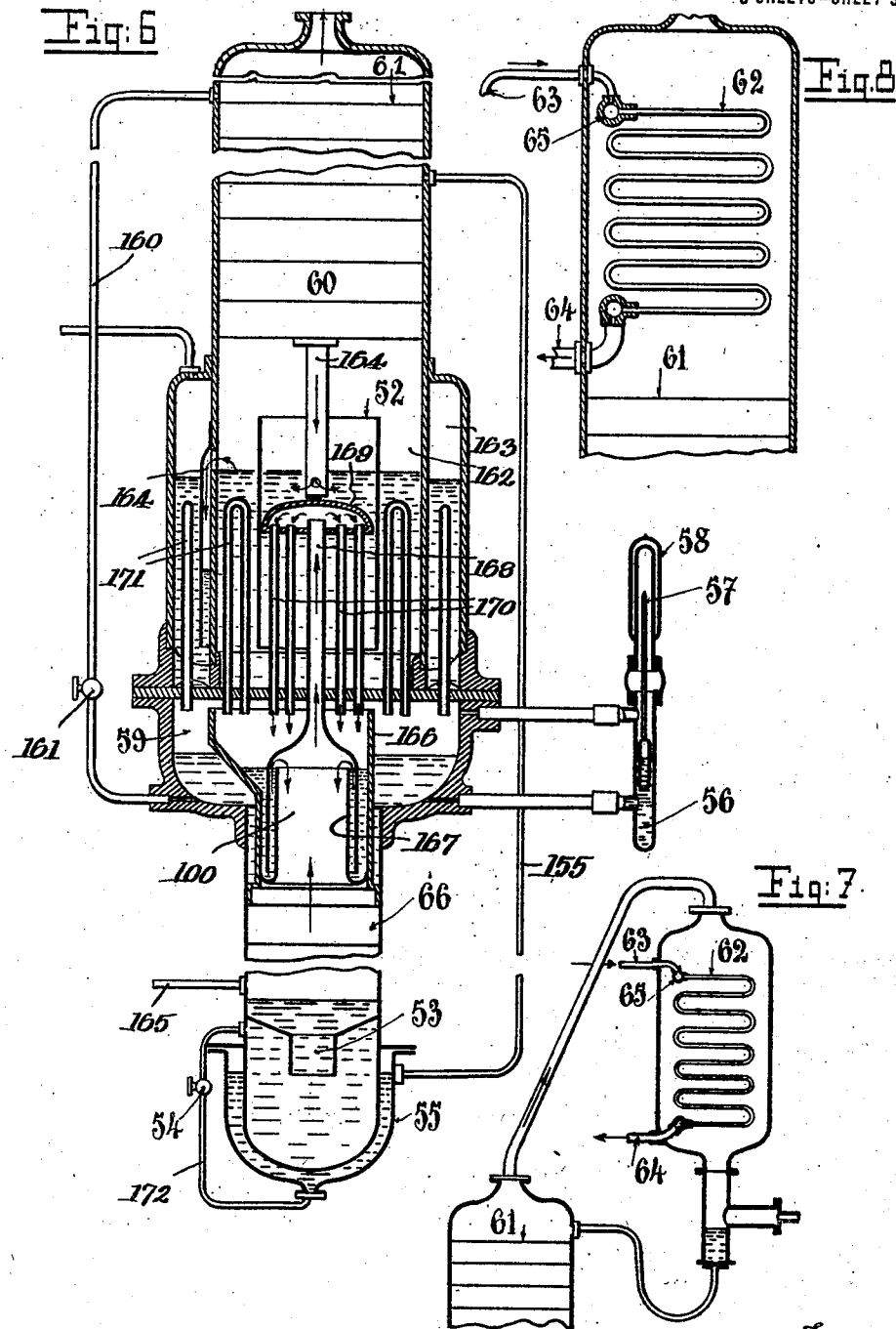


Fig. 5



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UNITED STATES PATENT OFFICE.

MAURICE HAZARD-FLAMAND, OF ST. VRAIN, FRANCE.

APPARATUS FOR DIVIDING AIR INTO ITS ELEMENTS BY FRACTIONAL DISTILLATION.

1,201,043.

Specification of Letters Patent.

Patented Oct. 10, 1916.

Application filed December 9, 1908. Serial No. 466,683.

To all whom it may concern:

Be it known that I, MAURICE HAZARD-FLAMAND, whose post-office address is St. Vrain, Seine-et-Oise, France, have invented certain new and useful Improvements in Apparatus for Dividing Air into Its Elements by Fractional Distillation, of which the following is a specification.

