(No Model.)

C. L. HORACK.

METHOD OF AND APPARATUS FOR OPERATING AQUA AMMONIA ENGINES.

No. 493,722. Patented Mar. 21, 1893.

Fig. 1.

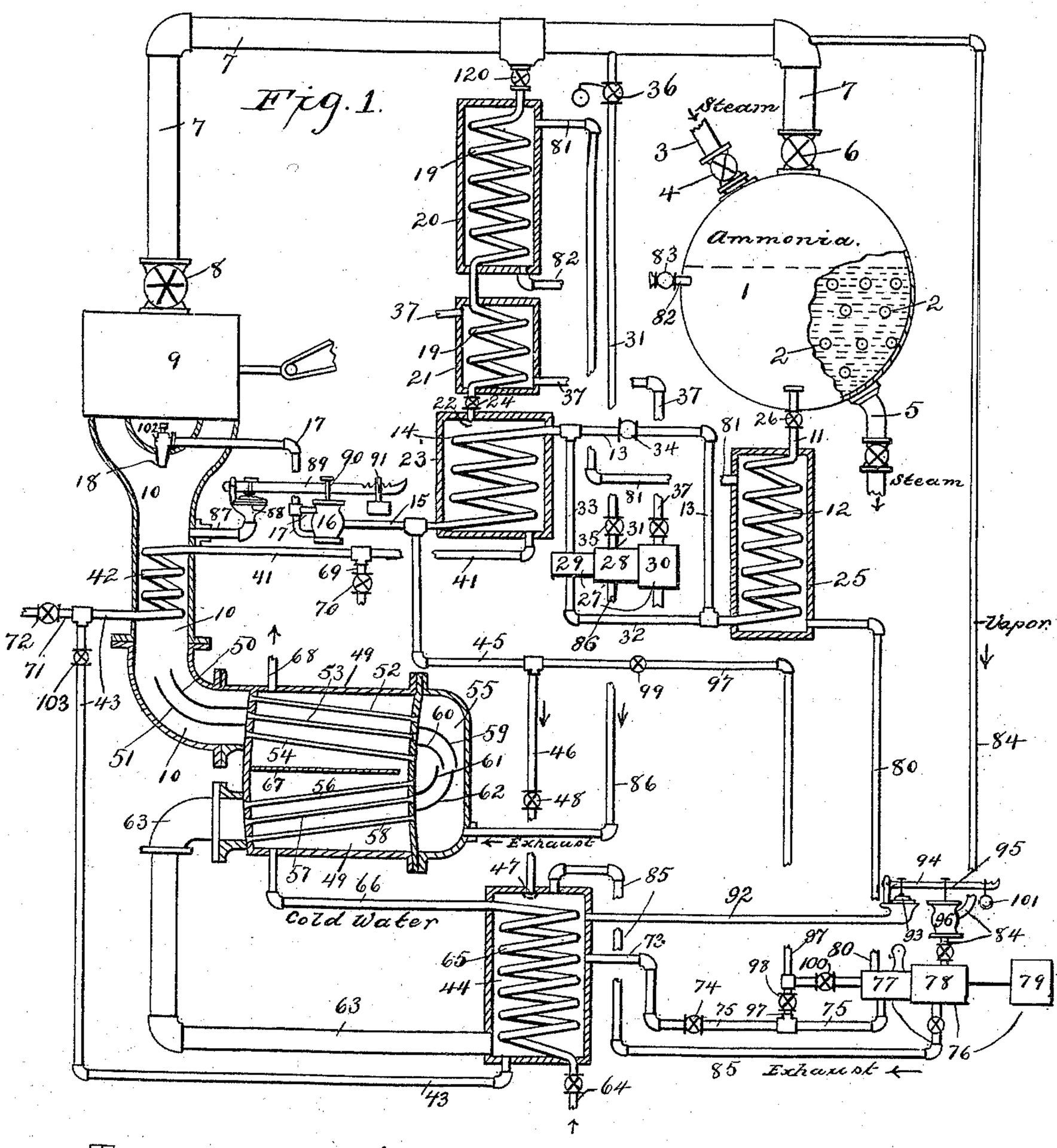


Fig. 4.

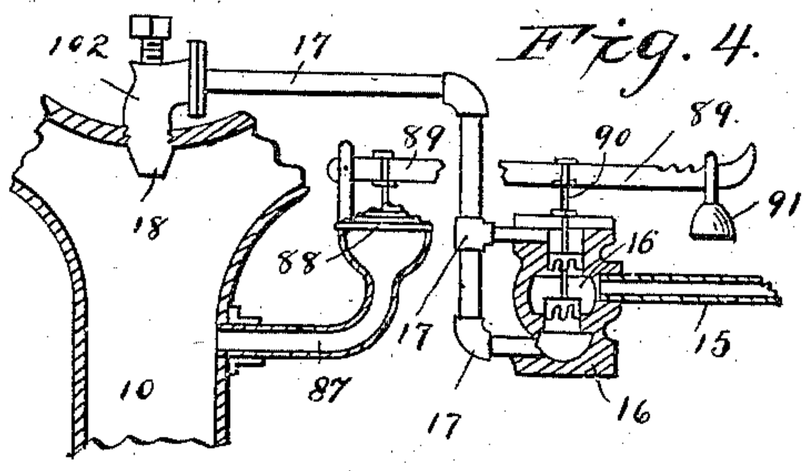


Fig. 2.

