

1,395,466.

2 SHEETS-SHEET 1.



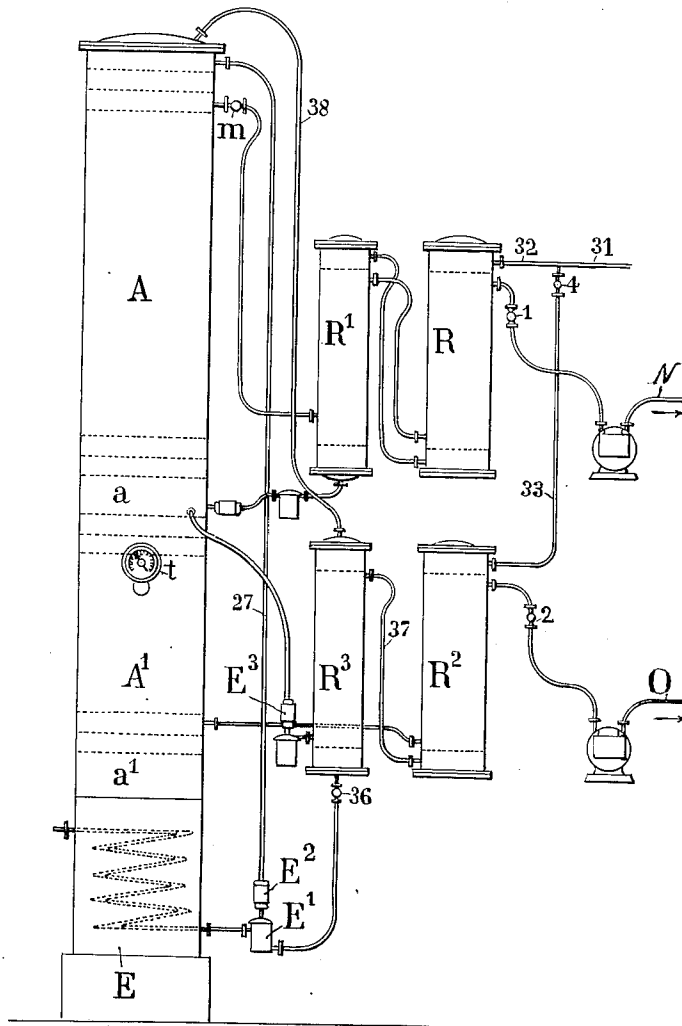
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E. A. BARBET.
 REGULATING MEANS FOR GAS SEPARATING APPARATUS.
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 2 SHEETS—SHEET 2.

Fig. 2.



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UNITED STATES PATENT OFFICE.

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REGULATING MEANS FOR GAS-SEPARATING APPARATUS.

1,395,466.

Specification of Letters Patent.

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To all whom it may concern:

Be it known that I, EMILE AUGUSTIN BARBET, a citizen of the French Republic, residing at No. 5 Rue de l'Echelle, Paris, France, have invented certain new and useful Improvements in Regulating Means for Gas-Separating Apparatus, of which the following is a specification.

This invention relates to the application of apparatus and means of regulating the speed of working to all apparatus for rectifying liquid air or liquefied gases of any kind, more particularly to the type of rectifier forming the subject matter of my earlier application for Letters Patent Serial No. 215,679 of 6 February, A. D. 1918, said rectifier being a continuous rectifier for liquid air and allowing of separating the whole of the oxygen and nitrogen in a state of purity in one distilling operation.

The improvements of the present invention are designed to assure a perfect regularity in the working of the rectifying apparatus. These improvements allow of obtaining nitrogen and oxygen in a state of absolute purity, and of assuring a great constancy of chemical composition of the various extractions of rare gases which can be effected by the invention, either when used simply for producing oxygen and nitrogen in a very pure state or for facilitating the subsequent rectification of the rare gases.

In the absence of a sufficient regularity, disturbances may occur in the working of the apparatus. As a matter of fact if during a certain period of time there is allowed to issue from the bottom of the rectifier a volume of oxygen which is either insufficient or on the contrary is excessive relatively to the quantity of oxygen entering the middle of the column in the form of air, the chemical composition of the liquids of the plates is inevitably varied to a considerable degree. Particularly the zone of maximum concentration of the argon changes its place and it is no longer possible to effect the extraction of this impurity at the appropriate stage, so that the nitrogen and the oxygen will not remain pure.

In other words, in order to produce nitrogen and oxygen in the perfection of purity, it is necessary to assure to the apparatus a fixed procedure in working and it is the object of this invention to apply a combina-

tion of regulating means such that the regularity of functioning of the process is automatically effected.

