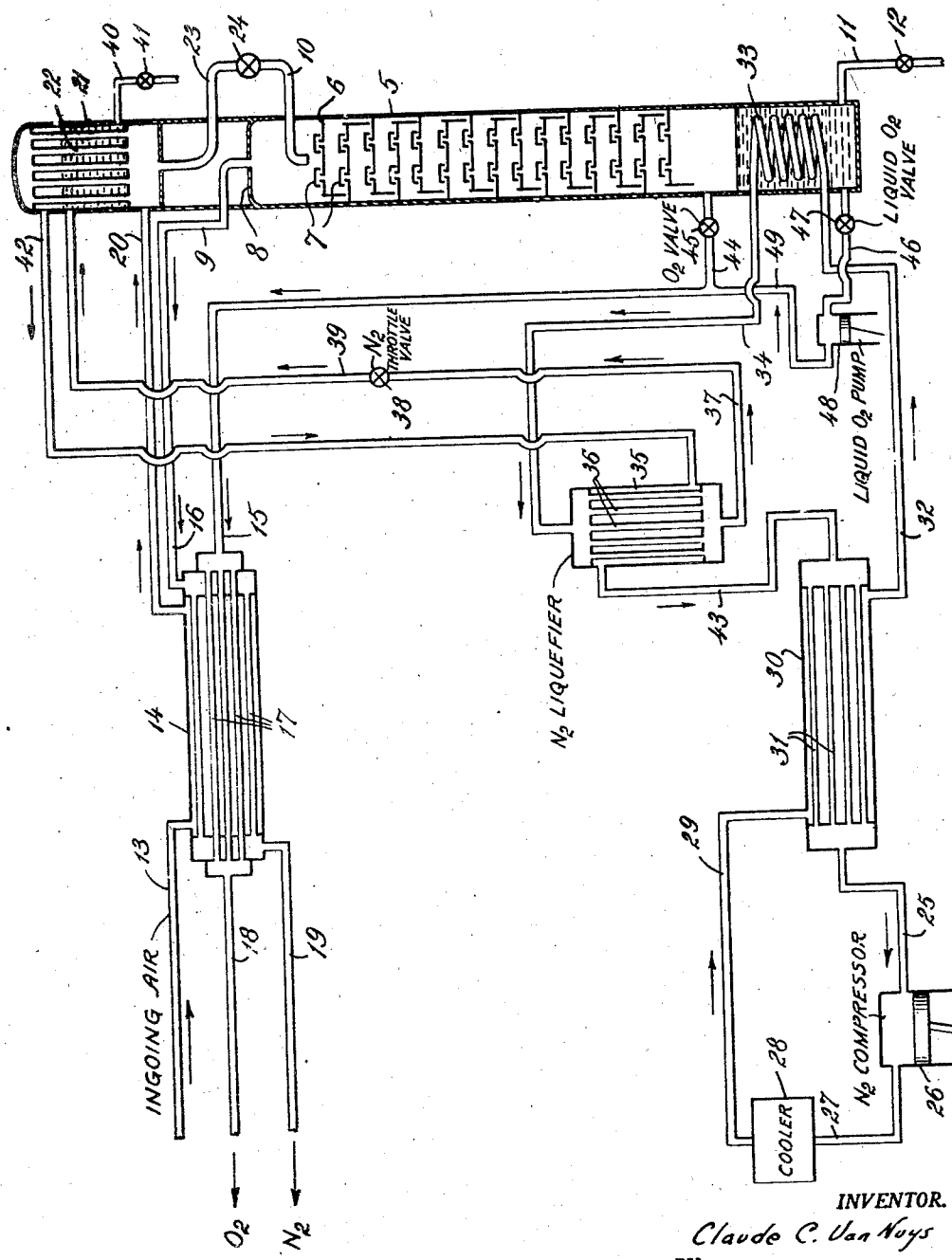
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SEPARATION OF THE CONSTITUENTS OF AIR

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SEPARATION OF THE CONSTITUENTS OF AIR

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1 Claim. (Cl. 62—175.5)

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This invention relates to the separation of atmospheric air into its constituents by liquefaction and rectification and particularly to improvements in the method and apparatus therefor.

