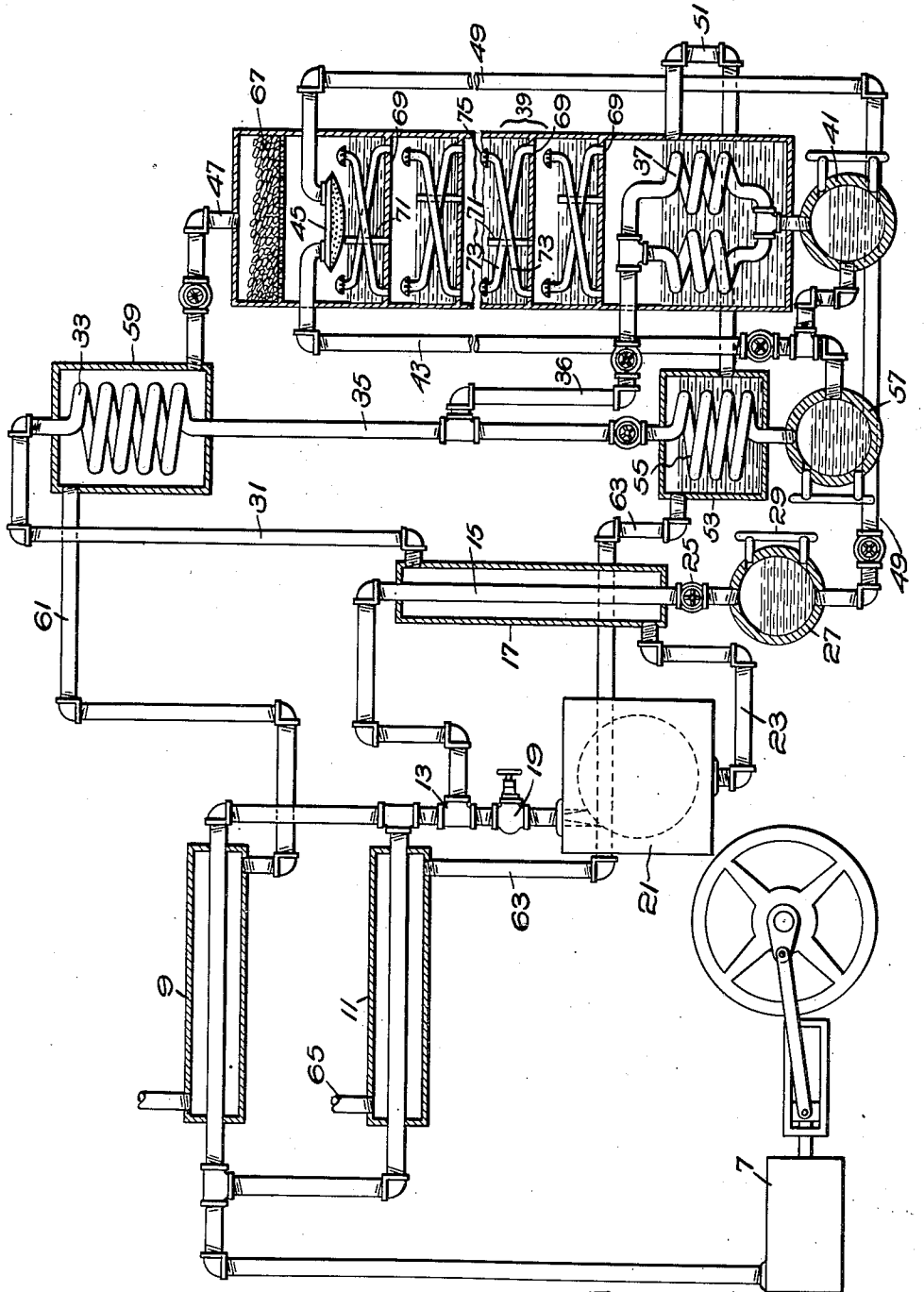
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METHOD OF SEPARATING MIXED GAS.

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METHOD OF SEPARATING MIXED GAS.

1,304,027. Specification of Letters Patent. Patented May 20, 1919.

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To all whom it may concern:

Be it known that I, CHARLES F. CROMMETT, a citizen of the United States, and a resident of Malden, in the county of Middlesex and State of Massachusetts, have invented an Improvement in Methods of Separating Mixed Gas, of which the following description, in connection with the accompanying drawing, is a specification, like characters on the drawings representing like parts.

This invention relates to a method of separating a constituent of a mixed gas and to mechanism for use in this and similar separation processes. My particular object is to provide a suitable method of producing commercial oxygen from atmospheric air.

