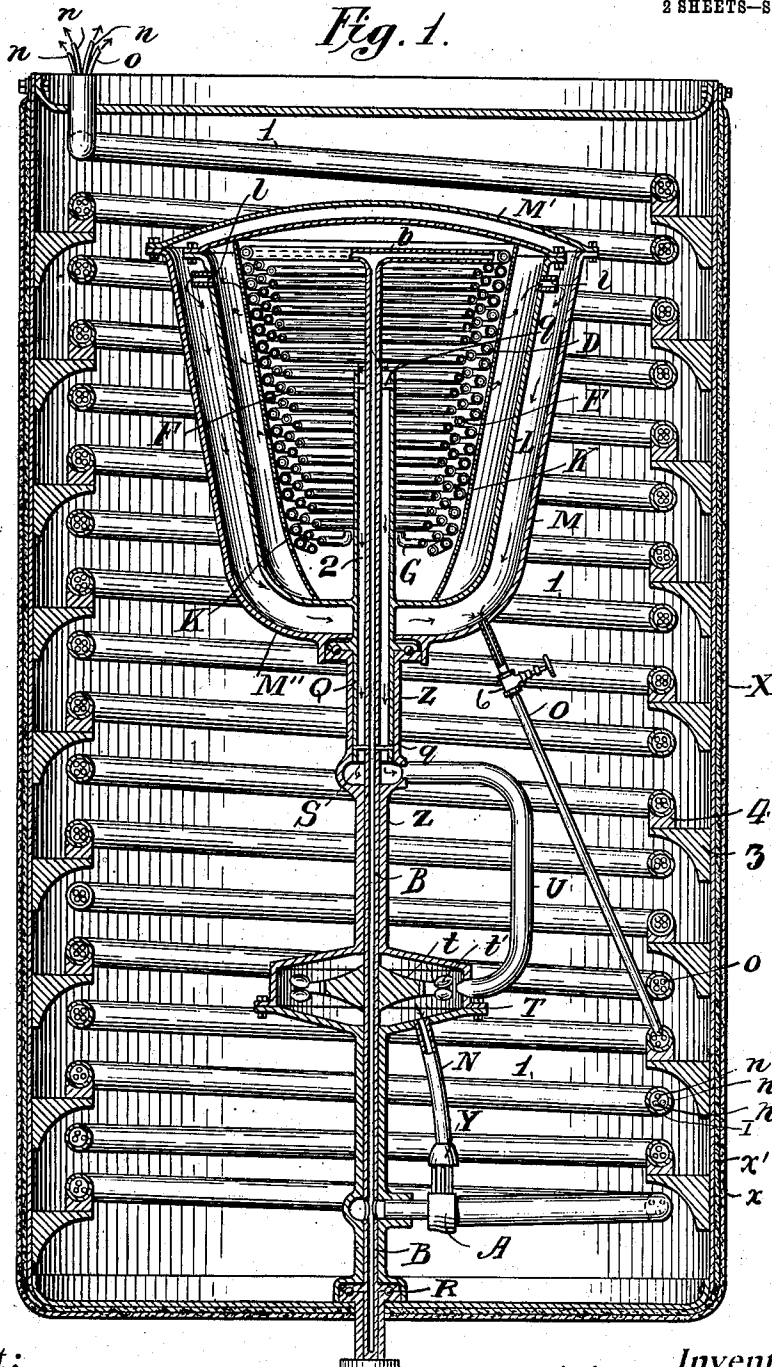


J. E. JOHNSON, JR.
 APPARATUS FOR SEPARATING OXYGEN FROM AIR.
 APPLICATION FILED DEC. 24, 1904.

933,462.

Patented Sept. 7, 1909.

2 SHEETS—SHEET 1.



Attest:

Herman Meyer
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Joseph E. Johnson Jr
 by *William R. Baird*
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Fig. 2.