In commercial liquefaction methods of separating oxygen from the atmosphere as heretofore practised, the necessary refrigeration to attain low temperatures is obtained by compression and subsequent expansion of the air treated. This necessitates initial compression of the air to relatively high pressure of the order of 15–20 atmospheres. Such compression can be attained only in reciprocating compressors which require oil lubrication. The oxygen of the air under such pressures and at the temperatures resulting from compression causes decomposition of the lubricating oil and the introduction to the air stream of substantial proportions of hydrocarbons in addition to any which may be present. The use of special lubricating oils does not avoid this source of contamination.

Since the hydrocarbons are not removed from the air stream by the usual treatment intended to separate moisture and carbon dioxide, they tend to accumulate and eventually find their way to the compartment of the apparatus where liquid oxygen accumulates. The presence of such material in contact with pure oxygen, whether liquid or gaseous, is undesirable. Hence very elaborate attempts have been made heretofore to eliminate the hydrocarbons at some point intermediate compression of the air and the formation of liquid or vapor rich in oxygen in which the hydrocarbons might accumulate. Such attempts involve operations which interfere with the efficiency of the cycle and the use of necessarily complicated equipment. Furthermore, these attempts have failed substantially to achieve the desired object. It is still possible for hydrocarbons derived from the lubricating oil to accumulate at points in the apparatus where gases or liquids rich in oxygen are present.

It is the object of the present invention to provide a simple and effective method and apparatus whereby the presence of hydrocarbons resulting from decomposition of oil in the compression of the air can be avoided and further improvements in the separation of oxygen from the atmosphere can be obtained.

Other objects and advantages of the invention will be apparent as it is better understood by reference to the following specification and the accompanying drawing, which illustrates diagrammatically the apparatus suitable for the practice of the invention.

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In accordance with the present invention, the air to be separated is not utilized to produce any refrigeration in the cycle. I employ instead a separate nitrogen cycle which acts as a heat transfer agent everywhere in the air cycle. The air need be compressed in accordance with my invention only to pressures not substantially higher than 3 atmospheres absolute. Usually a pressure of 2 atmospheres or sufficient pressure only to ensure movement of the gas through the apparatus is needed to accomplish the purpose of the invention. Such pressures are easily attainable in variable types of blowers which require no internal lubrication. Hence no lubricating oil and decomposition products thereof are mingled with the air which is eventually separated to recover oxygen therefrom.

The nitrogen which affords the refrigerative effect is compressed, circulated and expanded in such a way as to provide sufficient cold so that the air can be liquefied at low pressure. The nitrogen of the refrigeration cycle does not mingle at any point with the air undergoing separation. Hence the presence of hydrocarbons in the nitrogen cycle is not inimical to the method and affords no possibility of accumulation of hydrocarbons in the presence of oxygen or products rich in oxygen. The nitrogen can be compressed to the necessary pressure, for example 2500 pounds per square inch, in starting the apparatus and from 900 to 1000 pounds per square inch thereafter, in any available form of compressor. Oil lubrication may be used. The quantity of nitrogen necessary for the refrigeration cycle will depend upon the size of the apparatus, but will not in any case exceed the quantity of air contained in the air separation cycle.

The procedure will be readily understood by reference to the drawing, in which 5 indicates a rectification column having the usual trays 6 and bubble caps 7. The column is provided at its tops with a diaphragm 8 having an outlet 9 through which the effluent, rich in nitrogen, escapes. Liquid oxygen accumulates in the bottom of the column, and the vapors therefrom rise through the trays 6 and bubble caps 7 in contact with liquid introduced through a pipe 10 which flows downwardly over the trays 6. A pipe 11 controlled by a valve 12 is connected to the bottom of the column to permit purging in the event that any impurity tends to accumulate in the pool of liquid oxygen.

Air, after initial compression to a pressure not greater than say 3 atmospheres absolute, in any

suitable apparatus but preferably in a blower (not shown) is introduced through a pipe 13 to an exchanger 14 where the air is cooled by heat exchange with the separated constituents, oxygen and nitrogen, which are delivered to the exchanger through the pipes 15 and 16 respectively. After flowing through tubes 17 of the exchanger, the oxygen and nitrogen are discharged through pipes 18 and 19 respectively. The air at low pressure and with its temperature reduced, is delivered by a pipe 20 to a liquefier 21 which is shown at the top of the column 5, though it need not be disposed in this particular position. The air is exposed in tubes 22 to the cooling effect of liquid nitrogen surrounding the tubes, and the resulting liquid air is delivered through a pipe 23 and valve 24 to the pipe 10 and thus to the column 5. As will be observed, all of the refrigerative effect is obtained through the liquid nitrogen surrounding the tubes 22. Neither the liquid nor the vapors resulting therefrom are mingled with the air undergoing liquefaction, and hence the latter is not contaminated by any impurities which may be present in the nitrogen.