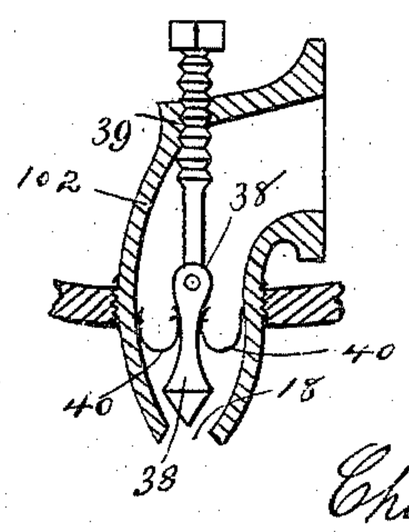
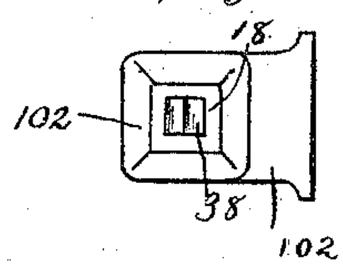


Fig. 3.



Witnesses:-

W. E. Bowen

J. L. Bowen

Inventor:

Chas. L. Horack

UNITED STATES PATENT OFFICE.

CHARLES L. HORACK, OF BROOKLYN, NEW YORK.

METHOD OF AND APPARATUS FOR OPERATING AQUA-AMMONIA ENGINES.

SPECIFICATION forming part of Letters Patent No. 493,722, dated March 21, 1893.

Application filed January 2, 1890. Renewed May 11, 1892. Serial No. 432,576. (No model.)

To all whom it may concern:

Be it known that I, CHARLES L. HORACK, a citizen of the United States, and a resident of Brooklyn, in the county of Kings and State of New York, have invented certain new and useful Improvements in Methods of and Apparatus for Operating Aqua-Ammonia Engines, of which the following is a specification.

My invention refers to aqua ammonia engines, wherein ammonia gas is expelled from aqua ammonia in a boiler or generator by heat, and the gas after propelling the piston of an engine, is reabsorbed by liquid withdrawn from such boiler and cooled, exhaust gas and absorbing liquid being thereupon returned jointly to such boiler or generator.

The objects of my invention are principally to improve the methods and the means generally employed for properly reabsorbing the exhaust vapor of the engine and for reconducting the combined exhaust vapor and absorbing liquid to such boiler, and also to properly regulate the pressure in the ammonia boiler. In order to accomplish these objects I employ artificial cold, which may be developed with the aid of ammonia gas generated in the same boiler in which the gas for propelling the engine is generated, for cooling the absorbing liquid, and for cooling also the combined exhaust gas and absorbing liquid, and I reabsorb such cooling gas in the same apparatus in which absorption of the exhaust of the engine takes place. I, further, arrange to produce, either automatically or otherwise, a pressure in the pipe carrying the absorbing liquid to the spray jet, higher than the pressure imparted to such liquid direct by the boiler, and thereby an increased discharge of liquid through such spray jet. I, further, provide, in case of excessive pressure in the ammonia boiler, automatically an additional amount of cooling liquid for cooling and liquefying ammonia gas, which may be used for refrigerating the absorbing liquid. I, further, arrange to absorb the exhaust vapor or gas of the engine by liquid discharged so as to form a mist, or practically continuous body of finely divided or "atomized" liquid reaching across the whole or a large part of a section of the exhaust pipe, as distinguished from the coarse distribution obtained with rose-heads, spreader plates in front of the outlet or similar devices. I, further, secure proper and approximately uniform working of all the parts of a surface condenser connected with the engine and acting as an absorber, by placing in the path of the absorbing liquid shelves or guides for conducting said liquid to all the tubes in the absorber. I, further, prevent the formation of "liquid seals" in the absorber by giving to its tubes such inclinations as will always secure drainage by gravity of the liquid from such tubes, even if the general position of the absorber should vary and depart from a level position, as will particularly occur on board of a ship. I, further, guard against the difficulties resulting from the accumulation of free ammonia gas in the suction pipe, or near the delivery end of an aqua ammonia pump, by arranging to inject into the spaces occupied by such gas cooled absorbing liquid. I, further regulate the vacuum in the exhaust pipe by providing in communication with it a diaphragm, the expansion or contraction of which, resulting from changes in the vacuum, operates a valve controlling the supply of absorbing liquid. I, further, guard against excessive pressure in the receiving well by providing similar appliances in combination with the vapor pipe which operates the feed pump. I, further, provide for heating the combined exhaust vapor and absorbing liquid, while passing from the feed pump to the boiler, by passing the same through an equalizer, wherein gas, which is to be liquefied for refrigerating purposes as mentioned above, is deprived of its heat. These and other features of my invention are more fully described in the following specifications and are set forth in the claims.

In the accompanying drawings I have shown in Figure 1 a side elevation, partly in section, of an ammonia engine apparatus constructed according to my invention. Fig. 2 represents, partly in section, the vertical view of the spray nozzle employed by me and Fig. 3 the bottom view of such nozzle, while Fig. 4 represents a vertical view partly in section of the apparatus for automatically regulating the amount of liquid discharged into the absorbing apparatus of the engine.

1 is a boiler wherein aqua ammonia is heated by steam circulating through tubes 2, 2 such

steam being admitted to chambers with which such tubes connect, through a suitable inlet pipe 3 connecting with a steam boiler, such inlet pipe being provided with a gate valve 4. The steam is discharged from such ammonia boiler through connection 5 having a suitable valve after the said steam has given up part of its heat to the aqua ammonia surrounding tubes 2, 2.

