G. CLAUDE.

DESICCATION OF AIR OR GASES.

APPLICATION FILED MAY 5, 1914.

1,323,014.

Patented Nov. 25, 1919.

2 SHEETS—SHEET 1.

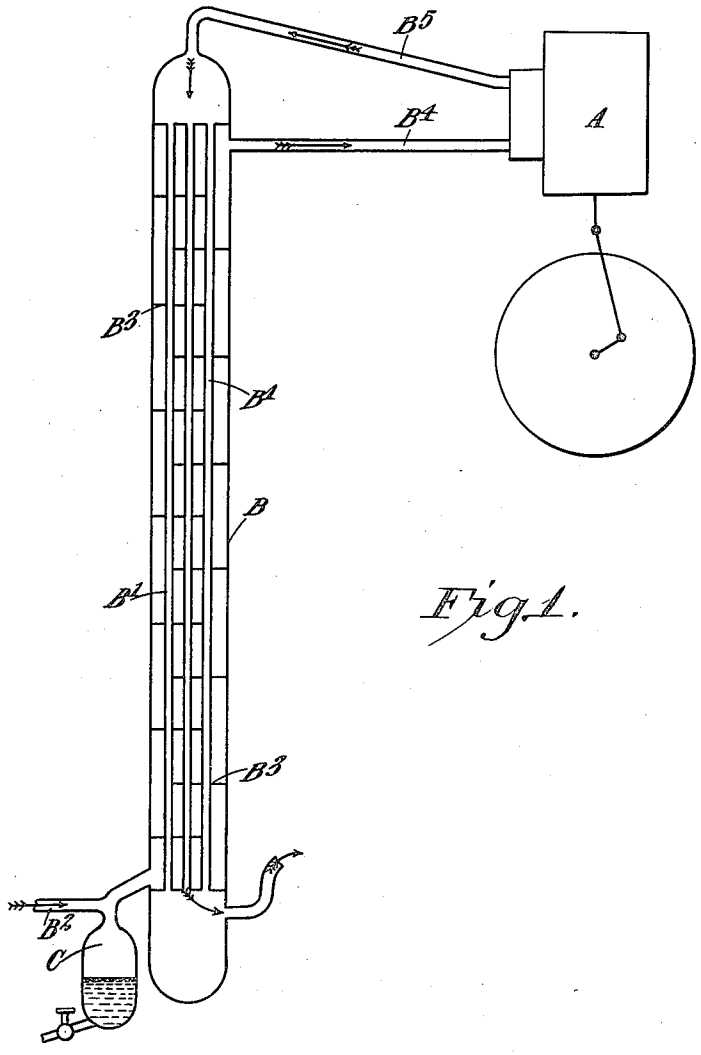


Fig. 1.

