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PROCESS OF SEPARATING OXYGEN FROM AIR.

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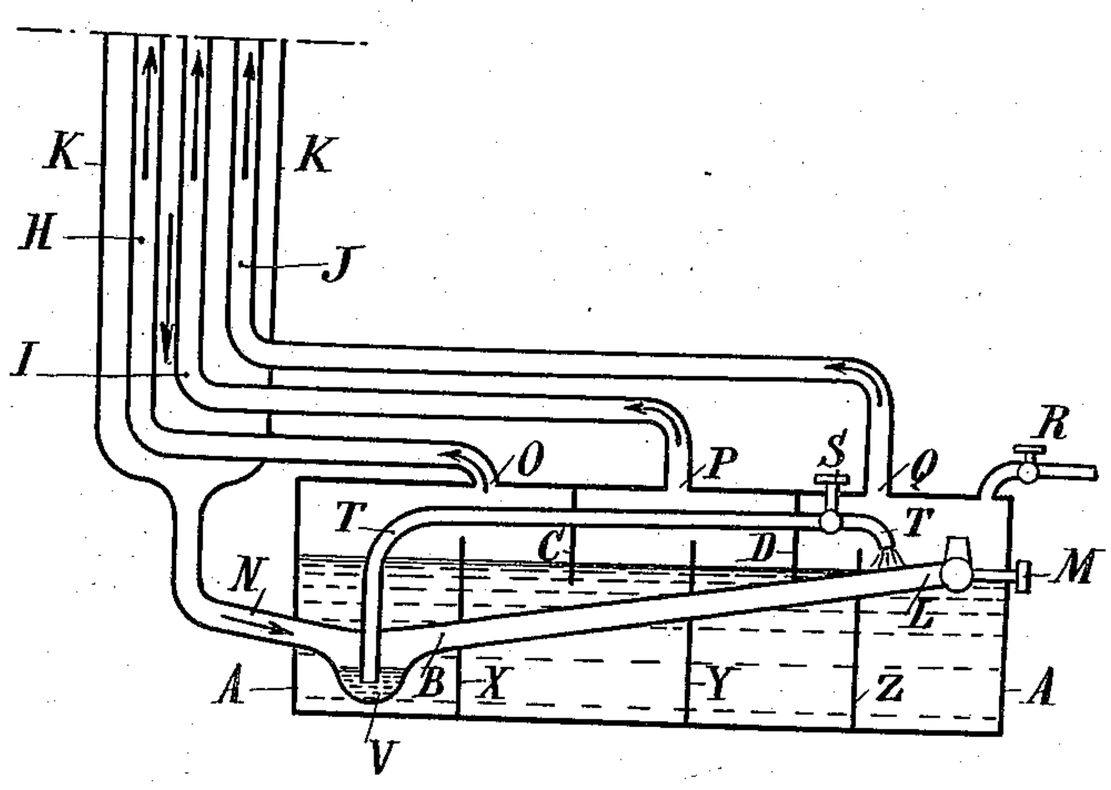
Patented June 8, 1909.



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UNITED STATES PATENT OFFICE.

GEORGES MARIE AUGUSTE CLAUDE, OF PARIS, FRANCE.

PROCESS OF SEPARATING OXYGEN FROM AIR.

No. 924,428. Specification of Letters Patent. Patented June 8, 1909.

Application filed August 5, 1903. Serial No. 168,282.

To all whom it may concern:

Be it known that I, GEORGES MARIE AUGUSTE CLAUDE, a citizen of the Republic of France, residing at 62 Lazare, Paris, France, have invented certain new and useful Improvements in the Manufacture of Oxygen by Means of Liquid Air; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This process has for its object improvements in the process for the production of super-oxygenated air and of oxygen by means of liquid air by the vaporization of the same and simultaneous liquefaction of gaseous air previously purified and subjected to a pressure greater than the liquid to be vaporized.