My invention relates to an apparatus for producing oxygen and nitrogen and more particularly to the production of these gases by means of an apparatus wherein the air is separated into its constituents by being subjected to low temperature conditions.

By my invention, I am enabled to produce oxygen and nitrogen from air by a fractional distillation process, the practice of which does not require the air to be liquefied before treatment. By this method, I separate the nitrogen and the oxygen under conditions which will insure substantially pure gases, approximating in volume the percentage of each gas contained in the air subjected to the treatment. My improved art or method utilizes nitrogen, at a pressure and a temperature which will liquefy oxygen, as the means for effecting the separation of the constituents of the air and hence a portion of the products secured by the practice of my method, may be utilized in a continuance of the practice and not only admit of a continuous method of separating the gases of the air, but an economical method as well. My improved method requires the maintenance of low temperatures during all steps thereof, and in the practice of the invention, I arrange to abstract from the air to be subjected to the treatment as high a percentage of the heat units as is practicable for the successful practice of my method, utilizing the gases being produced for this purpose. I also utilize the relatively higher temperature of the gaseous oxygen produced by my method, for conditioning the nitrogen used in converting the liquid oxygen to gaseous form and the nitrogen used in lowering the temperature of the air to the temperature of its saturated vapors. Furthermore, I utilize the liquid oxygen in liquefying or otherwise conditioning the nitrogen to be used in the distilling column or chamber with the incidental vaporization of said oxygen.

The method above referred to is not

claimed herein, the same being made the subject matter of a divisional application.

In the apparatus for carrying on my aforesaid method or art, I provide in conjunction with one or more multiple stage distilling columns, means whereby the atmospheric air before being delivered to said distilling column or columns is brought to the temperature of its saturated vapors and means for maintaining a continuous circulation of nitrogen starting from the nitrogen delivery end of the distilling column or columns in the form of a gas and ending adjacent said outlet in the form of a liquid, suitable devices being arranged intermediate said points for utilizing the heat units of said nitrogen in carrying on the aforesaid method. I also provide in conjunction with said distilling column or columns means for separating the liquid oxygen and subjecting the separated bodies to the action of the nitrogen in a manner to gasify said oxygen for the two-fold object of utilizing a portion of said gases in the distilling column and conditioning another portion thereof for withdrawal from the apparatus as a product. I also provide means whereby the products of the machine are utilized in maintaining the low temperatures throughout the apparatus necessary to the successful operation thereof.

In conditioning the air, I preferably employ a device in which the nitrogen used in the distilling operation aids in developing the necessary low temperatures in the air under treatment and in which impurities in the air will be removed prior to its introduction to the distilling column so as to permit the production of substantially pure oxygen and substantially pure nitrogen.

The invention consists in an apparatus for dividing air into its elements embodying the novel features of construction and combination of parts all as hereinafter set forth and described and more particularly pointed out in the claims hereto appended.

Referring to the drawings: Figure 1 is a view partly in elevation and partly in section of an apparatus embodying my invention; Fig. 2 shows a modification thereof by which the desired low temperatures may be maintained throughout the distilling column; Fig. 3 is a view of a further modification for the same purpose; Figs. 4, 5 and 6

show modifications in the construction of the apparatus shown in Fig. 1; and Figs. 7 and 8 show an apparatus which may be used in conjunction with a distilling column for clarifying the upper portion thereof.

Like letters refer to like parts throughout the several views.