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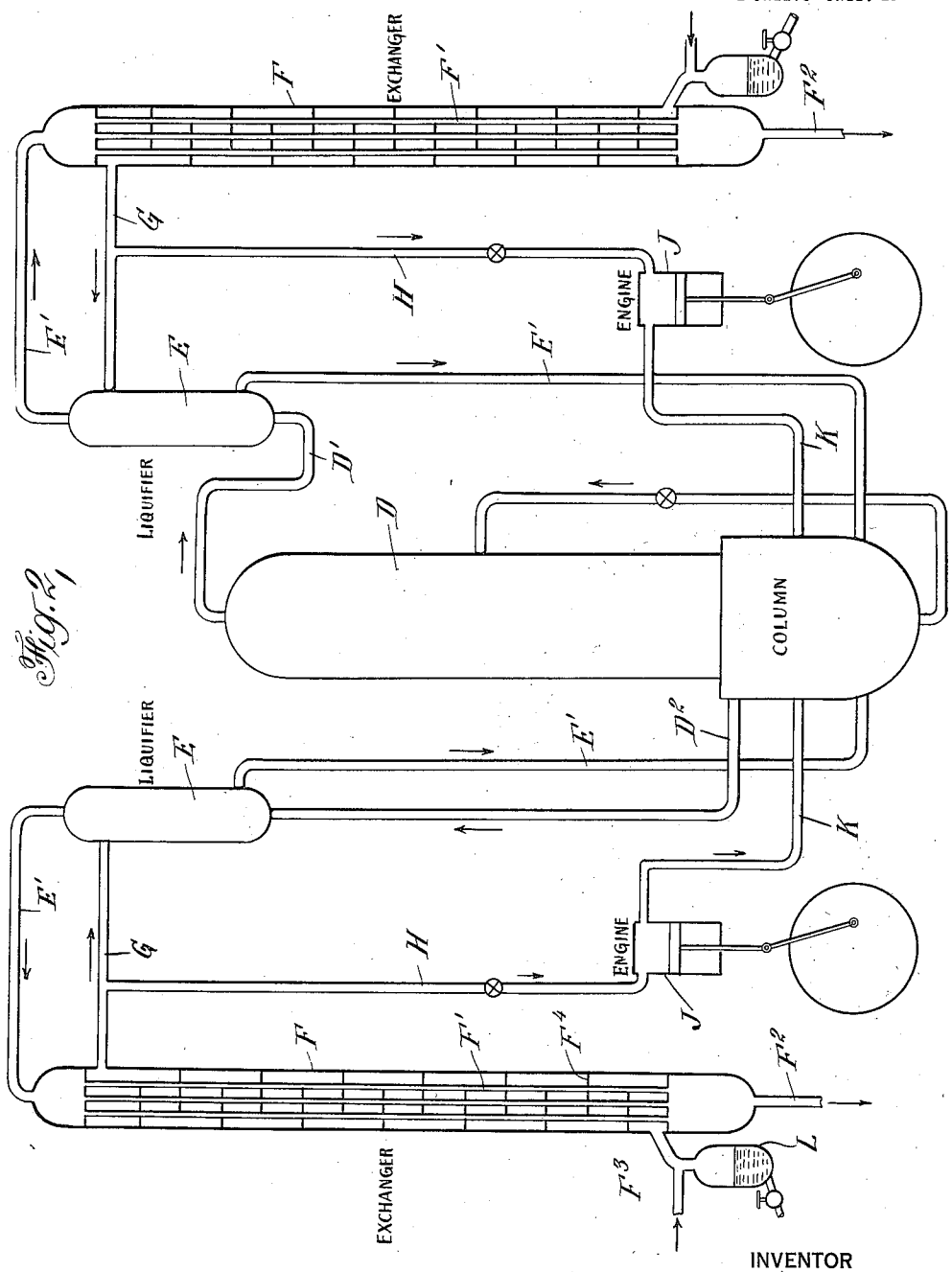


Fig. 2.

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GEORGES CLAUDE, OF PARIS, FRANCE, ASSIGNOR TO L'AIR LIQUIDE (SOCIETE ANONYME POUR L'ETUDE ET L'EXPLOITATION DES PROCEDES GEORGES CLAUDE), OF PARIS, FRANCE.

DESICCATION OF AIR OR GASES.

1,323,014. Specification of Letters Patent. Patented Nov. 25, 1919.

Application filed May 5, 1914. Serial No. 836,500.

To all whom it may concern:

Be it known that I, GEORGES CLAUDE, a citizen of the Republic of France, residing at 48 Rue St. Lazare, Paris, in the Republic of France, have invented certain new and useful Improvements in the Desiccation of Air or Gases, of which the following is a specification.

This invention relates to the desiccation of air or gases, particularly such as are intended to undergo a process of liquefaction or partial liquefaction.

It is known that air intended to be liquefied should be subjected to thorough desiccation. It would seem that the very fact that the air is necessarily cooled to a very low temperature should render any preliminary desiccation unnecessary, because humid air thus cooled gives up all its moisture in the usual temperature exchangers, the intense cooling thus itself constituting the most effective method of desiccation possible. However, the deposit of the moisture in the form of hoar frost obstructs the flow of air through the nests of tubes of the exchangers, and it is precisely this fact that has hitherto necessitated desiccation of the air prior to its admission to the exchangers.

According to the present invention purely refrigerative desiccation is rendered possible by conducting the cooling process by interchange of temperatures in such a manner that obstruction due to the deposit of hoar frost will not take place until after the lapse of a very long time, or that the hoar frost deposited can be removed periodically. When the air to be cooled and liquefied leaves the usual compressors it is generally saturated with moisture, and it is known that when air in this condition is cooled the greater part of its moisture is deposited in the liquid state above zero centigrade. An exchanger adapted to effect purely refrigerative desiccation ought therefore to permit of the continuous elimination of the moisture in the liquid state. For this to occur, it is necessary that the compressed air should follow an inclined path and, for example, pass from below upward, to permit the condensed moisture to flow back toward the hotter parts whence it can be withdrawn. Such an upward circulation of the compressed air along tubes is the reverse of what is most practical, however, because owing to its progressively decreasing temperature the compressed air becomes increasingly dense as it ascends. For instance, if the compressed air circulates in this manner in the straight tubes of a vertical nest of tubes, the effect of this impractical procedure is very pronounced and the action of the tubular exchanger is exceedingly poor.