This invention utilizes a fact that my experiments have proved, although it is denied by authorities on the subject, that if gaseous air which has been previously compressed and cooled be compelled to become partially liquefied in a bath of liquid air the liquid obtained is richer in oxygen than air, this fact of itself alone would be quite insufficient to insure a complete separation of the oxygen, but I have found means to utilize it by combining it with various conditions so that it is possible for me by liquefying only a portion of the air treated to extract into the liquefied portion almost the whole of the oxygen of the air treated, the gaseous residue consisting of almost pure nitrogen. Thus instead of having, as in all the known processes, to previously liquefy the whole of the air in order to obtain the whole of the oxygen in the liquid formed it is sufficient in my process to merely liquefy a portion of this air, namely the portion which is most easily liquefiable, and this is one of the essential features of my process, as is also the obtaining in the gaseous residue of practically pure nitrogen. In order to obtain this transference of all the oxygen in the part liquefied, the partial liquefaction is operated in a progressive manner and in such a way that the liquefied portions return to the rear, that is to say, circulate in a direction contrary to the gases and that during the condensation a washing of the gases by the liquefied parts is effected, which washing has for its effect to liquefy the oxygen of the gaseous residue by vaporizing a corresponding quantity of nitrogen of the liquid. These conditions are realized by employing for instance as liquefying apparatus a simple group of inclined tubes which enables the liquefied air to be returned to the rear in the opposite direction to that of the gaseous air. It will be noticed that I here employ two powerful effects acting in combination for the same result; on the one hand the liquid formed at the expense of the gas at each point of the liquefying arrangement being richer in oxygen than the said gas the latter is impoverished in oxygen. On the other hand this gaseous residue is still further impoverished in oxygen by its contact with the inverse current of liquid very poor in oxygen formed on the discharge side. These phenomena being repeated and the separating effects which result therefrom combining in all the extent of the liquefying arrangement insure great efficacy for my arrangement.

The liquefaction may be operated in any suitable manner provided that the liquefier is immersed in liquid air, but it is preferable to cause a regular circulation, and in an inverse direction, of the liquid air to be evaporated and of the gaseous air to be liquefied. In consequence of this regular inverse circulation the liquid which is richest in nitrogen and consequently the coldest is used for liquefying the least liquefiable gas and the liquid which is least cold is reserved for liquefying the most easily condensed part of the air treated thus allowing the pressure of the air to be treated to be diminished.

In order to allow of the specification being better understood I will now refer to the accompanying drawing, in which as an example a diagram of an apparatus is shown which enables the improved process in question to be put in practice.

This apparatus comprises an evaporating vessel A filled first with liquid air derived from any suitable source and in which is immersed a liquefying pipe B L inclined toward the point of admission N of suitably purified and compressed air already cooled by its passage through an exchanger K in a reverse direction to that of the evaporated gases escaping from the vessel A by apertures O P Q. The evaporating pipe B L has a collector V

from which a pipe T draws liquefied air which it then discharges toward the end L of the evaporating tube. The vessel A is provided with partitions C D and also diaphragms X Y Z immersed in the liquid and allowing it to circulate as shown. Liquid air evaporates in the vessel A along the whole length of the tube B L and gaseous air is liquefied in a practically equivalent quantity in the pipe B L.

Owing to the inclination of the liquefying pipe B L the liquefied air retrogrades constantly toward the lowest part of this pipe, that is to say toward the collector V.

In its return toward the rear, the liquid air condensed toward the end L and consequently relatively poor in oxygen, seeing that it has been formed from a gas already partially exhausted, comes progressively in contact with air which is becoming richer in oxygen at the same time that its temperature rises because the liquefying pipe is bathed toward the end B in liquid air from which the oxygen has been more and more evaporated. Nitrogen is thus induced to evaporate and is replaced in the liquid by oxygen. The result is that when it reaches the bottom of the liquefying pipe, that is to say at B, the liquid which runs is very rich in oxygen, while the gas which escapes at the end L by a tap M having circulated in contact with gradually poorer and finally liquid very poor in oxygen is found to be thus exhausted to the possible maximum. Of course the liquid air formed and enriched and accumulated in the collector V is drawn from this collector by the pipe T which then discharges it intermittently or continuously at the coldest side of the evaporator, that is to say toward the end L of the pipe, so as to induce a regular progression in spite of the violent ebullition by the use of the diaphragms X Y Z immersed in the liquid. The almost pure uncondensed nitrogen discharged from the tap M may be collected separately and sent through exchanging device K while the more or less pure oxygen is collected by the pipes P I and O H.

I declare that what I claim is:

1. The process of separating oxygen from air, which consists in compressing and cooling gaseous air, passing such compressed and cooled air through but not in direct contact with previously liquefied portions of the air, liquefying a portion of the compressed and cooled air in contact with a portion thereof which is not liquefied, and separating the liquid obtained from the gaseous residue.

2. The process of separating a gaseous mixture composed of gases which liquefy at different temperatures which consists in liquefying that gas which is most easily liquefiable, separating the liquefied from the unliquefied gas, and then permitting the liquefied gas to vaporize.