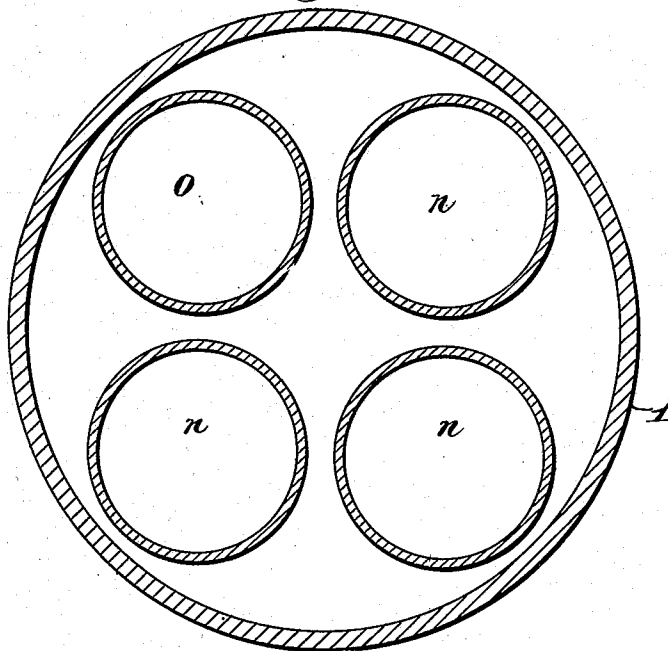


Fig. 3.

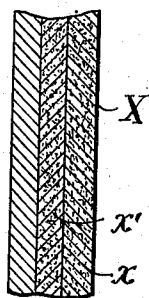


Fig. 4.

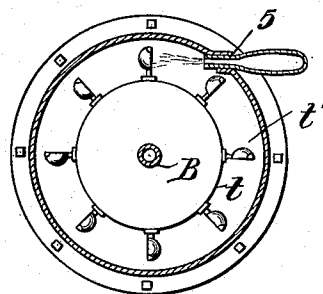


Fig. 5.



Attest:

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UNITED STATES PATENT OFFICE.

JOSEPH E. JOHNSON, JR., OF LONG DALE, VIRGINIA.

APPARATUS FOR SEPARATING OXYGEN FROM AIR.

933,462.

Specification of Letters Patent.

Patented Sept. 7, 1909.

Application filed December 24, 1904. Serial No. 238,194.

To all whom it may concern:

Be it known that I, JOSEPH E. JOHNSON, JR., a citizen of the United States, residing at Long Dale, in the county of Alleghany and State of Virginia, have invented certain new and useful Improvements in Apparatus for Separating Oxygen from Air, of which the following is a specification.

My invention relates to the means employed for separating from the air the oxygen and nitrogen of which it is mainly composed, and its novelty consists in the construction and adaptation of the parts.

The object of my invention is to use air cooled and condensed to the point of liquefaction as the basis of the operation to be carried out in the apparatus described.

It is well known that when liquid air is evaporated, or passes from the liquid to the gaseous state, a partial separation of the two gases of which it is composed takes place because the nitrogen boils at a lower temperature than the oxygen when both are under the same pressure. It is also a fact that at the pressure of the atmosphere the specific gravity of liquid nitrogen is about 0.8 while that of liquid oxygen is 1.1. This latter fact cannot readily be taken advantage of, however, as a means for separating the two elements because liquid nitrogen and oxygen dissolve each other in all proportions to form a homogeneous solution similar to that formed by a mixture of alcohol and water. However, when, in addition to the different specific gravities of the two elements, advantage is taken of their different boiling points, a method of separation is possible and the object of my invention is to provide an apparatus in which to utilize this phenomena for the purpose stated.

I use the heat absorbed by the conversion of the separated oxygen from the liquid to the gaseous state and the raising the temperature of the separated nitrogen to assist in the liquefaction of the cooled and compressed air to such a point that advantage can be taken of the difference in the boiling points of the two liquids and in the slight difference in their specific gravities to effect the desired separation, and I employ the apparatus hereinafter described for the purpose of utilizing this difference in specific gravities just at the pressure and temperature when the separation due to the difference in the boiling points is practicable.

In the drawings there is represented a

preferred form of the apparatus referred to. The process carried out therein forms the subject matter of Letters Patent of the United States, No. 783,045, dated Feb'y 21, 1905.

In the drawings, Figure 1 is a vertical section and partial side elevation of the apparatus designed to carry out the successive steps of my process; Fig. 2 is an enlarged cross section of the exchange pipe; Fig. 3 is an enlarged detail of the wall of the casing showing the layers of insulating material; the turbine and Fig. 5 is a side elevation of Fig. 4 is a horizontal transverse section of one of the turbine cups or buckets.