In carrying out the present invention, which avoids the above mentioned defect, the compressed air is not caused to circulate in the tubes of the nest but around the latter, and it is the expanded air or the gases resulting from subsequent separation or partial separation of the constituents of the air that circulate in the tubes, the impractical action being harmless under these circumstances owing to the small density and the far higher velocity of the said expanded air or gases. As regards the compressed air, its circulation around the tubes of the nest is regulated by baffles in such a manner as to make it follow a sinuous path comprising horizontal portions in free and open communication with each other and in which the progressive change of density cannot make itself felt. An exchanger of this kind will act for more than a day before becoming obstructed and it is only necessary to interchange it with another at the proper moment in order to render the operation continuous. An indirect advantage of this type of exchanger is the facility with which it permits the current of compressed air to reheat the expanded air or gases in separate and distinct fractions traveling through an equal number of fractions of the nest of tubes.

The employment of this type of exchanger in a special manner as will now be described is especially important in that it renders it possible to operate with a single exchanger while insuring the running of an air liquefying apparatus for a very long time. The deposit of moisture in solid form naturally presents the maximum importance in the region of the exchanger where the temperature approximates 0° C. It is, so to say, localized in this region for a very short length. If it were possible momentarily to shift the point of zero temperature toward the upper part of the exchanger, this hoar frost would melt, the

resultant water would flow toward a collector, and the exchanger would be restored to its maximum efficiency. Now there is nothing easier than to attain this result. It is only necessary for the entering compressed air to be momentarily at a higher temperature than usual before it enters the exchanger, this rise of temperature being preferably obtained by eliminating the cooling at the last stage of the compression for the proper length of time. The calorific mass operative in the exchanger is sufficient to enable this operation to be effected without the temperature at the cold end of the exchanger being in any way modified, and consequently without any perturbation intervening in the operation of the appliances of which the exchanger constitutes one of the elements.

In the accompanying drawings I have illustrated diagrammatically two forms of apparatus adapted for use in the practice of my invention as hereinbefore described.

Figure 1 is an illustration of the apparatus in which expanded air is employed as the cooling medium, and Fig. 2 is an illustration of an apparatus in which the gases resulting from separation or partial separation of the constituents of the air following a liquefaction operation are employed as the cooling medium.

In Fig. 1, A represents an engine operating by the expansion of the compressed air to produce external work, B is the casing of a vertical temperature exchanger and B′ the nest of tubes therein; B^2 is the inlet for the compressed air to the casing B, and C is a receptacle in which the condensed moisture can collect. The humid compressed air enters the casing B at B^2 and passes upwardly around the tubes B′ by the zig-zag path formed by the baffles B^3, and then passes out by the pipe B^4 to the engine A. The expanded air from the engine A passes by the pipe B^5 into the top of the exchanger and descends through the tubes B′ and the condensed moisture passes from one baffle plate to another and finally passes into the receptacle C.

In Fig. 2, D represents a liquefying and rectifying column discharging respectively through pipes D′ and D^2 vaporized nitrogen and oxygen which passes through the liquefiers E and is delivered through pipes E′ to the exchangers F as hereinbefore described, consisting of a casing inclosing a nest of tubes F′ through which the cold gases from the liquefiers pass, escaping through the outlets F^2. The compressed air or gas enters the casing of each exchanger through an inlet F^3 and passes upwardly around the tubes F^4 being required by the baffles F′ to follow a zig-zag or sinuous path, the direction of movement of the air being periodically reversed and transverse to its general upward trend. The cooled compressed gas from the exchangers is delivered through pipes G to the liquefiers E where it is subjected to heat interchange with the nitrogen and oxygen from the column whereby the compressed gas is liquefied and delivered through the pipes E′ to the bottom of the column D. A portion of the cold compressed gas is withdrawn through pipes H from the pipes G and passes through engines J where it is expanded with the production of external work and delivered through pipes K to the bottom of the column D.