In the following description and claims the ammonia boiler will be termed "the generator" in order to distinguish it from a steam boiler, and as, as far as my invention is concerned, it is immaterial what form of generator is used and what heating agent is employed in connection therewith, I would state that I do not intend to confine myself to the use of such a generator as is illustrated in the drawings. The gas expelled from the aqua ammonia will fill the upper space of the generator and, gate valve 6 being open, will pass through the main vapor pipe 7 into the engine cylinder 9, after its throttle valve 8 has been opened and, after propelling the piston in said cylinder, will pass into exhaust pipe 10. From the lower part of the generator solution, weakened by the expulsion of part of its gas, is conducted to the exhaust pipe 10 through pipe 11, coil 12, pipe 13, coil 14, pipe 15, valve 16 and pipe 17 being discharged into said exhaust pipe through jet 18, for the purpose of meeting there the exhaust vapor of the engine and absorbing part of the same, the gas still remaining free after such discharge of the absorbing liquid being disposed of and absorbed by bringing the same as well as the absorbing liquid in contact with proper cooling surfaces as described hereinafter.

It is well known that absorption of ammonia gas by weak solution will take place more readily, the lower the temperature of such solution is, hence the vacuum obtained on the piston of the engine cylinder will be improved as such temperature is lowered and I therefore make special provision for cooling the absorbing liquid as follows:

19 is a coiled pipe which receives ammonia gas under generator pressure from main vapor pipe 7 when cock or valve 120 is open, and as said coiled pipe within reservoirs 20 and 21 is surrounded by cooling liquid, as specified below, the gas within such coil becomes liquefied and, being permitted to escape through a small aperture 22 into reservoir 23 again assumes the gaseous form and in doing so takes up the latent heat of vaporization, which it had previously surrendered in reservoirs 20 and 21.

24 is a valve or cock for regulating the flow of liquefied gas through aperture 22. The method of liquefying ammonia gas expelled from aqua ammonia in a generator, by cooling it while under generator pressure and re-expanding it again for purposes of refrigeration as described above does not differ from that employed heretofore in "absorption refrigerating apparatus," but the combination of such apparatus with an aqua ammonia engine as employed by me covers various novel features. The absorbing liquid which circulates through coil 14, as mentioned above, will furnish the latent heat of vaporization to the ammonia gas in reservoir 23, within which said coil is located, and may thus be reduced to a very low temperature, particularly also as provision is made to give such absorbing liquid a preliminary cooling while passing through coil 12 in reservoir 25 the feed liquid which in a comparatively cool condition is being made to surround such coil while returning to the generator as mentioned more fully hereinafter. In addition to using the feed liquid as cooling medium for the absorbing liquid, or in place of such liquid, cooling water might be used to lower the temperature of the absorbing liquid sufficiently, so as to finally apply to best advantage the artificial cold produced, to the absorbing liquid while passing through coil 14. As the absorbing liquid while in transit from the generator to the exhaust pipe will always contain a certain amount of ammonia gas held in physical absorption, said liquid will have its freezing point considerably below that of water, and no danger is therefore to be anticipated as far as the freezing of the liquid in the pipe is concerned, particularly also as the same is kept moving under pressure, cock 26 being provided to shut off the supply upon stopping the engine, while thereupon pump 27 may be used to clear such system of piping of liquid. Said pump 27 is provided principally for the purpose of producing at the spray jet 18, when desired, a pressure greater than that produced in the generator, and is so connected with the main vapor pipe 7 as to cause an increased flow of absorbing liquid to the absorbers and toward the generator, while at the same time furnishing additional cooling liquid for the purpose of lowering the temperature of such absorbing liquid, thereby making it more capable of reducing the pressure in the generator when it again reaches the same.

28 is the vapor cylinder of pump 27 while 29 is a cylinder for pumping absorbing liquid and 30 is a cylinder for pumping water, the pistons of the three cylinders being connected so as to move together and the area of the piston in cylinder 29 being smaller than that in cylinder 28, so as to produce a greater pressure in the discharge pipe in cylinder 29 than exists in vapor pipe 31 which conveys the vapor for operating pump 27 to it from main vapor pipe 7. The suction pipe 32 as well as the discharge pipe 33 of cylinder 29 connect with pipe 13. The check valve 34 is placed in pipe 13 between the points where pipes 32 and 33 connect with the same. Said valve is adjusted so as to become closed when pump 27 is set in motion and thereby pressure is produced in pipe 33 exceeding that in 32, and consequently the pressure at the spray jet 18 and the amount of liquid discharged

from it may thus, by the action of pump 27, be increased beyond that which would be obtained there from direct generator pressure.

35 is a cock in pipe 31 and must be kept open while automatic starting and stopping of pump 28 are desired.

36 is a weighted valve in pipe 31 so adjusted as to open when a given excessive pressure is reached in pipe 7, thereby starting pump 27 and increasing the flow of absorbing liquid, as described. The water cylinder 30 through its discharge pipe 37 forces cooling water into reservoir 21 thus facilitating the liquefaction of gas in coil 19 and to that extent also relieving the generator. Said discharge pipe might however instead be connected with any other part of the apparatus wherein it would serve as a cooling medium for the absorbing liquid or for the said liquid combined with the exhaust vapor of the engine. If it be desired to operate pump 27 before excessive pressure is reached in the generator, it is only necessary to detach the weight from valve 36.

While the discharge nozzle 18 might be constructed as a rose-head or with an unobstructed outlet, and in the latter case might be provided with a spreader plate for distributing the liquid while impinging upon such plate, my preferred form of a spray nozzle is constructed as follows:—Within the casing 102 is placed the tongue 38, suspended from a pivot at the lower extremity of pin 39, which pin is screwed into casing 102 from above, as shown. Said tongue is constructed wedge-shaped at its lower end, the surfaces forming said wedge being made approximately parallel with the parts of the walls of spray jet 18 facing the same. In consequence a stream of absorbing liquid will pass out of nozzle 18 on each side of tongue 38 and said streams will meet outside of said nozzle and being discharged under great pressure will meet and impinge upon each other with great force, so as to fill the whole section of exhaust pipe 10 with fine mist, which, particularly if cooled to a temperature artificially low, will promptly absorb a large amount of exhaust vapor, carrying with it, by adhesion, the vapor still remaining free, toward cooling surfaces provided as described hereinafter.

