E. M. WILEY.

PROCESS OF EXTRACTING NITROGEN FROM AIR.

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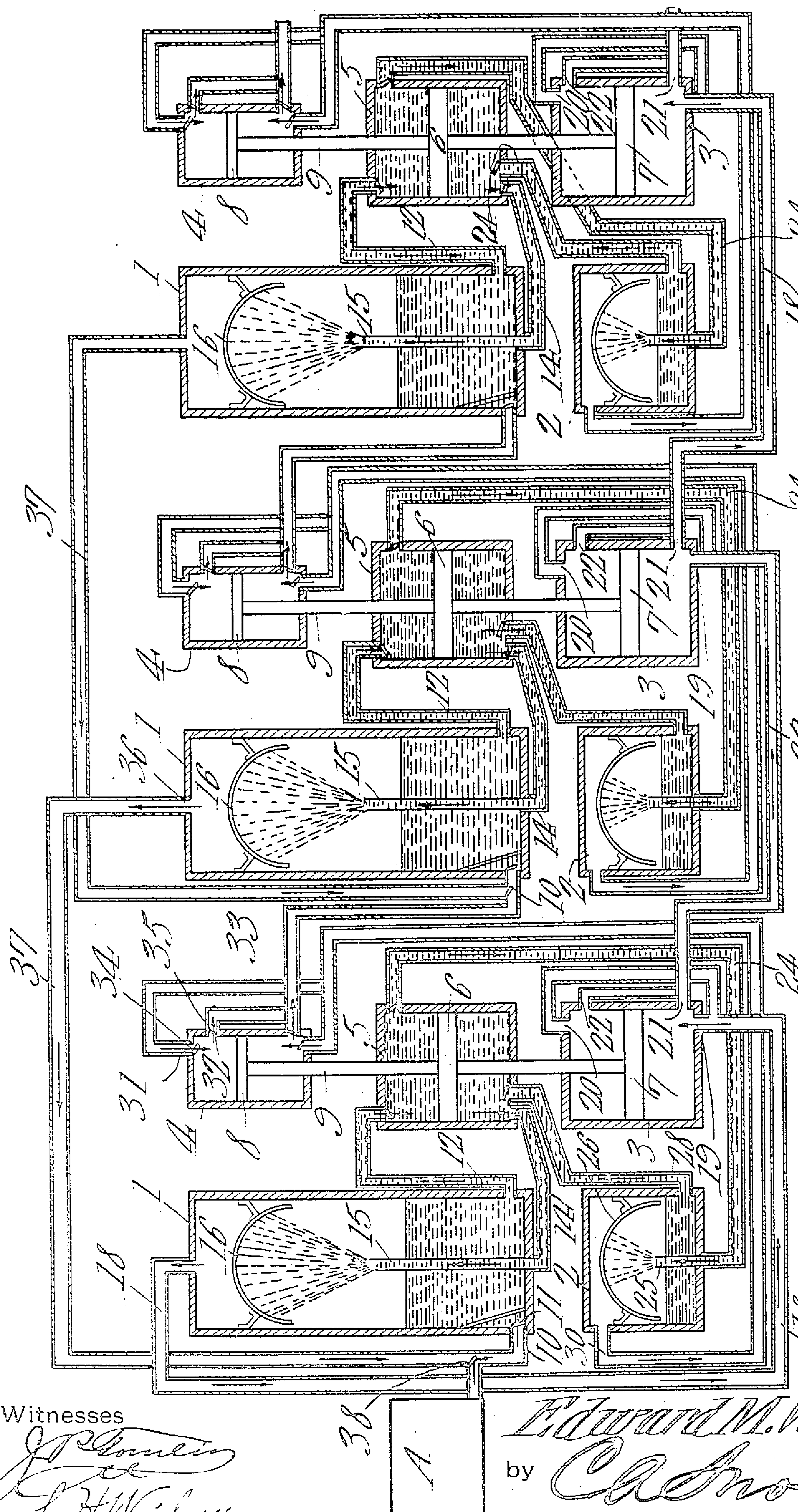
1,056,244. Patented Mar. 18, 1913.



Witnesses

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EDWARD M. WILEY, OF ADAMS, INDIANA.

PROCESS OF EXTRACTING NITROGEN FROM AIR.

1,056,244. Specification of Letters Patent. **Patented Mar. 18, 1913.**

Application filed April 21, 1911. Serial No. 622,523.

To all whom it may concern:

Be it known that I, Edward M. Wiley, a citizen of the United States, residing at Adams, in the county of Decatur and State of Indiana, have invented a new and useful Process of Extracting Nitrogen from Air, of which the following is a specification.

This invention relates to a new and useful method of reducing the proportion of nitrogen to oxygen in air.

One of its objects is to utilize as a motive force the air being acted upon, this air constituting means for actuating pumps embodied in the apparatus.