My invention will best be understood by reference to the following description of the operation of the apparatus of which the accompanying drawing is a diagram chiefly in section.

Referring, therefore, to the drawing and assuming that the intention is to produce oxygen from atmospheric air, the operation may be carried on as follows:—Air is compressed in the compressor 7 shown at the lower left hand side of the figure to substantially its critical pressure, say about six hundred pounds. The compressed air is then passed through coolers or interchangers 9 and 11 which may operate on the counter current principle. The cooling medium is supplied as hereinafter described. The compressed air delivered from the interchangers is divided into two parts at the point 13 and a part is delivered to the inner chamber 15 of a constant pressure liquefier 17. The remaining portion passes through the throttle valve 19 and is expanded in a suitable engine, here shown as a turbine 21. This expansion may be carried on until the pressure drops to three or four atmospheres. The power developed by the turbine may be applied to any useful purpose. The cold expanded air exhausted from the turbine is delivered through pipe 23 to the liquefier 17 and serves to liquefy the air in the chamber 15 over which it passes, preferably in counter current. The liquefied air is released from the chamber 15 through the pressure maintaining valve 25 to the liquid receiver 27 which may be provided with a sight gage, as shown.

The expanded air leaving the liquefier 17 passes through pipe 31 and the coil 33 of a cooler hereinafter to be referred to, and is delivered through pipes 35 and 36 to coils 37 situated in the lower chamber of a rectifying column denoted generally by the numeral 39, which column is preferably of a particular design hereinafter more fully to be described, although my process may be practised with any suitable form of column. The expanded air is liquefied in the coils 37, evaporating a corresponding amount of liquid in the chamber, and the liquefied air may be delivered from the coils to the container 41 from which it is delivered by means of the pipe 43 to the distributing rose 45. The liquid air descends from the rose 45 in contact with the vapors or gases evaporated from the liquid in the lowermost chamber of the tower and rectification of the liquid air is effected in the usual manner. As the process proceeds the liquid in the lower chamber gradually becomes substantially pure oxygen and the vapors exhausted from the pipe 47 at the top of the tower are highly nitrogenous. These vapors are substantially 93% nitrogen.

The liquid air formed in the liquefier 17 and delivered to the container 27 may be conducted by pipe 49 to the rose 45 to compensate for thermal losses in the process of separation. The oxygen collected in the lower chamber of the tower 39 may be caused to overflow through pipe 51 to a chamber 53 which may contain an evaporating coil 55 adapted to receive expanded air from the pipe 35 and liquefy the same. The liquefied air from the coil 55 is delivered to a container 57 which is in connection with the pipe 43 and hence with the rose 45.

The nitrogenous vapors exhausted at 47 from the top of the tower are utilized to cool the expanded air, as such, subsequent to its exhaust from the turbine 21 and prior to its delivery to the liquefying coils 37 and 55. Herein it is discharged to the chamber 59 surrounding the coil 33 already referred to which is interposed between the liquefier 17 and the rectification column. The nitrogenous gases passing in counter current over this coil cool the expanded air which has been somewhat heated in liquefying the compressed air in the liquefier. The nitrogenous vapors may then be delivered through the pipe 61 to the interchanger 9 to precool the compressed air. I have herein shown

two interchangers 9 and 11, the interchanger 11 being connected by a pipe 63 with the oxygen-receiving chamber 53, so that the vapors evaporated by the expanded air in coil 55 will serve to cool the compressed air in the cooler 11. The oxygen may be withdrawn at 65 and utilized in any desired manner.

To facilitate an understanding of the principles of my invention I will give by way of an example sets of temperatures under which apparatus might operate, although I do not wish to be understood as confining myself to these exact figures. The air may be cooled in the coolers 9 and 11 to about —100° C. and will be exhausted from the turbine 21 at about —140° to —150° C. The expanded air after liquefying the compressed air in the liquefier 17 will be discharged therefrom by pipe 31 at substantially —100°. The gases from the rectifying column 39 at the pipe 47 have a temperature of substantially —190° and by their use in the cooler 59 they may be caused to cool the expanded air so that it enters the coils 37 and 55 at low pressure, at substantially —175°. The process here disclosed is designed to produce the most efficient combination of the several steps. I have ascertained that to operate the turbine engine 21 efficiently the air should not be delivered thereto at much less than —100° C. By utilizing the nitrogenous gases to cool the expanded air, as here shown, they are most efficiently employed as they can bring the air down to low temperature and yet have ample coldness sufficiently to cool the compressed air prior to its delivery to the turbine 21 and the liquefier 17.