In the apparatus shown in Fig. 1 in the accompanying drawings, I employ a multiple stage distilling column 6, discharging into which is a pipe 7 adapted to deliver air at the temperature of its saturated vapors. This pipe communicates with said column at a stage intermediate the top and bottom thereof at a point where the temperature of the column will be substantially that of the vapors introduced thereto. The air at any desired or necessary pressure is delivered into the apparatus through the pipe 1 which has a nozzle 3 discharging into a refrigerating chamber 4 with which the pipe 7 communicates. It is in this chamber that the air to be treated is brought to the temperature of its saturated vapors, suitable means being provided in conjunction with this chamber for bringing the air to the desired temperature. Incidentally in bringing the air to this temperature impurities will be precipitated and will accumulate in the bottom of the chamber. The bottom of the column is provided with a boiler 23 adapted to receive the liquefied oxygen and surrounding this boiler is a chamber 26, from which oxygen in the boiler is adapted to flow through the tube 25 thus dividing the liquid oxygen so that the portion thereof within the boiler 26 will be in direct communication with the stages of the distilling column: while the portion 26 will be separated from the distilling column in a manner to permit the withdrawal of the gaseous oxygen therefrom as a product of the apparatus. Below the boiler 23 and vaporizer 26 is a condensing chamber or balloon 101 adapted to receive the nitrogen being constantly circulated through the apparatus and expose the surface of said boiler and said vaporizer to the action of this nitrogen in a manner to gasify the oxygen contained therein with a resultant condensation of said nitrogen. Leading from said condensing chamber or balloon 101 and discharging into the upper portion of the distilling column 6 is a pipe 32 having a valve 33 arranged in the length thereof for controlling the rate of flow of the nitrogen from said chamber to the upper portion of the distilling column. As heretofore described, the air upon entering the column 6 is gradually separated by fractional distillation into its constituents, the oxygen descending from stage to stage and the nitrogen ascending from stage to stage until it, in the upper portion of the column, is in a gaseous condition. The gaseous nitrogen is

withdrawn from the column through the nitrogen offtake pipe having in its length the exchanger 2 through which the pipe 1 passes so as to utilize the low temperature of this gas in raising the temperature of the air under treatment. In the length of said pipe is an offtake opening 27 from which a portion of the nitrogen withdrawn from the distilling column is removed as a product of the apparatus. The said gases are withdrawn from the column by means of the compressor 28 or any equivalent device which pass these gases through a refrigerator 29 and the pipe 31 to the tubes 5 within the chamber 4 and thence through the pipe containing in its length the valve 18 to the condensing chamber or balloon 101. It will thus be seen that I provide means for continuously circulating nitrogen through the apparatus while permitting the withdrawal of that portion thereof constituting the product of nitrogen gas. The pipe 31 is provided with two branches as shown, one of which passes through the heat exchanger 2 and the other of which passes through the heat exchanger 30 into which the pipe 34 communicating with the condenser 26 discharges. The off-take for the oxygen is indicated at 35. By this construction, it will be observed that the heat exchangers 2 and 30 are maintained at a low temperature by the nitrogen withdrawn from the upper portion of the distilling column and from the oxygen withdrawn from the apparatus as a product; that the exchanger 2 acts to lower the temperature of the air introduced in the apparatus and the nitrogen being delivered to the condensing chamber, and that the exchanger 30 serves to raise the temperature of the oxygen being delivered from the apparatus and to lower the temperature of the nitrogen passing to the said condensing chamber or balloon. By passing the nitrogen through the tubes 5, I utilize this circulating nitrogen for lowering the temperature of the air to be treated while passing through the refrigerating chamber 4. Oxygen may also be withdrawn either in a liquid or gaseous state by means of the valve controlled pipe 36.

Other means than the refrigerating chamber 4 and its appurtenances may be used for bringing the air to the temperature of its saturated vapors, Fig. 2 and Fig. 3 each illustrating a refrigerating mechanism which may be used in conjunction with the distilling column 6 and its appurtenances for conditioning the air preparatory to its delivery to said column.

In the modification shown in Fig. 2; instead of passing the nitrogen through the tubes 5 for the purpose of compensating for the loss through radiation, I provide a liquid air chamber to which liquid air is introduced by the pipe 11. The air to be treated

enters through the pipe 8 flows upwardly in this chamber through the pipe 9 in contact with the liquid air trickling along the walls of said pipe and passes out through the pipe 10 passing to the column through the siphon 13 which receives liquid air through the pipe 12 from the bottom of the chamber 9. The apparatus shown in Fig. 2 may be used as a substitute for the refrigerating chamber 4 and its appurtenances. In Fig. 3 I have shown an apparatus for supplying this cold of compensation utilizing nitrogen. In this form, the upper portion of the distilling column is provided with a tank 15 receiving liquid nitrogen through the pipe 14. Arranged in this tank is a coil 16 through which the air to be treated is passed, the outlet of said coil 16^a, shown to the right of the figure, delivering the air at the desired stage of the distilling column. The nitrogen delivered through the pipe 14 may come from the condensing chamber or balloon 101 or in part therefrom and in part from any other desired source, the overflow from this chamber aiding in the separation of the air into its constituents.