With the foregoing and other objects in view the invention consists in certain novel details of operation which will be hereinafter more fully described and pointed out in the claims.

In the accompanying drawing I have shown, diagrammatically, the apparatus to be used in carrying out the present method.

This invention is based upon the fact that air does not dissolve as a whole when mixed with water, but the oxygen and nitrogen dissolve each in proportion to its intrinsic solubility and partial pressure. For example, should air be at 760 m. m. and its composition be 1/5 oxygen and 4/5 nitrogen, the separate solubilities of the gases are respectively 4 and 2 volumes in 100 volumes of water. Their partial pressures being 1/5 and 4/5 of an atmosphere, the amounts actually dissolved will be

$$4\times1/5=0.8$$

and

$$2\times4/5=1.6$$

in 100 volumes of water. The ratio of full oxygen to nitrogen will therefore be 1:2.

In carrying out the invention a desired number of sets of tanks and pumps are utilized, each set or unit including a high pressure tank 1, a lower pressure tank 2, and a pump made up of a power cylinder 3, an air containing cylinder 4 and a water containing cylinder 5. A water forcing piston 6 is located in cylinder 5, a drive piston 7 is arranged in cylinder 3, and an air forcing piston 8 is located in cylinder 4, all three of the pistons being fixedly connected to a rod 9. High pressure tank 1 has an air inlet 10 leading from a suitable air compressor A and provided with a valve 11 for preventing back flow of fluid from the tank. An outlet pipe 12 extends from the bottom of tank 1 to one end of cylinder 5. Another pipe 14 extends from the other end of cylinder 5 and opens into a nozzle 15 extending upwardly within tank 1 from the bottom thereof and adapted to direct a spray of water against a spreading dome 16 supported in the upper portion of the tank.

An outlet pipe 18 extends from the top of tank 1 and opens into inlet ports 19 and 20 formed at the ends of cylinder 3, the outlet ports 21 and 22 of said cylinder opening into a pipe 23 extending to the inlet ports of the cylinder 3 of the next unit. A pipe 24 extends from an outlet port formed at that end of cylinder 5 to which pipe 12 is connected, this pipe 24 discharging into a nozzle 25 which extends upwardly within the tank 2. Said nozzle is adapted to discharge a spray of water upon a spreading dome 26 supported in tank 2. Another pipe 28 connects the bottom portion of tank 2 with that end of cylinder 5 to which pipe 14 is connected.

An outlet pipe 30 extends from the upper end portion of tank 2 and opens into the inlet ports 31 at the ends of cylinder 4 and the outlet ports 32 open into a pipe 33 which serves to conduct air under pressure to the inlet 10 of the tank 1 of the next unit. The ports 19, 20, 21 and 22 of cylinder 3 may be provided with any desired valve mechanism for opening and closing them in proper succession to insure reciprocation of the piston 7 when air under pressure is directed into the cylinder. Such mechanism is so well known that it is not deemed necessary to illustrate or describe it in the present case. The same valve mechanism would be extended to the various ports in the cylinder 5 to produce the effect of admitting water from the high pressure tank 1 through pipe 12 into one end of cylinder 5 and discharging the same volume of water into tank 1 through pipe 14 from the other end of cylinder 5 at one stroke of the pump, and with the opposite stroke of the pump the water in the cylinder would be discharged into the low pressure tank 2 through pipe 24 and an equal volume of water received from tank 2 into the other end of cylinder 5 through pipe 28. The ports 31 in cylinder 4 have valves 34 for preventing escape of air therethrough from the cylinder 4 while ports 32 are also provided with valves 35 to prevent the admission of air through them and into the cylinder. All of the units of the apparatus are of the same general arrangement as has been described and the air outlet ports 36 of the tank 1 of the third unit are connected by an "overflow" pipe 37 to the pipe 33 of the next preceding unit and the outlet 36 of the second unit is similarly connected to inlet 10 of the tank of the first unit, each pipe 37 having a valve 38 to prevent back flow of air therethrough.

From the foregoing it will be apparent that when air under pressure is admitted to inlet 10 it will rise through the water in tank 1 of the first unit, pass through pipe 18 to power cylinder 3 and cause the piston 7 to reciprocate. Piston 6 will also be reciprocated and will spray water into the compressed air in tank 1 and withdraw an equal amount of water at the same time from the tank and spray it into tank 2 from which an equal quantity is drawn back at the same time into cylinder 5, thus completing a circuit. The air in tank 2 is then drawn into cylinder 4 by piston 8 and discharged, under pressure, into the inlet 10 of tank 1 of the next unit. Let it be assumed that the capacity of the first unit of the apparatus is one hundred gallons of water per minute, of the second set fifty gallons per minute, and of the third set thirty gallons per minute, and the pressure in the tanks 1 about thirty atmospheres, or 450 lbs. to the square inch. As the solubility of oxygen in water is about four volumes to one hundred volumes of water, and of nitrogen about two volumes to one hundred volumes of water, and as ordinary air consists of about one volume of oxygen and four volumes of nitrogen, one hundred gallons of water will, as a result of the partial pressure of each gas and the different solubilities thereof, absorb