I shall next describe the particular form of rectification column herein disclosed and which I prefer to use. At the lower part of the column is provided the liquid receiving chamber in which are disposed the coils 37 or any other suitable liquefaction means and the waste gases are discharged from the top of the column above the rose 45, conveniently through a filling 67 of crushed coke, glass balls or the like. My improvements are more particularly directed to the construction of the tower between the rose 45 and the liquid chamber at the bottom of the tower and are designed to facilitate a thorough separation of the oxygen by thermal contact partially direct and partially indirect. For this purpose I divide the column into stages or chambers by means of partitions 69 and provide overflow pipes 71 for maintaining bodies of liquid of constant level in the several chambers. These overflow pipes are preferably out of line in adjacent chambers, as illustrated, in order to prevent liquid from passing directly from one through another.

The vapors arising from the liquid chamber at the bottom of the column pass through pipes 73 opening from the top of one chamber above the liquid level, through the partition 69, and discharging at their upper ends above the liquid level in the chamber above. The intermediate portions of the pipes are beneath the surface of the body of liquid so that the vapors arising therethrough are in indirect thermal contact with the liquid in the chamber. These intermediate portions are preferably of comparatively great length and for this purpose they are deflected from the upright direction. I have herein shown them as crossing the chamber from side to side at a slight inclination so that the vapors rising therethrough will travel through a comparatively long path and the liquid separated therefrom will gravitate rearwardly in contact with the rising vapors.

Preferably I provide suitable means for disseminating or breaking up the column of vapor rising through the pipes and herein I have shown roses 75 at the upper ends of the pipes. Conveniently the lower ends of the pipes of one stage are opposite the upper ends of the pipes of the next lower stage so that the liquid falling backwardly from one comes into contact with the vapors arising from the other. In the present instance the roses are provided with domed tops which serve as baffles to cause the liquid discharged from the upper pipes to be broken up and brought into intimate contact with the vapors arising through the lower pipes and those evaporated from the body of the liquid in the chamber. In the present instance the domed tops of the roses are imperforate and they are provided with lateral perforations, as shown, to discharge the rising vapors. By this means most thorough dissemination and mixing of the liquid and vapors is provided for which insures thoroughness in the rectification process.

By the construction described I have provided for a very efficient separation of the liquid air and for the production of an oxygen of high purity. Difficulty has hitherto been experienced in producing pure oxygen with rectifying columns wherein the contact is entirely direct. On the other hand, indirect contact apparatus, as hitherto known, is inefficient. In the present instance I provide for a thorough direct mingling of the ascending and descending currents which assures effective interaction of the same but prevents nitrogen being carried down mechanically. It might be said that in each chamber or stage of the column a rectifying process goes on and the large contact surface provided for by the deflected central portion of the pipes 73 insures requisite heating of the liquid in each chamber and also a thorough separation by indirect con-

tact without possibility of contamination of the vapors ascending through the pipes 73.

Having thus described a preferred form of my invention, what I claim as new and desire to secure by Letters Patent is:—

1. A process of separating a mixed gas, as air, comprising the following steps:—compressing and cooling the mixed gas, expanding a portion thereof, liquefying the remainder by thermal contact with the expanded portion, thereafter cooling the expanded gas by the waste gases or vapors of the rectification process about to be referred to, liquefying the cooled gas by evaporating the liquid resulting from the rectification process, and effecting rectification by causing both quantities of liquefied gas to descend in countercurrent to the gases or vapors arising from such evaporation.

2. A process of separating a mixed gas, as air, comprising the following steps:—compressing the gas and cooling it, expanding a portion thereof with the production of recoverable external work, liquefying the remainder by thermal contact with the expanded portion, subjecting the expanded gas to a second cooling operation, liquefying the same by evaporating the liquid resulting from the rectification process about to be referred to, effecting rectification by causing the liquefied mixed gas to descend in countercurrent to the gases or vapors arising from such evaporation and utilizing the gaseous or vaporous products of the rectification first for said second cooling operation and then for the first cooling.

3. A process of separating a mixed gas comprising the following steps:—compressing and cooling the gas, expanding a portion thereof with the production of external recoverable work, liquefying the remainder by thermal contact with the expanded portion, thereafter liquefying the expanded gas by evaporating the liquid resulting from the rectification process about to be referred to, effecting rectification by causing the liquefied mixed gas to descend in countercurrent to the gases or vapors arising from such evaporation and conducting the gaseous or vaporous products of the rectification into thermal contact with the expanded gas as such.

In testimony whereof, I have signed my name to this specification.

CHARLES F. CROMMETT.