In the drawings, B is a hollow shaft vertically placed. Near its bottom it is provided with a connection A leading from the exchanger 1, presently to be described. At any suitable point there is arranged a ball bearing R around this shaft and above this ball bearing there is supported a turbine case T, within which is a turbine *t* of common form. Secured to the case T and arranged above it, is a long pipe or sleeve gland Z terminating at its upper end in the centrifugal separator casing M. There is an enlargement of the pipe B at S above the case T and this communicates with a lateral pipe U leading to the case. Within the pipe, or sleeve gland, Z is a second hollow shaft Q surrounding and concentric with the shaft B to which it is rigidly secured, in such a manner as to leave an annular space between them, for instance by inserting the pins *g, g*, to keep them apart. This shaft Q terminates at the enlargement S of the pipe Z which, between this point and the turbine case T, is a close running fit on the hollow shaft. In a similar manner, the pipe Z closely fits the shaft Q above this point. The shaft Q terminates within the separator. It may be said here that the nitrogen developed within the centrifugal separator C escapes into the annular space 2 between the shafts to the enlargement S and thence to the turbine *t* through the pipe U. The rotation of the turbine causes or assists in the rotation of the moving parts of this separator.

The centrifugal separator C comprises first an outer casing M in the form of an inverted truncated cone and it is provided with a suitable cover M' and bottom M''. Within this casing is the centrifugal separator proper. It consists of a conical shell L

provided with outlet ports *z*. Within the shell, *L*, is a perforated diaphragm *K* terminating in the upper and lower walls of the shell. Within the diaphragm *K* are arranged three coils of pipes, an outer series of coils *D*, an intermediate series of coils *E* and an inner series of coils *F*, the lowermost coils of the series *D* and *E* and the uppermost coils of the series *E* and *F* communicating with each other. The lowermost coil of the series *F* terminates in upwardly extending outlet pipes *G*. The uppermost pipe of the series *D* communicates directly with the hollow shaft *B* (previously referred to) through the lateral pipe *b*. The series of pipes is arranged in the form of substantially a paraboloid of revolution.

Surrounding the centrifugal separator casing and the shafts and turbine case, is arranged the exchanger 1 above referred to. This consists of a long coiled pipe *I* within which are four smaller pipes *o*, *n*, *n*, *n*, with a space surrounding them and inside of the larger pipe. The four small pipes branch out at the top of the exchanger and lead to any suitable reservoirs for the oxygen and nitrogen discharged therefrom. The exchanger at its bottom communicates with the inner shaft *B* by the coupling *A* above referred to. The small pipe *o* of the exchanger is connected with the outer fixed shell *M* of the centrifugal separator by a small pipe *O* (the purpose of which will presently be referred to) provided with a suitable control valve 6 and the other three small pipes *n*, *n*, *n*, of the exchanger are connected by a coupling *Y* to a pipe *N* leading down from the turbine case. The whole is surrounded by an external casing *X* made of any suitable size and material and suitably insulated from the outer atmosphere by layers *x*, *x'* of wool, felt, mineral wool or the like, and provided with interior brackets 3 for the support of the exchanger, insulating pieces 4 being inserted between the brackets and the exterior of the exchanger.

The turbine *t* is of usual form. It is provided with cups or buckets *t'* and the pipe *U* is provided with a suitable nozzle 5 adapted to direct the stream of fluid against the buckets to cause the rotation of the turbine.

The mode of operation of this device is as follows: Compressed air which has been cooled, freed from water-vapor, carbonic acid and dust, is introduced into the pipe *I* of the exchanger 1 at its top and within the space outside of the four small pipes *o*, *n*, *n*, *n*. Passing down through the coils of the exchanger it becomes colder and colder from the fact that the nitrogen and oxygen produced in the apparatus are at the same time passing upward through the smaller pipes within the exchanger, the oxygen through the pipe *o* and the nitrogen through the

three pipes *n*, *n*, *n*. In this manner the heat remaining in the cooled and compressed air is further removed to raise the temperature of the outflowing oxygen and nitrogen, so that the incoming air, by the time it reaches the bottom of the exchanger, is cooled down to within a few degrees of the temperature of the discharging gases just subsequent to their evaporation from the liquid condition. From the exchanger 1 the air is led inwardly toward the center of the coil through the connection *A* and enters the hollow shaft *B*. The air passes on up through the hollow shaft to its top where it terminates in the branch pipe *b* leading to the first or outermost series of coils *D* in the centrifugal separator. It then passes downward through these coils until it reaches the lowermost one of the series, whence it passes into the coils *E*. It then passes upward through the coils *E* until it reaches the uppermost one of that series whence it passes into the coils *F*. It then passes downward through this series of coils until it is permitted to escape through the outlets *G*, the terminal of the lowermost coil of this series. The coils are secured to and supported on the perforated diaphragm *K* between which and the shell *L* of the centrifugal separator there is considerable annular space. All of these parts of the centrifugal separator rapidly revolve when the apparatus is in operation.