The nitrogen travels in an independent refrigeration cycle. It is delivered by a pipe 25 to a compressor 26 which may be a reciprocating compressor of the type ordinarily used in liquefaction plants. The nitrogen is compressed to the required pressure for maintenance of the desired refrigerative effect. Usually in starting operation a pressure as high as 2500 pounds per square inch is necessary. Thereafter a pressure of 900 to 1,000 pounds per square inch is ordinarily sufficient. Any pressure may be used to afford sufficient refrigeration for maintenance of the operation. The compressed nitrogen is delivered by a pipe 27 to a cooler 28 and thence by a pipe 29 to an exchanger 30 where it circulates about tubes 31 carrying cold nitrogen returning in the cycle. The temperature of the compressed nitrogen is reduced, and it is delivered through a pipe 32 to a coil 33 immersed in the pool of liquid oxygen at the bottom of the column 5. The nitrogen is thus further cooled in vaporizing the portion of the oxygen.

Thereafter the nitrogen is delivered through a pipe 34 to a liquefier 35 and passes through tubes 36 therein in heat exchange relation with cold nitrogen vaporized at a lower pressure. The liquid nitrogen is withdrawn through a pipe 37 and delivered through an expansion valve 38 and pipe 39 to the liquefier 21 where the nitrogen liquid serves, as hereinbefore described, to effect liquefaction of the low pressure air. A purge 40 controlled by a valve 41 permits removal of portions of the nitrogen liquid in the event of any substantial contamination thereof, particularly through leakage of oxygen into the system.

The nitrogen vapor from the liquefier 21 is withdrawn through a pipe 42 and delivered to the liquefier 35. It circulates about the tubes 36, effecting partial liquefaction of the high pressure nitrogen in the tubes. The nitrogen vapor is then delivered through a pipe 43 to the exchanger 30 and passes through the tubes 31 thereof to the pipe 25 which again delivers the nitrogen to the compressor. Additional nitrogen may be added from any source to the cycle as may be necessary for the maintenance thereof.

Since the nitrogen employed for refrigeration travels in an independent cycle, it is immaterial whether or not it may carry hydrocarbons. These hydrocarbons, if present, cannot mingle with the air undergoing separation and thus arrive at a point in the system where oxygen or products rich in oxygen are present. Thus the liquid oxygen which accumulates in the bottom of the column 5 is free from any contaminating hydrocarbons which might have been introduced owing to the necessity of employing oil in the initial compression of the air. The use of the blower to compress the air obviates that possibility. The oxygen is partially vaporized in the bottom of the column 5 and the vapor may be withdrawn through a pipe 44 controlled by a valve 45 and delivered to the pipe 15 and thence to the exchanger 14. Alternatively, liquid oxygen may be withdrawn from the pool through a pipe 46 controlled by a valve 47 and delivered to a liquid oxygen pump 48 and thence by a pipe 49 to the pipe 15. The oxygen, which is delivered eventually through the pipe 18, is substantially free from contaminating impurities, particularly those of a hydrocarbon origin.

The invention as described affords a practical and simple solution of a problem which has existed for many years in the commercial production of oxygen by liquefaction and rectification. It obviates most of the danger inherent in the operation of methods of liquefaction in which refrigeration is maintained by initially compressing the air to elevated pressures and the unavoidable contamination of the air with lubricating oils.

Various changes may be made in the details of procedure and in the apparatus as described without departing from the invention or sacrificing the advantages thereof.

I claim:

The method of separating the constituents of atmospheric air which comprises compressing the air to a relatively low pressure without contaminating the air with lubricating oil, maintaining a separate nitrogen cycle including compression of the nitrogen to relatively high pressure and liquefaction of the nitrogen by heat exchange with cold nitrogen vapors, liquefying the compressed air by heat exchange with liquid nitrogen, thereby vaporizing the nitrogen, and rectifying the liquid air to separate a liquid fraction consisting of oxygen.

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