$$1/5 \times 4 = 4/5$$

gallons of oxygen at a pressure of one atmosphere and

$$4/5 \times 30 = 24$$

gallons at a pressure of 30 atmospheres. For the same reasons the same one hundred gallons of water will absorb

$$4/5 \times 2 = 8/5$$

gallons of nitrogen at a pressure of one atmosphere and at 30 atmospheres the absorption will amount to

$$8/5 \times 30 = 48$$

gallons of nitrogen. This absorption of oxygen and nitrogen thus takes place in the high pressure tank 1 of the first unit and when the solution is directed in the form of a spray into the low pressure tank 2 of the unit, the air will be separated from the water and be forced by the piston 8 of the unit into the inlet 10 of the tank 1 of the second unit, this air consisting of 24 gallons of oxygen and 48 gallons of nitrogen, or a mixture in the proportion of one volume of oxygen to two volumes of nitrogen. Water in the tank 1 of the second unit would absorb

$$1/3 \times 4 = 4/3$$

gallons of oxygen and

$$2/3 \times 2 = 4/3$$

gallons of nitrogen at the pressure of one atmosphere for 100 gallons of water. But the capacity of this unit is only 50 gallons per minute and, the pressure being thirty atmospheres, twenty gallons of oxygen

$$(4/3 + 2 = 2/3 \times 30 = 60/3 = 20 \text{ gallons})$$

and twenty gallons of nitrogen

$$(4/3 + 2 = 2/3 \times 30 = 60/3 = 20 \text{ gallons})$$

will be exhausted from the low pressure tank 2 of the second unit and forced into the tank of the third unit, the mixture thus produced consisting of one gallon of oxygen to one gallon of nitrogen. Applying the foregoing rule, the third unit having a capacity of thirty gallons per minute would yield eighteen gallons of oxygen and nine gallons of nitrogen, this being in the proportion of 2 to 1. Thus is produced from the first unit twenty-four gallons of oxygen and 48 gallons of nitrogen equaling 72 gallons of one oxygen to two nitrogen; from the second unit twenty gallons of oxygen and twenty gallons of nitrogen, equaling forty gallons of one oxygen to one nitrogen; and from the third unit eighteen gallons of oxygen and nine gallons of nitrogen, equaling twenty-seven gallons of two oxygen to one nitrogen. Obviously, the foregoing process can be carried out indefinitely it being limited solely by the number of units employed. As the third unit receives forty gallons per minute from the second unit and discharges twenty-seven gallons per minute, it will have an overflow of thirteen gallons of air per minute and this will return to the tank 1 of the second unit. As this tank receives seventy-two gallons from the first unit and an overflow of thirteen gallons it will have an overflow of 72 plus 13 = 85 gallons less 40 gallons discharge, equaling 45 gallons overflow which thus returns to the tank 1 of the first unit via one of the pipes 37, the air flowing from this tank serving to drive the pumps in the manner hereinbefore set forth. The overflow from each tank has the effect of relieving the tank from which it comes, of nitrogen, and it contains a larger amount of oxygen than the mixture in the tank into which the overflow is discharged, thus enriching the mixture.

As a single pump would only produce an intermittent flow of water into and from the tanks, the use of a double pump or two or more single or double pumps would be more suitable than a single pump for each pair of tanks to produce a continual flow of water into and from the tanks, especially for an apparatus of large capacity and high pressure, the principle involved being the same as with a single pump to each pair of tanks.

What is claimed is:

1. The herein described method of reducing the proportion of nitrogen to oxygen in air, consisting in directing air under pressure into a high pressure tank, setting up a circulation of water through said tank to saturate the water with oxygen and nitrogen, directing the saturated water into a low pressure tank to separate the oxygen and nitrogen therefrom, withdrawing the gases from the low pressure tank and directing them under pressure into a second high pressure tank, directing a current of water through said tank and through a low pressure tank to produce a mixture having a smaller proportion of nitrogen to oxygen and directing overflow gas from said second high pressure tank back to the first high pressure tank, and utilizing the overflow from the first high pressure tank for actuating the air and water forcing means.

2. The herein described method of reducing the proportion of nitrogen to oxygen in air consisting in setting up simultaneously separate circulations of water through the high and low pressure tanks of separate units, and directing air under pressure into the high pressure tanks of the units, to be partly absorbed by the water and conveyed to the low pressure tanks from which the air is conveyed to said air directing means, and returning excess air from the high pressure tank of each unit to the high pressure tank of the next preceding unit, the excess of air in the high pressure tank of the first unit being utilized to actuate the air and water forcing means.

In testimony that I claim the foregoing as my own, I have hereto affixed my signature in the presence of two witnesses.

EDWARD M. WILEY.

Witnesses:

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