40, 40 are springs intended to steady tongue 38. If an obstruction should occur on either side of said tongue, owing to foreign substances such as scale from the generator becoming lodged there, the pressure behind such substances will force the same out of the nozzle, deflecting sidewise if necessary the tongue 38 until the outlet or outlets are again clear, when the springs 40, 40 will again force said tongue back into its original position. If an increase or a reduction in the size of the outlet or outlets should be desired, it is only necessary to screw upward or downward the pin 39 and with it tongue 38 suspended from it. It will readily be seen that a similar result would be obtained as far as the distribution of the liquid is concerned, if the nozzle 18 were provided with a circular outlet and the lower end of tongue 38 were made conical. In the case of a large exhaust pipe a series of nozzles as described might be employed in order to secure proper distribution of the liquid.

41 is a pipe carrying the ammonia gas expanded in reservoir 23 to coil 42 placed in the exhaust pipe underneath spray jet 18, the gas then being made to pass through pipe 43 into the lower part of receiving well 44 where it is absorbed by the combined absorbing liquid and exhaust vapor of the engine, aided if necessary by further absorbing liquid introduced into said well through a branch pipe from pipe 15 said branch pipe 45, 46 terminating in a nozzle 47 in the upper part of the well, so as to discharge the liquid, preferably in a fine spray, in the body of unabsorbed gas which after forcing its way upward through the liquid in the lower part of the well would gather there.

48 is a cock or valve for regulating the amount of absorbing liquid so discharged. The nozzle 47 had best be constructed similar to nozzle 18 and the pressure in the well might be regulated by means of a diaphragm subject to the pressure in the well and operating a supply valve, the same as described below with reference to regulating the pressure in the exhaust pipe of the main engine.

Owing to the fact that when the refrigerating gas leaves reservoir 23 it will still have a low temperature, I make use of it for cooling the combined absorbing liquid and exhaust vapor in exhaust pipe 10 by directing the said liquid and the gas carried along by adhesion, or otherwise drawn or forced downward through said exhaust pipe, toward the coils of coiled pipe 42. The liquid so dripping from coil to coil, or while passing downward along said coils, will be relieved of part of the heat of absorbtion evolved upon meeting of gas and liquid and thus further absorption will be made possible and will be accomplished. This heat of absorption which is always developed upon the mixing of ammonia gas and water or weak aqua ammonia, forms the greatest obstacle to prompt absorption of all the exhaust vapor and hence to the obtaining of a good vacuum, as by such heat gas will again be set free and will have a tendency to rise again in the exhaust pipe.

While the use of very cool absorbing liquid and of refrigerating gas as cooling medium in the cooling pipes nearest to the absorbing jet will overcome this difficulty in a great measure, it is desirable to make provision for further absorption and with the aid of less expensive cooling fluid than used in artificial refrigeration. For such purpose I provide absorber 49 constructed similar to a surface condenser and constructed so as to have the absorbing liquid and exhaust vapor pass successively through sections of tubes in contact with cooling water, each section containing several rows of lateral tubes. The tendency of the liquid passing downward through ex-

haust pipe 10 will be to flow through the lowest tubes in each section, while the tendency of any free gas entering the absorber will naturally be to fill the upper tubes in each section and this separation of liquid and vapor will have a tendency to retard and temporarily defeat absorption, which must be accomplished while liquid and gas are in immediate contact.

In order to make the various rows of tubes in each section perform proportionate service, I provide in absorber 49 the rows of tubes which connect directly with the exhaust pipe 10, with aprons projecting into the path of said two fluids, so as to catch and convey proportionate amounts of the two fluids to said rows of tubes.

50 and 51 are the aprons supplying the rows of tubes indicated by 52 and 53, while the lower curved inner wall of the exhaust pipe 10 performs like service for row of tubes 54. The vertical part of the exhaust pipe is generally much narrower than the part of absorber 49 which contains the upper section of tubes, hence the curved part of the exhaust pipe containing the aprons mentioned above had best be widened gradually so as to approximate the width of the absorber where it is joined to the same, the aprons extending the full width of said widened exhaust pipe.

55 is a vertical chamber through which the liquid, after leaving tubes 52, 53, 54 must drop in order to reach rows of tubes 56, 57, 58. The shelves 59, 60, 61 and 62 in said chamber are provided in order to give to rows of tubes 56, 57 and 58 proportionate amounts of liquid. 59 is placed directly underneath the outflow ends of row of tubes 52 and 60 underneath those of tubes 53, both said shelves being made to slope downward from said tubes, although they might instead be made horizontal. Shelf or apron 61 is placed underneath the inflow ends of the tubes 56 and apron 62 underneath those of tubes 57, both sloping upward from said inflow ends. Apron 59 extends to the right beyond 62; 62 extends beyond 60, and 60 beyond 61, so that liquid passing out of tubes 52 will be conducted by apron 59 to the lower part of chamber 55 where it will enter tubes 58, while liquid from tubes 53 will be conducted by apron 60 so as to drop down upon apron 62 and to enter from there tubes 57, while liquid flowing out of tubes 54 will fall upon apron 61 and from there enter into tubes 56. While dropping downward in chamber 55 the liquid will pick up such gas as may exist there in a free condition and will either absorb it or carry it along into the lower section of tubes.