In the form of the invention shown in Fig. 3 the tank 15 is in communication through the tube 15^a with the distilling column adjacent the upper stage thereof so that nitrogen delivered through the pipe 14 will, as it overflows the tank 15, fall within the upper portion of said distilling column in a manner to meet the incoming vapors in the manner described in connection with the form of the invention shown in Fig. 1. The tank 15 and coil 16 are used for conditioning the air prior to its delivery to the distilling column thus performing the function for which the refrigerator 4 and its appurtenances is designed in the form of the invention shown in Fig. 1.

In the modification of the invention shown in Fig. 4, the distilling column 41, boiler 39 and vaporizer 40 are the same as in the preferred form of the invention. The arrangement of exchangers is also the same as that shown in Fig. 1, although these exchangers are not used to impart cold to the nitrogen passing to the condenser. In this form of the invention, the condensing chamber 42, by means of which the liquid oxygen in the boiler and vaporizer is converted into a gas or vapor, is at the top of a distilling column into which the air to be treated is delivered through the pipe 37 containing therein the valve 37^a. The contact of the air delivered through this pipe with the nitrogen upon the stages of this column 38 will bring it to the desired temperature and it will pass with some nitrogen in all probability through the pipe 43 to a stage of the column 41. In the meanwhile, the nitrogen rising to the top of the column 38 will act upon the oxygen in the boiler and in the vaporizer

and the condensed portion thereof will pass upwardly through the pipe 32 upon the upper stage of the column 41. The effect of the structure shown in Fig. 4 and its mode of operation excepting as to the manner of conditioning the air for delivery to the main distilling column is the same as that shown in Fig. 1.

In the modification shown in Figs. 5 and 6, the air is prepared for introduction in the main distilling column by substantially the same mechanism shown in Fig. 4. In Fig. 5 the boiler is shown at 45 and the condenser for the nitrogen at 51. Centrally of said condenser is a chamber 51^a. Discharging into it are the tubes 48 carried by a hollow head 48^a and located in the boiler 45. The head 48^a is in communication through the pipes 48^b with a second head 48^c which in turn is in communication through the pipes 48^d with a drum 148. This drum is in communication through the pipes 148^a with a drum 149 communicating through the pipe 150 with the distilling column 151.

At 152 I have shown the nitrogen pipe for delivering the liquid nitrogen to the upper portion of a distilling column surmounting the boiler 45 and at 153 I have shown an oxygen offtake pipe for withdrawing oxygen from the chamber 154 corresponding with the chamber 26 in the form of the invention shown in Fig. 1. The tubes 49 and 50 lead from the condensing chamber 51 into the boiler 45 to the chamber 154 for the purpose of securing a more effective ebullition of the liquid oxygen contained in said boiler and said chamber. The pipe 46 extends from the drum 148 to one of the stages of the distilling column 151 for the purpose of delivering the conditioned air to this column. In this form of the invention the air to be treated is first distilled in the column 151 the product passing through the pipe 150 and the various heads and tubes communicating therewith, some nitrogen being delivered to the condenser 51 and the remainder of the products being re-delivered to the column 151 through the pipe 46 from whence they pass to the distilling column surmounting the boiler 45 in the manner shown and described in connection with the form of the invention shown in Fig. 4 of the accompanying drawings.

In the modification shown in Fig. 6, the main multiple stage distilling column is shown at 60, the liquid nitrogen being delivered to the upper part of this column through the pipe 160 communicating with the condenser chamber 59 and having in the length thereof a valve 161 for controlling the rate of the flow of the nitrogen. Above the condensing chamber 59 and below the lowermost stage of the column 60 is a boiler 162 surrounded by a chamber 163, in communication therewith through the duct

164. Within the boiler 162 is a diaphragm 52 into which oxygen is discharged from the lowermost stage of the column 60 through the pipe 164. Below the condensing chamber 59 is a distilling column 66 for the treatment of the air preliminary to its delivery to the distilling column 60, air being delivered adjacent the lower portion of said column 66 through the pipe 165.

10 Within the condensing chamber 59 is a partition 166 open at the top so as to be in communication with said chamber, and having at the bottom thereof a trough indicated at 167. Seated in the trough 167 is

15 the lower enlarged head of a conduit 168 opening into a drum 169. A plurality of tubes 170 extend from said drum and discharge into the space within said partition 166. A plurality of tubes 171 project from

20 the space within said partition 166 and from the condenser chamber 59 into the boiler 162 and chamber 163 respectively, thus facilitating the condensation of the nitrogen passed through the tubes 171 and

25 the volatilization of the oxygen contained in said boiler and said chamber. The air delivered through the pipe 165 passes upwardly through the distilling column 66 and is brought to the desired temperature and partially rectified. This air passes through the