The compressed air is thus subjected in the exchangers F to heat interchange with the cold expanded gases resulting from the separation of the constituents of the original moisture in the column and any moisture carried by the compressed gas is separated and caused to flow backwardly over the baffles F^4, being finally delivered to the receptacles L. The moisture from the compressed gas is thus separated in accordance with the principles hereinbefore explained and the gas flowing to the liquefiers E and engines J is substantially dry. It will be noted that the exchangers provide a plurality of superposed zones freely communicating with each other but separated to prevent return of the gas which becomes gradually colder as it ascends.

The operation would not be modified in any way if the exchanger, instead of being vertical, ascended at a sufficiently steep incline to cause the liquid formed to flow down without being carried along by the gaseous current.

The type of exchanger described above and its method of operation are obviously applicable to gases other than air, and in particular to water gas intended for the manufacture of hydrogen by a process of partial liquefaction.

What I claim and desire to secure by Letters Patent of the United States is:—

1. In the liquefaction of gases, the method of separating moisture from a gas which comprises, compressing the gas and subjecting it while under pressure and while following a substantially unrestricted sinuous and upwardly directed path to heat interchange with a colder expanded gas moving downwardly in a path traversing said sinuous path.

2. In the liquefaction of gases, the method of separating moisture from a gas which comprises, compressing the gas and subjecting it while under pressure and while following a substantially unrestricted sinuous and upwardly directed path to heat interchange with a gaseous medium, produced by the evaporation of the gas following liquefaction thereof and moving downwardly in a path traversing said sinuous path.

3. In the liquefaction of gases, the method of separating moisture from a gas which comprises, compressing the gas and subjecting it while flowing in a general upward direction through a plurality of superposed zones freely communicating with each other but requiring movement of the gas in a direction transverse to its general direction while in each zone, to heat interchange with a colder expanded gas moving downwardly in a path traversing said zones.

4. In the liquefaction of gases, the method of separating moisture from a gas which comprises, compressing the gas and subjecting it while flowing in a general upward direction through a plurality of superposed zones freely communicating with each other but requiring movement of the gas in a direction transverse to its general direction while in each zone, to heat interchange with a gaseous medium, produced by the evaporation of the gas following liquefaction thereof and moving downwardly in a path traversing said zones.

5. In the liquefaction of gases, the method of separating moisture from a gas which comprises, liquefying and rectifying the gas following the separation of moisture therefrom and subjecting compressed incoming gas to indirect contact with the rectification products, while said compressed incoming gas flows upwardly through a plurality of superposed zones freely communicating with each other but requiring movement of the incoming gas in directions transverse to the general upward flow thereof through said zones, said rectification products moving downwardly in a path traversing said zones.

6. In the liquefaction of gases, the method of separating moisture from a gas which comprises, subjecting the incoming compressed gas to indirect contact with the cold expanded product resulting from the liquefaction and vaporization of preceding portions of said gas, while said incoming compressed gas flows upwardly through a plurality of superposed zones freely communicating with each other but requiring movement of the incoming gas in directions transverse to the general upward flow of said gas through said zones, said expanded product moving downwardly in a path traversing said zones.

7. In the liquefaction of gases, the method of separating moisture from a gas which comprises, subjecting the incoming compressed gas to heat interchange with the cold expanded product resulting from the liquefaction and partial separation of the constituents of preceding portions of said gas, while said incoming compressed gas follows a substantially unrestricted sinuous and upwardly directed path traversed by the path of said expanded product.

8. In the liquefaction of gases, the method of separating moisture from a gas, which comprises, compressing the gas and subjecting it while under pressure and while following a substantially unrestricted sinuous and upwardly directed path to heat interchange with a colder expanded gas moving downwardly in a path traversing said sinuous path, and momentarily shifting the region of zero temperature in said path.

9. In the liquefaction of gases, the separation of moisture from a gas which comprises, compressing the gas and subjecting it while under pressure and while following a substantially unrestricted sinuous and upwardly directed path, to heat interchange with a gaseous medium, produced by the evaporation of the gas following liquefaction thereof and moving downwardly in a path traversing said sinuous path, and momentarily shifting the region of zero temperature in said path.

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

GEORGES CLAUDE.

Witnesses:
PIERRE HAULIER,
CHAS. P. PRESSLY.