Rows of tubes 52, 53, 54 are shown to slope downward from the exhaust pipe 10, while rows of tubes 56, 57, 58 slope downward toward pipe 63 which pipe withdraws the contents of absorber 49 to well 44, which well it enters near its bottom and below its liquid line. Giving the tubes inclined positions as indicated will facilitate the drainage of the liquid through the same when the main body of the absorber is in its usual vertical position. Such arrangement also has the further advantage that, where the main exhaust pipe and with it the absorber temporarily depart from their vertical position, as will happen on board of a ship when not on an even keel or when rolling, the rows of tubes, even if not maintaining as sloped positions as indicated on the drawings will still be capable of draining the liquid from the exhaust pipe 10 and toward the pipe 63, while, if the pipes were originally placed in horizontal positions, the same might thus temporarily assume positions sloping upward from said exhaust pipe, and downward from pipe 63, whereby liquid seals would be formed at the inlets to the tubes, preventing the free flow or passage of the gas with the absorbing liquid into and through said tubes on their way toward well 44. To further promote absorption a water pipe 65 passes through the well in the form of a coil, the water afterward entering absorber 49 through pipe 66 and leaving it through pipe 68.

67 is a division plate in the water space of the absorber extending from its left end to near its right end, so as to compel the passage of the cooling water in the absorber first to the right along tubes 56, 57, 58 and afterward to the left along tubes 52, 53, 54. 64 is a cock for regulating this water supply.

In pipe 63 a vacuum pump might be placed for withdrawing liquid and gas from absorber 49 and forcing it into well 44 thus further aiding absorption therein by compression.

69 is a branch pipe of 41 and is provided with a cock 70, while 71 is a branch pipe of pipe 43 and is provided with a cock 72. These branch pipes are provided for the purpose of substituting water as cooling medium in coil 42 instead of refrigerating gas, when it is desired to temporarily do away with operating the refrigerating apparatus. In such case cock 24, and cock 103 in pipe 43 would have to be closed and cocks 70 and 72 would have to be opened, pipe 69 being made to connect with any suitable water supply.

76 is a feed pump and water pump combined which obtains its supply of vapor for operating it through pipe 84 connecting with pipe 7 and discharges its exhaust vapor through pipe 85 into the upper part of well 44 and near nozzle 47, the liquid distributed by such nozzle aiding in its absorption.

86 is the exhaust pipe of pump 27 and is made to enter the lower part of absorber 49, so as to absorb the vapor discharged by it by means of the liquid distributed by nozzle 18.

As it is desirable to withdraw no more absorbing liquid from the generator than is necessary to obtain a proper vacuum in the exhaust pipe 10, which vacuum will affect and correspondingly regulate the vacuum in the engine cylinder, I regulate the discharge of said liquid into pipe 10 automatically as described hereinafter, an apparatus as described for such purpose being applicable whether or

not such liquid is made to pass through pump 27. A pipe 87 is made to branch out from main exhaust pipe 10 and is closed at its enlarged end by a diaphragm 88. The hinged lever 89 attached to and moving with said flexible diaphragm also connects with and regulates the movement of stem 90 of valve 16 through which the absorbing liquid circulates. Said valve is preferably constructed as a balanced valve as shown, so as to be independent in its movements of the pressure existing within pipe 15 and is similar in its construction and connections to throttle valves used in air compressors, where the pressure of the compressed air regulates the quantity of steam supplied to the steam cylinder. Said valve 16 is arranged so that its water way and consequently its discharge of liquid into pipe 17 will be reduced when its stem is moved downward and that said waterway will be increased when the stem with the disks attached to it within said valve, moves upward. The inherent spring power of diaphragm 88 has a tendency to resist any pressure upon it in a downward direction, while the weight 91 near the lower end of lever 89 has a tendency to counteract the upward force of said diaphragm. The operation of the two forces combined will prevent any violent agitations of the diaphragm and consequently of the working parts of valve 16 when changes of pressure take place within the exhaust pipe and consequently within pipe 87. The valve 16 having been so adjusted by properly locating weight 91 on lever 89 as to allow under the pressure ordinarily existing in pipe 15 the passage of an amount of absorbing liquid through it just sufficient to produce the desired vacuum in pipes 10 and 87, any reduction of the pressure within said pipes will cause the outer atmosphere to force diaphragm 88 inward, thereby lowering lever 89 and with it the valve stem 90 and the disks controlling the water-way so as to reduce the latter, thus preventing the discharge through nozzle 18 of more absorbing liquid than the circumstances call for. On the other hand, if an increase of pressure in pipes 10 and 87 should take place the diaphragm will thereby be forced outward and consequently valve 16 will be so affected thereby as to increase its water way until the pressure in the exhaust pipe is again reduced. Pipe 87 might be made to branch out from exhaust pipe 10 at any suitable point and particularly above the spray jet. The diaphragm might also be attached to pipe 10 direct, and instead of said diaphragm a piston might be used.

In case the pump 27 be employed regularly for forcing the absorbing liquid toward nozzle 18, the diaphragm 88 might be made to regulate in a corresponding manner the passage of vapor through the throttle valve of said pump, instead of agitating liquid valve 16. Valve 16 and its connections might be so adjusted as to close entirely after a nearly perfect vacuum in pipe 10 had been obtained after stoppage of the engine. It is also important to guard against excessive pressure in well 44 which might occur if liquid and gas were continuously carried into it, without providing proper relief by withdrawing from it a sufficient quantity of the saturated solution. To guard against such difficulties I regulate such pressure, by increasing or decreasing the speed of feed pumps 77, 78 in accordance with the pressure existing in the well. The apparatus employed by me for such purpose corresponds closely with that described above for regulating the discharge of the absorbing liquid and is constructed as follows: 92 is a pipe connecting with the interior of well 44 and is provided with flexible diaphragm 93, which will be forced outward as the pressure in the well increases and will lift the hinged lever 94 attached to it, which lever through valve stem 95 regulates the movement of the working parts of valve 96 in vapor supply pipe 84 of feed pump 76, so as to increase the vapor way of said valve, thereby increasing the performance of the pump in withdrawing liquid from the well. In an analogous way the performance of the pump will be reduced by reducing the supply of vapor to said pump, as the pressure in the well goes down.