30 tube 100 and the pipe 168 to the drum 169 from whence it falls backwardly through the tubes 170 to within the compartment 166. Through this circulation, it is caused

35 to give up a considerable percentage of its heat to the oxygen within the boiler 162. The air, due to the lowering in its temperature, will accumulate within the partition 166 until it overflows the trough 167 and

40 falls through the pipe 100 passing downwardly through the distilling column 66 until it reaches the bottom thereof. To avoid such ebullition of this air while in the bottom of the column 66 as will unnecessarily agitate it, I surround the bottom

45 of the column with a jacket 55 into which the liquid accumulated in the bottom of the column 66 is delivered through the pipe 172 having in the length thereof an expansion valve 54. To prevent the passage of

50 frozen mist or of solidified carbonic acid, to the lower portion of the column 66 I provide a decantation diaphragm 53. In conjunction with the condenser 59, I provide

55 a sight gage for indicating the conditions within said condenser consisting of a bulb 56, a float 57 and a cap 58 surrounding the upper portion of the bulb 56, as perfect a vacuum as is practicable being

60 maintained between said cap and said bulb for the purpose of insulating the upper portion thereof. Different portions of the bulb 56 are connected respectively with the upper and the lower portions of the chamber

65 59.

Figs. 7 and 8 illustrate an arrangement which may be applied to the upper portion of any of the main distilling columns heretofore described. This device comprises a refrigerating coil 62, 63 and 64 upon which

70 a portion of the nitrogen vapors beyond the upper stage of the column is adapted to condense in order to retard the flow of gas from said upper stages. This device also serves as a compensation for the loss of heat

75 throughout the apparatus through the reduction of the temperature of the nitrogen thereby. In Fig. 7 this column is shown in a casing independent of the column shown at 61, while in Fig. 8 the coil is

80 shown in the upper portion of this column. In the forms of the invention shown in Figs. 7 and 8 the desired operative effect is secured by expanding nitrogen in the coil

85 62, 63 being the inlet extension of said coil and 64 the outlet extension.

While I have shown various constructions adapted for separating the air into its constituents, it is not my intention to limit the invention to the various constructions shown. The essential characteristics

90 of the apparatus employed are a main multiple stage distilling column, means for bringing air to the temperature of its saturated vapors before introducing it to a

95 stage intermediate the top and bottom of said column, means for introducing liquid nitrogen adjacent the top of said column, a receptacle for liquid oxygen in communication with the bottom of said column and

100 a condenser adjacent said last named means adapted to contain liquid nitrogen or a cloudy distillate thereof for the purpose of converting said liquid oxygen into a gas and

105 means for withdrawing gaseous oxygen and gaseous nitrogen from the apparatus. In each of the forms of the invention shown, it will be found that there is presented characteristics

110 pertaining to one or more of the essential elements of this apparatus, the variations shown in Figs. 1 to 4, 5 and 6 relating to different structures used in conditioning the

115 air, the main distilling column being practically the same in each form of the invention shown.

Having described the invention what I claim as new and desire to have protected by Letters Patent is:—

1. An apparatus for separating air into its constituents embodying therein a multiple stage distilling column, means wherein

120 air may be brought to the temperature of its saturated vapors, connections between said means and said column, a boiler into which liquid oxygen is delivered from the

125 lowermost stage of said column, means adapted to receive an agent whereby the oxygen in said boiler may be vaporized, means whereby oxygen in said boiler is withdrawn in gaseous form therefrom and means

130

delivering liquid nitrogen to the upper portion of said column.

2. An apparatus for separating air into its constituents embodying therein a multiple stage distilling column, means wherein air may be brought to the temperature of its saturated vapors, connections between said means and said column, a boiler into which liquid oxygen is delivered from the lowermost stage of said column, a condenser in surface contact with said boiler, means adapted to deliver nitrogen to said condenser, whereby the oxygen in said boiler may be volatilized, means whereby oxygen in said boiler is withdrawn in gaseous form therefrom and means conveying liquid nitrogen from said condenser to the upper portion of said column.

3. An apparatus for separating air into its constituents embodying therein a multiple stage distilling column, means wherein air may be brought to the temperature of its saturated vapors, connections between said means and said column, a boiler into which liquid oxygen is delivered from the lowermost stage of said column, means adapted to receive an agent whereby the oxygen in said boiler may be vaporized, means whereby oxygen in said boiler is withdrawn in gaseous form therefrom, means delivering liquid nitrogen to the upper portion of said column, and means whereby cold of compensation is delivered to said column with the air.