3. The process of separating the gaseous mixture composed of gases which liquefy at different temperatures, which consists in progressively liquefying that gas in the mixture which is most easily liquefied.

4. The process of separating a gaseous mixture composed of gases which liquefy at different temperatures which consists in progressively liquefying that gas which is most liquefiable, and separating the liquefied and unliquefied gases, and permitting the liquefied gases to vaporize.

5. The process of separating a gaseous mixture composed of gases which liquefy at different temperatures, which consists in permitting the gaseous mixture to flow in one direction, liquefying that gas which is most easily liquefied, causing the liquefied gas to return in the inverse direction in which the gaseous mixture is supplied and in contact therewith.

6. The process of separating a gaseous mixture composed of gases which liquefy at different temperatures, which consists in causing the gaseous mixture to move in one direction, liquefying that gas which is most easily liquefiable, forcing the liquefied gases to return in an inverse direction to the non-liquefied gases and to move in contact therewith, and separating the liquefied and non-liquefied gases.

7. The process of separating a gaseous mixture composed of gases which liquefy at different temperatures, which consists in causing the gaseous mixture to move in one direction, liquefying that gas which is most easily liquefiable, forcing the liquefied gases to return in an inverse direction to the non-liquefied gases and in contact therewith, separating the liquefied and unliquefied gases, and permitting the liquefied gas to vaporize.

8. The process of separating a gaseous mixture of oxygen and nitrogen which consists in forcing the mixture in one direction, liquefying the oxygen, causing the liquefied oxygen to return in an inverse direction and in contact with the unliquefied gas, causing the unliquefied gas to escape, and causing the liquefied oxygen to vaporize.

9. The process of separating a gaseous mixture of oxygen and nitrogen which consists in compressing and cooling the mixture, forcing the cooled mixture into a receiver, progressively liquefying the oxygen, causing the liquefied oxygen to return in an inverse direction and in contact with the incoming compressed gaseous mixture, and withdrawing the gaseous nitrogen.

10. The process of separating a gaseous mixture of oxygen and nitrogen which consists in compressing and cooling the mixture, forcing the cooled mixture into a receiver, progressively liquefying the oxygen, causing the liquefied oxygen to return in an inverse direction and in contact with the incoming

compressed gaseous mixture, withdrawing the gaseous nitrogen and permitting the liquefied oxygen to vaporize.

11. The process of separating a gaseous mixture composed of differing volatility, which consists in passing such mixture while compressed and cool through but not in direct contact with a body of liquid resulting from previously liquefied portions of the gaseous mixture, progressively liquefying the portion of the compressed and cooled mixture which is most easily liquefiable by vaporizing some of the outside body of liquid, and causing the liquefied portion as soon as formed to return in the opposite direction to that in which the gaseous mixture is flowing and in contact therewith.

12. The process of separating a gaseous mixture composed of gases of differing volatility, which consists in passing such mixture while compressed and cool through but not in direct contact with a body of liquid resulting from previously liquefied portions of the gaseous mixture, progressively liquefying the portion of the compressed and cooled mixture which is most easily liquefiable by vaporizing some of the outside body of liquid, causing the liquefied portion as soon as formed to return in the opposite direction to that in which the gaseous mixture is flowing and in contact therewith, and separating the liquefied and unliquefied portions.

13. The process of separating a gaseous mixture of oxygen and nitrogen, which consists in forcing the compressed and cool mixture to flow in one direction progressively and partially liquefying this gaseous mixture by vaporizing a portion of the liquid resulting from previously liquefied portions of the gaseous mixture, causing the liquefied portion as soon as it is formed to flow backward in an opposite direction to that of the gaseous mixture and in contact with the unliquefied portion, and collecting the liquid richer in oxygen so produced separately from the unliquefied portion rich in nitrogen.

14. The process of separating a gaseous mixture of oxygen and nitrogen, which consists in forcing the compressed cool mixture to flow in one direction through but not in direct contact with a body of liquid resulting from previously liquefied portions of the gaseous mixture, liquefying progressively a portion of the mixture which is most easily liquefiable by vaporizing progressively and at successive stages some of the aforesaid body of liquid, causing the liquefied portion to return in an inverse direction and in contact with the incoming compressed gaseous mixture, and collecting the liquid rich in oxygen separate from gaseous nitrogen.

In testimony that I claim the foregoing I have hereunto set my hand this 24th day of July 1903.

GEORGES MARIE AUGUSTE CLAUDE.

Witnesses:

EDMOND LECOUTURIS,

AUGUSTUS E. INGRAM.