It frequently happens that the suction pipe of a pump taking its supply of liquid from a well containing aqua ammonia, such as cylinder 77 of the feed pump contain entrapped therein unabsorbed gas to such an extent as to form a gas seal, which will prevent liquid from entering the pump cylinder and will thus interrupt the operation of the pump. To overcome this difficulty I provide pipe 97 which connects the suction pipe 75 of said pump with pipe 45 containing the cooled absorbing liquid under pressure. In said pipe 97 I place cocks 98 and 99. The check valve 74 between pipes 73 and 75 is adjusted to close toward the well 44, and when said cocks are opened the absorbing liquid, previously cooled so as to possess great absorbing power will be forced into that part of the suction pipe near the pump which contains said free gas and by absorbing said gas will again permit the pump to operate. Valve 74 will prevent the passage of such absorbing liquid to well 44. If free gas should reach the delivery end of the pump and there interfere with its operation in a similar manner as air frequently does in water pumps, I dispose of it in a manner corresponding with that described above by introducing the cool absorbing liquid there from pipe 97 through pipe 99, opening for such purpose cock 100. Ordinarily cocks 98 and 100 will be kept closed until absorption of such free gas becomes necessary. Cock 99 is only provided to permit using pipe 97 as a chamber in which free gas from the suction pipe may accumulate, cock 98 being then open, until finally such gas is disposed of by opening cock 99. 101 is the weight on lever 94. The feed pump forces the combined absorbing liquid and exhaust vapor, now form-

ing a strong solution, through pipe 80, reservoir 25, pipe 81, reservoir 20 and pipe 82 back into the generator, 83 being a suitable check valve for retaining the liquid in the generator. In reservoir 25 the feed liquid has imparted to it part of the heat of the absorbing liquid and in reservoir 20 part of the heat contained in the ammonia gas which is to be used for refrigerating purposes, thus turning to useful account heat which would otherwise have to be wasted. It will readily be seen that instead of bringing the absorbing liquid, and the combined absorbing liquid and exhaust vapor, in direct contact with passages containing the refrigerating gas as described above, brine might be used, as is frequently done in similar apparatus, as an intermediary between the refrigerating gas and the fluids to be refrigerated, without affecting the nature of my invention or the intended scope of such of the following claims as make reference to such subject.

I claim as new and desire to secure by Letters Patent—

1. The method herein described of heating aqua ammonia, using part of the gas so evolved for propelling an engine, compressing and cooling another part of said gas in a by-pass around the engine, allowing it to expand afterward therein, thus producing artificial cold, for the purpose of thereby cooling liquid to be used for absorbing the exhaust vapor of said engine, substantially as set forth.

2. The method herein described of heating aqua ammonia, using part of the gas so evolved for propelling an engine, compressing and cooling another part of said gas in a by-pass around the engine, allowing it to afterward expand therein thus producing artificial cold, cooling thereby liquid to be used for absorbing the exhaust vapor of said engine, reabsorbing the exhaust vapor from the engine and the gas used for refrigerating the absorbing liquid in the same absorbing apparatus and forcing the same jointly back into the generator, wherein the ammonia gas was evolved, substantially as set forth.

3. The method herein described of operating an aqua ammonia engine by vapor developed by heating aqua ammonia in a generator, and absorbing the exhaust vapor of the engine by liquid withdrawn from said generator, said absorbing liquid being lowered in temperature first by bringing the pipe containing it in contact with cooling water and by afterward passing it through a chamber in such proximity or relation to that part of a by-pass around the engine wherein ammonia gas from the generator after having been liquefied is expanded, so as to impart the artificial cold of such gas to the absorbing liquid, substantially as set forth.

4. The method herein described of operating an aqua ammonia engine by vapor developed in a generator, and absorbing the exhaust vapor of said engine by liquid withdrawn from said generator, said absorbing liquid being lowered in temperature by passing it through a chamber in such relation or proximity to a column of ammonia gas expanded after having been liquefied and being continuous between the generator and the absorber, as to impart the artificial cold of such gas to said absorbing liquid, substantially as set forth.

5. The method herein described of absorbing the exhaust vapor of an ammonia engine and absorbing ammonia gas expanded for purposes of refrigeration by bringing absorbing liquid withdrawn from the generator, and cooled, first in contact with the exhaust vapor from the engine, and afterward bringing the combined absorbing liquid and exhaust vapor in contact with the ammonia gas expanded for purposes of refrigeration, substantially as set forth.

6. The method herein described of absorbing the exhaust vapor of an ammonia engine and absorbing ammonia gas expanded for purposes of refrigeration, which consists in first bringing absorbing liquid in contact with the exhaust vapor from the engine, then passing the combined absorbing liquid and exhaust vapor through an absorber and in such proximity or relation to the passages wherein ammonia gas from the generator is expanded after having been cooled, as to have the artificial cold so produced serve as cooling agent in said absorber and finally bringing the combined exhaust vapor and spraying liquid in contact with the ammonia gas so expanded for purposes of refrigeration, substantially as set forth.

7. The method herein described of developing ammonia gas by heating aqua ammonia in a generator, passing part of said gas through an engine cylinder for propelling its piston, liquefying another part of said gas by cooling it under pressure, allowing it to expand for purposes of refrigeration, absorbing the exhaust from the engine and the gas expanded for purposes of refrigeration by liquid withdrawn from the generator and cooled, passing the absorbing liquid combined with the exhaust of the engine and with such gas previously used for refrigeration back into the generator and using such combined gas and liquid as a cooling medium in said liquefaction while on their way to the generator, substantially as set forth.