The invention is illustrated in the accompanying drawings, in which—

Figure 1 is a diagrammatic view of the improved apparatus.

Fig. 2 is a similar view of a modified form of a portion of the apparatus shown in Fig. 1.

In order to avoid complicating the drawings a portion of the accessory devices of the rectifying column proper have been omitted.

The regulation is based on the adjustment of the exits of pure gases which is effected once for all by hand, being based on the readings or indications of meters inserted in the pipes leading to the respective gas-holders.

In the drawings only the two main exits are shown, namely N for the nitrogen and O for the oxygen, from the rectifier A A¹. If the apparatus is constructed to rectify 1000 cubic meters of air per hour, the sensitive cock 1 is so adjusted that the meter on the nitrogen exit will indicate exactly 790 cubic meters per hour, while the cock 2 must be so adjusted as to allow simultaneously only 210 cubic meters of oxygen to pass through.

When this has been done it is merely necessary to regulate the entry of air into the apparatus in such a manner that the latter shall remain regularly at the desired rate of working.

For this purpose the special thermometer *t* for these low temperatures must be kept under observation to enable the temperature of ebullition of each plate to be maintained at the requisite value. If the absolute temperature is seen to drop from 1 to 2°, this will mean that there is a risk of having a small quantity of nitrogen remaining in the oxygen in the bottom. Vice versa, if the temperature rises from 1 to 2°, there is a risk of carrying a little oxygen over into the nitrogen.

The deliveries of the meters can only be maintained if the pressure in the gas-holders and the pressure inside the rectifier are constant. Therefore the first regulation to be made is that of the pressure of the gases in the rectifier, and in particular in the base of the apparatus.

For this purpose a first regulator V V¹

of a known type is employed, but in which instead of water there is placed oil thoroughly freed from moisture which is not liable to solidify in great cold.

5 The lower vessel is maintained through the pipe 20 at the pressure of the lower part a^1 of the rectifier and the float v of V^1 acts upon a throttle 3 provided in the air inlet pipe 31. When the pressure drops, the
10 throttle will open a little more, and vice versa.

The air is shared between the nitrogen recuperators R and R^1 through the pipe 32, and the oxygen recuperators R^2 through
15 the pipe 33. Since the loss of head due to the passage through the oxygen recuperators is less than in the nitrogen recuperators, there will be a tendency for greater amount of passage through the oxygen re-
20 cuperators R^2 , and then this air will not be sufficiently cooled. This is obviated by interposing a valve-cock 4 in the pipe 33 which is regulated according to the respective indications of the thermometers T and
25 T^1 placed on the pipes 34 and 35 with supply air to the column A A^1 .

It is however necessary that the operator should be able to adjust the speed of working of the apparatus at will. For this purpose the bottom of the reservoir V is provided with a cock y and connected by a flexible pipe y^1 to a reservoir Y capable of ascending and descending. This reservoir Y
30 is suspended from a pulley W with a counterweight Z.

Assuming that the apparatus is working, and the level in the lower vessel V is at 1', and that the operator wishes to diminish the admission of air. For this purpose he
40 causes the level in the lower reservoir V to rise from 1' to 2'. If the movable reservoir is raised into its uppermost position Y, and the cock y be opened gently, the liquid will pass from Y gradually into V, and the
45 working pressure will be diminished by the vertical head comprised between 1' and 2'.

Assuming now that it is desired to accelerate the working and to lower the level of the incongealable liquid to 3'. Y must be
50 lowered into a position below V^1 and y is opened gently. This time the liquid from V will rise in Y. y must be closed as soon as the gage 21 is indicating the desired level, and the working pressure will be increased by the difference in heat between
55 1' and 2'.

Regulation of the heating supplied by the compressed nitrogen.

60 The pressure existing in the lower part of the rectifier is the result of several causes *i. e.:*

1. The counter-pressure of the gas-holders. It may be so arranged that this counter-pressure will be constant.
65

2. A loss of head due to the passage through the recuperators. This loss of head should likewise be assumed to be approximately constant, because the discharge of the nitrogen and the discharge of the oxygen are adjusted to a practically invariable hourly rate. 70

3. A loss of head due to the bubbling of the air to be rectified. This air passes only over the upper plates. The regulator must
75 maintain the volume of this air constant, and therefore there is a loss of head which will be constant.

4. The heating produced in the lower part by the condensation of the nitrogen under
80 pressure generates a certain hourly volume of oxygen which bubbles up in all the plates of the apparatus, those at the bottom as well as those at the top.