It is well known that when a body of liquid is rapidly revolved on a vertical axis, its surface assumes the shape of a paraboloid of revolution and the series of coils *D*, *E* and *F* are so arranged as to conform roughly to the outline of such paraboloids. Assuming for the moment that the air within the interior of the centrifugal separator has been liquefied or that normal liquid air has been introduced therein, this liquid will be at a lower pressure and temperature than the air in the coils *D*, *E* and *F*. Consequently, as the air passes down through these coils, it loses heat through the walls of the coil and is completely liquefied by the time it reaches the discharge port *G*. This newly liquefied air is then discharged into the body of liquid within the centrifugal separator. It at once begins to evaporate. The vapor which rises from it is almost wholly composed of nitrogen because of the fact that nitrogen boils at a lower temperature than oxygen and both are under the same pressure. The residual liquid is therefore largely oxygen. As soon as a large portion of the nitrogen has evaporated from the "top" or inner surface of the liquid, the liquid remaining becomes much heavier than normal liquid air owing to the superior specific gravity of liquid oxygen. In the meantime the nitrogen has escaped into the annular space 2 and caused the rotation of the turbine and of the centrifugal separator in the

manner presently to be described. Under the influence of the centrifugal force induced by the high speed at which the centrifugal separator is rotated, this layer of oxygen-laden liquid air, which has been deprived of part of its nitrogen, "sinks" to the outermost space of the centrifugal separator passing through the perforations of the diaphragm K. The liquid which is thus caused to move to the outer surface of the centrifugal separator is also moved away from the series of condensing coils which constitute the source of heat which is causing the evaporation of the nitrogen. It is obvious that new layers of liquid air which have been deprived of a portion of their nitrogen are continuously formed under this operation and as the process is kept up, a body of pure, or almost pure, oxygen, will be found at the outermost part of the apparatus while the interior surface will consist of the liquid which has last entered and which contains almost the quantity of nitrogen in normal air.

The outlet ports *l* of the conical shell L are located at or near its top and, therefore, farthest away from the center of the inverted truncated cone. The outermost layers of the liquid are almost, or quite, pure oxygen, and are permitted to flow through these ports into the annular space between the shell L and the outer casing M. From this space it flows through the pipe O (and the valve 6 being opened) down to the small pipe *o* of the exchanger, entering the exchanger, in the case illustrated, at the fourth coil from the bottom. It is desirable to have this counter-current coil for the oxygen at this place rather than at the extreme bottom of the apparatus because the liquid oxygen is warmer than the escaping nitrogen and it enters the exchanger, therefore, at a point where the cooled air coming down the exchanger is about at the same temperature as its own. The oxygen gradually passes up through the small pipe *o* of the exchanger 1, being converted from the liquid into the gaseous state as it progresses, and is discharged at the top or conveyed into any suitable reservoir, as may be desired.

The space within the centrifugal and above the surface of the liquid is filled with practically pure nitrogen vapor. This vapor passes into the top of the pipe Q and so on down the annular space 2 to the outlet S whence it passes through the pipe U to the turbine T, the peripheral speed of the turbine being such as to remove the energy of the nitrogen discharging against it as fully as possible. This turbine is the source of rotation of the centrifugal. The nitrogen, having performed this work, leaves the turbine case at the bottom and passes through the pipe N and coupling Y into the three small pipes *n*, *n*, and *n* of the exchanger 1 whence it

flows upward alongside of the oxygen until it reaches the terminals of this series of pipes whence it may be led into a reservoir and disposed of at will.

While I have described this apparatus as relating only to the separation of oxygen and nitrogen from the air, it will, of course, be understood that it is readily applicable to the separation from a liquid of any of its ingredients having slightly different boiling points and specific gravities. For instance, it might be used in the separation of crude oils, or of mixture of alcohol and water.