8. The method herein described of developing ammonia gas by heating aqua ammonia in a generator, liquefying gas so generated by cooling it while under pressure, allowing it to expand for purposes of refrigeration, absorbing the expanded gas by liquid withdrawn from the generator and cooled, and employing the combined gas and absorbing liquid as a cooling medium in said liquefaction, prior to forcing the same back into the generator, substantially as set forth.

9. The method herein described of liquefying ammonia gas, using it while expanding as cooling medium for the absorbing liquid of an ammonia engine and conducting such gas

through pipes draining toward a receiving well, for the purpose of absorbing it therein, substantially as set forth.

10. The method herein described of absorbing the exhaust vapor of an aqua ammonia engine by liquid discharged under pressure from one or more outlets under such directions, as to make different currents of said liquid impinge upon each other under pressure outside of said outlet or outlets, for the purpose of dispersing, or of atomizing, said absorbing liquid in the passage through which the exhaust vapor flows, substantially as set forth.

11. The method herein described of absorbing the exhaust vapor of an ammonia engine, which consists in reducing the absorbing liquid in temperature by conveying it through passages cooled artificially and discharging it into the absorbing apparatus from one or more outlets in such directions as to make different currents of said liquid impinge upon each other under pressure outside of said outlet or outlets, substantially as set forth.

12. The method herein described of absorbing the exhaust vapor of an ammonia engine, which consists in bringing said vapor in contact with absorbing liquid dispersed in the form of a spray and conveying the combined absorbing liquid and exhaust vapor through an absorber provided with lateral tubes, after first dividing said liquid and vapor carried along by adhesion, for the purpose of making said tubes perform proportionate amounts of absorption, substantially as set forth.

13. The method herein described of absorbing the exhaust vapor of an ammonia engine, which consists in bringing said vapor in contact with absorbing liquid and conveying absorbing liquid and exhaust vapor through rows of lateral tubes in an absorber, after first dividing said liquid and vapor carried along by adhesion, for the purpose of making all said rows of tubes perform mixing of liquid and vapor, and absorption, substantially as set forth.

14. The method herein described of absorbing the exhaust vapor of an ammonia engine, which consists in bringing the exhaust vapor in contact with absorbing liquid and carrying the two combined through an absorber provided with tubes inclined downward so as to drain the resulting liquid from said absorber, substantially as set forth.

15. The method herein described of converting the liquid pressure at the absorbing jet of an ammonia engine from generator pressure into pump-pressure, by passing such liquid through a pump placed in a by-pass around a suitable valve located in the pipe leading from the generator to the absorbing jet, substantially as set forth.

16. The method herein described of forcing absorbing liquid automatically, upon excessive pressure in the generator, toward suitable cooling appliances prior to returning it to said generator, which consists in automatically opening a valve, for conducting vapor from the generator through such valve to the vapor cylinder of a pump, placed in a pipe withdrawing liquid from the generator and conducting it to a jet which discharges it into such cooling appliances, substantially as set forth.

17. The method herein described of automatically increasing the supply of cooling liquid for purposes of liquefaction of ammonia gas and refrigeration resulting therefrom as the pressure in the generator and with it the amount of gas subject to liquefaction increases, which consists in automatically opening a valve for conducting vapor from the same source from which the gas for cooling purposes is withdrawn, to the vapor cylinder of a pump, the water cylinder of such pump being made to discharge thereupon cooling liquid into passages in contact with the gas in process of liquefaction, substantially as set forth.

18. The method herein described of relieving the suction pipe of an aqua ammonia pump of free ammonia gas, which consists in discharging into such suction pipe absorbing liquid withdrawn from the generator and cooled, while such free gas remains confined in said suction pipe, substantially as set forth.

19. The method herein described of relieving the suction pipe of an aqua ammonia pump of free ammonia gas, which consists in discharging into said suction pipe absorbing liquid cooled artificially while keeping such gas confined between the pump and a suitable valve substantially as set forth.

20. The method herein described of relieving the discharge pipe of an aqua ammonia pump or of relieving such pump of free gas, which consists in introducing into said pump at or near the point where in a water pump the air-cock is usually located, absorbing liquid under pressure, substantially as set forth.

21. The method herein described of relieving the discharge end of an aqua ammonia pump of free gas, by introducing into it absorbing liquid, refrigerated, substantially as set forth.

22. The method herein described of regulating, in an ammonia engine apparatus, the supply of absorbing liquid to the spray jet in accordance with the pressure existing in the exhaust pipe of the engine, which consists in converting an increase or decrease of pressure in the exhaust pipe into motion of a valve located in or connected with the pipe containing the spray jet, whereby such increase or decrease of pressure will increase or decrease the quantity of liquid passing to the spray jet, substantially as set forth.

23. The method herein described of regulating in an ammonia engine apparatus, the supply of absorbing liquid to the spray jet in accordance with the pressure existing in the absorbing apparatus of the engine, which consists in converting an increase of pressure in the absorbing apparatus into motion of a

valve located in or connected with the pipe containing the spray jet, thereby increasing or decreasing the effective water way for supplying the spray jet, substantially as set forth.

24. The method herein described of regulating the amount of saturated liquid in the receiving well of an ammonia engine apparatus, which consists in converting an increase or decrease of pressure therein into motion of a valve controlling the supply of vapor for operating the feed pump, thereby increasing or decreasing the vapor passages in the pipe supplying the feed pump, as the pressure in said well increases or decreases, substantially as set forth.