It is this last bubbling up which must be
85 regulated and rendered constant because without this, if the heating temperature were to drop, the loss of head of the column would diminish, and the large regulator V V^1 would deliver into the column an excess
90 of air which would disturb the established rate of working. In other words, the large regulator V V^1 works well only if there is no fear of disturbance due to variation of the heating of the column. 95

It is therefore very important to regulate this heating.

The gases which the worm E evolves by its action are alone to be caused to bubble in the bottom plates, that is to say, in the
100 distilling plates (A^1). They are therefore alone the cause of the difference of pressure to be found between the lower part a^1 and the level of the air inlet a . Each time the intensity of ebullition varies, the difference
105 of pressure will also vary.

These variations will be obviated by means of the second small regulator V^2 V^3 the lower vessel of which is maintained at the pressure of the base of the column by the
110 pipe 22, and the upper vessel of which is kept at the pressure of the air feed plate by the pipe 5. The same oil reservoir Y with which V^2 is in communication through
115 y^2 with the bottom of v^2 , will allow the operator to vary the setting of this regulator at will, but once he has regulated the variation of the level of the liquid in the two vessels, the regulator will maintain a corresponding and constant loss of head in the apparatus. 120

This regulator V^2 V^3 controls the throttle 7 for the admission of the nitrogen vapor through the pipe 26 and regulates its admission to the worm E.

At the exit of the worm there is situated
125 a separator E^1 which allows only liquefied nitrogen to pass. It is advisable to provide a liquid meter E^2 behind this separator in order to ascertain the degree of the heating effected. 130

5. There is another precaution to be taken. The nitrogen compressor J is liable to go wrong, to work too fast or too slowly.

The path of the nitrogen passing through the compressor J is as follows: the gaseous nitrogen at the top of the column passes through the pipe 23, the recuperator K and the pipe 9 to the compressor J, whence it passes through the pipe 24, the cooler K¹ and the pipe 25, into the tubes K, and through the pipe 26 into the cooler-worm E; thence it passes through the discharge cock E¹ and the meter E², and rises in the liquid state through the pipe 27 to the top of the column.

If the compressor is working too fast, it will supply a too great weight of compressed nitrogen, and this nitrogen being prevented from passing by the throttle 7, the pressure will rise. The consequence is a loss of motive power. In order to avoid this, it is sufficient to provide on the delivery conduit of the nitrogen, for instance at the point 8, a safety valve adjusted to the desired pressure; the escape of nitrogen through this valve will return into the suction pipe 9 of the compressor.

If on the contrary the compressor is working too slowly, there is a risk of there being no ebullition whatever in the apparatus owing to the absence of a sufficient pressure of the nitrogen. If in these conditions the air should continue to enter the apparatus, the whole system of working will be quickly destroyed. It is absolutely necessary to avoid this eventuality.

With this object the pressure of the nitrogen acts through the pipe 28 against the underside of a piston working in the cylinder 10; this piston being suitably loaded by a spring 11 which can be more or less stressed.

The piston is surmounted by a rod acting upon the lever 13 operating the valve 12 controlling the air only. As soon as the necessary pressure begins to drop, the valve 12 restricts the admission of the air. If the pressure drops to a point such at which there will be no ebullition of the oxygen, the valve will close completely.

There is still a further precaution to be taken: it is possible as a matter of fact that the compressor designed to supply the rectifier with the thousand cubic meters of air per hour, should slacken, and no longer supply sufficient air. It is necessary that the operator should know this immediately in order to reestablish the normal working.

When this insufficiency of air supply occurs, the pressure in the apparatus drops, and therefore the float *v* of the large regulator V V¹ will descend. If this descent is considerable it is desirable that warning should be given. The actual float has the function of giving this alarm.

16 is a whistle provided on the air supply duct. This whistle is set in operation when the counter-weighted lever 17 is lifted. So long as the float is situated at a normal level, the chain passing over the two grooved pulleys 14 and 15 will be slack, and the whistle will not sound.

If however the float descends to a sufficient distance, the chain will become taut and will finally raise the lever 17 and thus operate the alarm whistle.

Owing to the provision of all these alarms, safety valves and automatic regulating devices, there is no further risk of the operator being taken unawares by the bad operation of the compressors, and the apparatus will work with an automatic and faultless regularity.

If desired a special whistle may be provided intended to give warning when the nitrogen compressor is no longer giving sufficient pressure, and the valve 12 is about to close. The lever 13 can be readily arranged to operate a whistle 18 whose sound will differ in tone from that of the whistle 16.

The absolute regularity of the working of the apparatus will be still better attained if the air to be rectified is admitted exclusively in the liquefied form. Moreover, owing to this new feature in the working, the distilling plates will work to their fullest extent as a consequence of the great renewal of the descending liquid.