4. An apparatus for separating air into its constituents embodying therein a multiple stage distilling column, means wherein air may be brought to the temperature of its saturated vapors including therein means for removing impurities from the air before delivering the air to said column, connections between said means and said column, a boiler into which liquid oxygen is delivered from the lowermost stage of said column, means whereby the oxygen in said boiler may be vaporized, means whereby oxygen in said boiler is withdrawn in gaseous form therefrom, and means delivering liquid nitrogen to the upper portion of said column.

5. An apparatus for separating air into its constituents embodying therein a multiple stage distilling column, means wherein air may be brought to the temperature of its saturated vapors, connections between said means and said column, a boiler into which liquid oxygen is delivered from the lowermost stage of said column, a condenser in surface contact with said boiler and means maintaining a continuous circulation of nitrogen from the upper part of said column in the form of gas through said condenser where it is liquefied and back to the upper part of said column.

6. An apparatus for separating air into its constituents embodying therein a multiple stage distilling column, means wherein air may be brought to the temperature of its saturated vapors, connections between said means and said column, a boiler into which liquid oxygen is delivered from the lowermost stage of said column, means adapted to receive an agent whereby the oxygen in said boiler may be vaporized, a vaporizer surrounding and in communication with said boiler, an offtake leading from said vaporizer, and means delivering liquid nitrogen to the upper portion of said column.

7. An apparatus for separating air into its constituents embodying therein a multiple stage distilling column, means wherein air may be brought to the temperature of its saturated vapors, connections between said means and said column, a boiler into which liquid oxygen is delivered from the lowermost stage of said column, means adapted to receive an agent whereby the oxygen in said boiler may be vaporized, a vaporizer surrounding said boiler, a siphon tube connecting said boiler and said vaporizer, an offtake leading from said vaporizer, and means delivering liquid nitrogen to the upper portion of said column.

8. An apparatus for separating air into its constituents embodying therein a multiple stage distilling column, means wherein air may be brought to the temperature of its saturated vapors, connections between said means and said column, a heat exchanger, an air pipe passing through said heat exchanger and discharging into said first named means, a boiler into which liquid oxygen is delivered from the lowermost stage of said column, a condenser, means withdrawing gaseous nitrogen from the top of said column, connections between said means and said condenser, connections between said condenser and the upper part of said column and means whereby oxygen in said boiler is withdrawn in gaseous form.

9. An apparatus for separating air into its constituents embodying therein a multiple stage distilling column, means wherein air may be brought to the temperature of its saturated vapors, connections between said means and said column, a boiler into which liquid oxygen is delivered from the lowermost stage of said column, a vaporizer surrounding and in communication with said boiler, a condenser in surface contact with said boiler and said vaporizer, a heat exchanger, an offtake leading from said vaporizer and discharging into said heat exchanger, and means withdrawing gaseous nitrogen from the upper portion of said column, passing it through said heat exchanger, delivering it to said condenser,

withdrawing it from said condenser and delivering it to the upper portion of said column.

10. An apparatus for separating air into
5 its constituents embodying therein a multiple stage distilling column, a refrigerating chamber, a connection between said refrigerating chamber and a stage of said column intermediate the uppermost and lowermost
10 stages thereof, means whereby air under pressure may be delivered to and expanded in said chamber, tubes in said chamber, a boiler adapted to receive liquid oxygen from the lowermost stage of said column, a vapor-
15 izer about said boiler, a condenser in surface contact with said boiler and said vaporizer, an offtake pipe whereby oxygen may be withdrawn from said vaporizer, a nitrogen offtake pipe communicating with
20 the upper portion of said column, a plurality of heat exchangers communicating respectively with said oxygen offtake pipe and

said nitrogen offtake pipe, said means for delivering air under pressure to said chamber passing through one of said heat ex- 25
changers, means withdrawing nitrogen from said column through said offtake pipe and one of said heat exchangers, a pipe connection between said last named means and said
30 tubes, passing through both of said heat exchangers, a pipe connection between said tubes and said condenser and a pipe connection between said condenser and the upper portion of said column whereby there
35 is a continuous circulation of nitrogen, leaving the upper portion of said column in a gaseous form and entering the upper portion of said column in a liquid form.

In testimony whereof I affix my signature,
in presence of two witnesses.

MAURICE HAZARD-FLAMAND.

Witnesses:

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H. C. COXE.