25. The method herein described of absorbing the exhaust vapor in an ammonia engine apparatus, which consists in discharging absorbing liquid withdrawn from the generator and cooled toward the coils of an absorber containing cooling fluid and surrounded by the exhaust vapor, and carrying vapor and absorbing liquid combined afterward laterally and downward along other cooling surfaces toward a receiving well, substantially as set forth.

26. In an ammonia engine apparatus a pipe conveying absorbing liquid from the generator, to the spray jet in the absorbing apparatus, a suitable valve placed in said pipe, and a by-pass around said valve and containing a pump, the suction end being connected with the aforesaid pipe between said valve and said generator, and its discharge end being connected with a pipe discharging into the absorbing apparatus, all combined substantially as and for the purposes set forth.

27. In the absorbing apparatus of an aqua ammonia engine a pipe leading from the liquid space of a generator along cooling surfaces into a passage conveying the exhaust vapor of the engine, such pipe being provided with a nozzle 18 having two outlet passages converging toward a point outside of said nozzle, all combined substantially as and for the purposes set forth.

28. In the absorbing apparatus of an ammonia engine a discharge nozzle for the absorbing liquid consisting of casing 102, tongue 38 suspended within said casing and springs 40, 40 for centering said tongue, substantially as set forth.

29. In the absorbing apparatus of an aqua ammonia engine, in combination with the engine cylinder and its exhaust pipe, a pipe conveying absorbing liquid from the generator to said exhaust pipe, a jet for distributing such liquid therein laterally and a coil through which cooling fluid circulates, such coil being placed in the path of the exhaust vapor of the engine and of the absorbing liquid so discharged, substantially as set forth.

30. In the absorbing apparatus of an aqua ammonia engine in combination with a jet discharging within it absorbing liquid, two absorbers for successively cooling the combined exhaust vapor and absorbing liquid while in transit toward a receiving well, one of said absorbers receiving its cooling medium from an apparatus producing artificial refrigeration, and the other having circulating through it cooling water, substantially as set forth.

31. In the absorbing apparatus of an aqua ammonia engine an absorber placed in the path of the combined exhaust vapor and absorbing liquid withdrawn from the generator, the cooling passages of such absorber being provided with two separate inlets and two separate outlets all having suitable valves, one of said inlets and one of said outlets connecting with an artificial refrigerating apparatus and the other inlet connecting with a water pipe, substantially as set forth.

32. In the absorbing apparatus of an aqua ammonia engine the combination with a nozzle discharging absorbing liquid between the exhaust ports of the engine and tubes of an absorber, and a plate or plates placed in the path of such liquid, for the purpose of diverting such liquid to said tubes and distributing it among the same, substantially as set forth.

33. In the absorbing apparatus of an aqua ammonia engine the combination of a pipe conveying absorbing liquid to a jet, with an absorber having sections of lateral tubes through which the liquid passes successively, together with a vertical chamber into which one section of tubes discharges the liquid and gas passing through the same and from which another section of tubes withdraws such liquid and gas, and plates in said chamber placed underneath and projecting beyond the outlets of the first named section, and other plates in said chamber placed underneath and projecting beyond aforesaid plates and connecting with, or leading to the inlets of the tubes in the second section, for the purpose of distributing liquid after its passage through the first section among the tubes, and the rows of tubes, of the subsequent section, all substantially as specified.

34. In an aqua ammonia engine apparatus the combination with an aqua ammonia pump, of its suction pipe, a check valve 74 in said pipe and a pipe 97 with proper valve, for the purpose of forcing absorbing liquid through it into the part of the suction pipe between said check valve and said pump so as to close said valve, for the absorption of free gas contained in such part of the suction pipe, substantially as set forth.

35. In an ammonia engine apparatus in combination with a pipe conveying absorbing liquid from the generator to the absorbing jet, a chamber 87 connecting with the interior of the absorbing apparatus, diaphragm 88 forming part of said chamber, lever 89 connected with said diaphragm and operating valve 16 for automatically adjusting the amount of absorbing liquid introduced into the absorbing apparatus through pipe 17, substantially as set forth.

36. In an aqua ammonia engine apparatus

in combination with a pipe conveying absorbing liquid from the generator to the absorbing apparatus, a chamber 92 connecting with the interior of the receiving well and closed by diaphragm 93 forming part of such chamber, lever 94 connecting with said diaphragm and operating valve 96 within vapor pipe 84 of pump 76, which pump regulates the amount of liquid stored in said well, substantially as set forth.

37. In the absorbing apparatus of an aqua ammonia engine a pipe conveying to it absorbing liquid from the generator, and spray nozzle 18 discharging such liquid into the exhaust pipe of the engine outward toward the coils of cooling pipe 42, substantially as set forth.

38. In an aqua ammonia engine apparatus, in combination with a generator wherein vapor of ammonia is expelled from aqua ammonia by heat, an engine propelled by such vapor, a pipe leading from the liquid space of the generator to the suction end of a pump, said pump, its discharge end being connected with a discharge nozzle placed between the exhaust ports of the engine and a receiving well, and cooling surfaces along which said liquid circulates while in transit from the generator to said well, substantially as set forth.

39. In an aqua ammonia engine apparatus, in combination with a generator wherein vapor of ammonia is expelled from aqua ammonia by heat, an engine propelled by such vapor, a pump forcing liquid withdrawn from the generator and cooled to a jet placed in the exhaust pipe of the engine, such jet being made to point, or to discharge, in the same direction in which the exhaust vapor travels toward the receiving well, substantially as set forth.

Signed at New York, in the county of New York and State of New York, this 31st day of December, A. D. 1889.

CHAS. L. HORACK.

Witnesses:
RUFUS M. WILLIAMS,
BRADBURY WILLIAMS.