Certain constructions and forms herein specifically described may be departed from and modified without destroying the usefulness of the device or departing from the spirit and scope of the invention. For instance, a single coil might be used, such as the coil D instead of the three coils D, E and F. The form of a paraboloid of revolution for the coils D, E and F need not be absolutely adhered to, such coils being capable of their functions if arranged in circular or substantially circular form. Other modifications might also suggest themselves to those skilled in the art which would not be considered as departures from the invention.

What I claim as new is:—

1. An apparatus for separating oxygen from air comprising a centrifugal separator provided internally with a plurality of series of coiled pipes, the inner coil of which communicates with the separator, means for introducing cooled compressed air into the outermost series of said pipes, means for rotating the separator, and means for removing the separated oxygen and nitrogen therefrom.

2. An apparatus for separating oxygen from air comprising a centrifugal separator provided internally with a plurality of series of coiled tubes, the inner coil of which communicates with the separator, a central inlet tube communicating with the source of air supply and with the outermost series of said tubes, means for rotating the separator, and means for removing the separated oxygen and nitrogen therefrom.

3. An apparatus for separating oxygen from air comprising a centrifugal separator provided internally with a plurality of series of coiled tubes, the inner coil of which communicates with the separator, a central inlet tube communicating with the source of air supply and with the outermost series of said tubes, means for rotating the separator consisting of a motor actuated by the vaporized nitrogen, and means for discharging the separated oxygen and nitrogen.

4. In an apparatus for separating oxygen from air, a centrifugal separator comprising interior coils of tubes communicating with the supply of air, means for separating the

incoming from the outflowing fluids, means for separating the liquid oxygen from the liberated nitrogen, means for drawing off the separated fluids and means actuated by the liberated nitrogen for rotating the separator.

5. In an apparatus of the class described, the combination with the centrifugal separator, of a pipe for discharging nitrogen, the turbine or motor adapted to be actuated by the outflowing nitrogen, the exchanger and the sleeved connection between the turbine and the centrifugal separator.

6. In an apparatus of the class described, the combination with the centrifugal separator, of a pipe for discharging nitrogen, the turbine or motor adapted to be actuated by the outflowing nitrogen, the exchanger, the sleeved connection between the turbine and the centrifugal separator, the separator casing, and the oxygen-carrying-pipe between the separator casing and the exchanger.

7. In an apparatus of the class described, a centrifugal separator comprising an external casing and central inlet pipe, a plurality of series of tubes connected to the inlet pipe and provided with a central discharge outlet, means for supporting the tubes, a peripheral outlet pipe for the discharge of the oxygen and a central outlet pipe for the discharge of the nitrogen, and means for rotating the centrifugal separator.

8. In an apparatus of the class described, a centrifugal separator comprising an external casing and central inlet pipe, a plurality of series of tubes connected to the inlet pipe and provided with a central discharge outlet, means for supporting the tubes, a peripheral outlet pipe for the discharge of the oxygen and a central outlet pipe for the discharge of the nitrogen, and means for rotating the centrifugal consisting of a turbine or motor, a conduit leading down from the nitrogen outlet to the turbine or motor and an operating connection between the motor and the separator.

9. In an apparatus of the kind described,

a centrifugal separator comprising an imperforate exterior conical shell and a similarly shaped perforated diaphragm provided internally with a series of coiled tubes arranged within the separator in the form substantially of a paraboloid of revolution, and means for rotating the tubes.

10. In an apparatus of the kind described, a centrifugal separator comprising an imperforate exterior conical shell and a similarly shaped perforated diaphragm, provided, internally with a plurality of series of coiled tubes arranged within the separator in the form substantially of a paraboloid of revolution, and means for rotating the tubes.

11. In an apparatus of the kind described, a centrifugal separator comprising a casing in the form of an inverted truncated cone, an imperforate internal conical shell, a perforated diaphragm within the shell a series of coiled tubes arranged within the separator in the form substantially of a paraboloid of revolution, and means for rotating the tubes.

12. In an apparatus of the kind described, a centrifugal separator comprising an imperforate exterior conical shell and a similarly shaped perforated diaphragm, provided internally with a series of coiled tubes arranged within the separator in the form substantially of a paraboloid of revolution, the diaphragm supporting said pipes within the separator, and means for rotating the tubes.

13. In an apparatus of the kind described, an imperforate exterior shell, a perforated diaphragm within the shell, and a series of coils of tubes within the shell adapted to be immersed in the body of liquid air to be treated.

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

JOSEPH E. JOHNSON, JR.

Witnesses:

HERMAN MEYER,
S. J. Cox.