My aforesaid patent application of 6 February, 1918, Serial No. 215,679, has already shown that it was easy to liquefy the air by the exchange of cold units with the 79/100 of pasteurized liquid nitrogen issuing at *m*.

As regards the 21/100 corresponding to the extraction of the oxygen (which takes place in the gaseous state), recourse is had to the artifice illustrated in Fig. 2.

In this figure in order to simplify the drawing only the central portion of the apparatus is shown; the left and right hand portions of Fig. 1 remain the same.

Behind the recuperator R² there is another exchanger R³ in which by means of the cock 36 a desired quantity of liquefied nitrogen is passed which is extracted from E¹. This nitrogen expands and therefore cools to about -194° C. and becomes cold enough to liquefy the air coming from R² through the pipe 37. The liquefied air issues through a discharge device, passes through a meter E³ and rises to the feeding plate. As regards the nitrogen which is gasified by way of exchange, it rises through the pipe 38, enters the top of the rectifier and returns to the compressor. A small additional quantity of nitrogen thus requires to be compressed and circulated by the compressor, but the expense

is compensated by the more regular working of the apparatus and by the increase of the plates A^1 in refining power.

All the regulators and alarms hereinbefore described and shown in the drawings are capable of modification in their construction and in their connection with the apparatus. The important feature is the utility, and the necessity of these various regulating devices, and the invention consists in the utilization of the physical phenomena of relative depressions for actuating the various devices.

It is to be understood that these various regulating devices are applicable to all apparatus for rectifying mixed liquefied gases, and as stated at the beginning hereof, they are more particularly required when it is desired to extract nitrogen and oxygen in a state of purity and to obtain the argon in a high degree of concentration.

What I claim is:—

1. In rectifying apparatus for treating mixed liquefied gases, regulating devices automatically operated by the variations of pressure in the various parts of the apparatus to maintain regular working of said apparatus, said regulating devices comprising in combination a regulator operated by the rise or fall of pressure at the base of the rectification column and controlling the supply of the liquid gas to be rectified, a second regulator operated by the difference in pressure between the feed chamber and the base of the rectification column and controlling the supply of heating medium to the rectification column, a valve which causes any excess of heating medium to be returned to the pump supplying said heating medium and a valve which reduces the amount of liquid fed to the rectification column should the pump supplying the heating medium deliver less than the requisite amount of said medium.

2. In rectifying apparatus for treating mixed liquefied gases, regulating devices automatically operated by the variations of pressure in the various parts of the apparatus to maintain regular working of said apparatus, said regulating devices comprising a regulator provided with a vessel containing a fluid maintained under the same pressure as the base of the rectification column and a float adapted to rise and fall according to the variations of pressure at the base of said column and in so doing to operate a valve controlling the inlet for the fluid to be rectified, the level of the fluid in said controlling device being adapted to be set to a desired level by adjustment of the height of an adjustable reservoir containing

fluid in communication with the fluid contained in the said vessel of the regulator.

3. In rectifying apparatus for treating mixed liquid gases, regulating devices automatically operated by the variations of pressure in the various parts of the apparatus to maintain regular working of said apparatus, said regulating devices comprising a regulator provided with a vessel containing a liquid under a pressure which is that due to the difference of pressure existing between the feed chamber and the base of the rectification column, and a float adapted to rise and fall according to the variations of the difference of said pressures and in so doing to operate a valve controlling the inlet for the heating medium supplied to the rectification column the level of the fluid in said controlling device being adapted to be set to a desired level by adjustment of the height of an adjustable reservoir containing fluid in communication with the fluid contained in the said vessel of the regulator.

4. In rectifying apparatus for treating mixed liquefied gases, regulating devices automatically operated by variations of pressure in the various parts of the apparatus said regulating devices comprising in combination a regulator operated by the rise or fall of pressure at the base of the rectification column and controlling the supply of the liquid gas to be rectified, a second regulator operated by the difference in pressure between the feed chamber and the base of the rectification column, said devices comprising vessels containing fluid the level of which for both regulators is adapted to be set to a desired level by the adjustment of one adjustable reservoir containing fluid in communication with the fluid contained in the fluid containing vessel of the regulators.

5. In rectifying apparatus for treating mixed liquid gases, regulating devices automatically operated by the variations of pressure in the various parts of the apparatus to maintain regular working of said apparatus, said regulating devices comprising an adjustably loaded valve placed in the circuit of the compressor supplying heating medium to the rectification column, said valve operating to return any excess of heating medium to the compressor, and a piston operated valve adapted to reduce the amount of fluid gases being fed to the rectification column should the supply of heating medium fall below a predetermined value.

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

EMILE AUGUSTIN BARBET.